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Report from IJCAI 2019, Top AI Conference for 50 years

Which Crisis is Coming First – of AI or of World Economy?

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Editorial

1 Introduction

This year IJCAI [1] - "International Joint Conference on Artificial Intelligence" - celebrates half a century of continuous conferencing as the world AI's most important global event. Over the last ten years, the number of submissions has grown steadily, by more than 30% in the last two years alone, and for 2019 it approached 5000 with 2700 committee members (Figure 1). The acceptance rate this year was less than 18%, one of the lowest ever, leading to 850 papers presented at the main conference, accompanied by three days of workshops. The papers from China (327, 38%) toppled the papers from EU (152) and USA (169) combined, while other countries followed with Australia (37), India (20), Japan (18) and areas like Eastern Europe or Africa far behind. The shift in recent years has been enormous, not only in terms of the number of papers, but also in terms of the number of new applications and the overall focus of countries and resources involved. The conference costs for one speaker, for example, amounted to several thousand euros. In terms of rewards, lifetime achievements and invited lectures, USA and EU still dominated due to inertia since the number of senior AI researches in Asia has only recently started to increase.

Besides Program Committee Chair Sarit Kraus, there were Tutorials Chairs, Workshop Chairs, Demo Chairs, Doctoral Consortium Chair, Robot Exhibition Chairs, Video Competition Chairs, Survey Chairs, and Chairs for Sister Conference Best Papers, Journal Track, Special Track on Understanding Intelligence and Human-level AI in the New Machine Learning era, Special Track on AI for Improving Human-Well Being. The distribution of IJCAI papers in 2019 by area, submitted and accepted is presented at Figure 2, some competitions in Figure 3.

2 Achievements and dilemmas

IJCAI is not only a conference, it is an annual presentation of the world's AI best and brightest and most relevant events, e.g. the meeting of world AI societies. Unfortunately, there are glitches, and this year the presence of national AI representatives was more than sporadic. Hopefully in 2020 the organizer will send an invitation to all national organizations in time. Another idea - as this is an informal organization, we will draw up a list of all national AI societies and submit an invitation in time. Better two invitations than none. In the world of over-aggressive web and other media advertising and social media, activities of scientific societies are somehow overshadowed. For example, while AI funds around the world are growing rapidly with an EU annual increase of around 50%, European AI societies (EurAI) have not increased their memberships, and no new European AI society joined in 2019. When asked why AI societies are not more aggressive in trying to attract more societies and members, the reply was that this can hardly be expected from a scientific organization - e.g. to use commercial advertising methods. Maybe, or maybe not and what is needed are strong vision and determination.

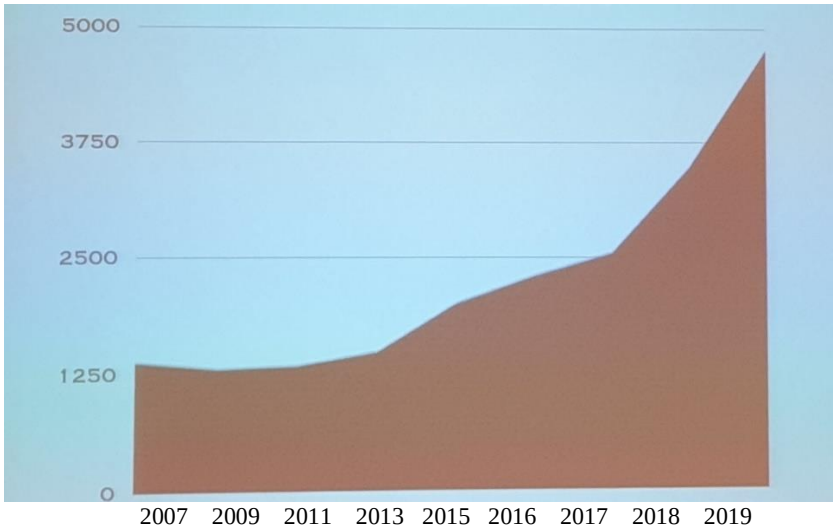

Figure 1: Submissions to IJCAIs.

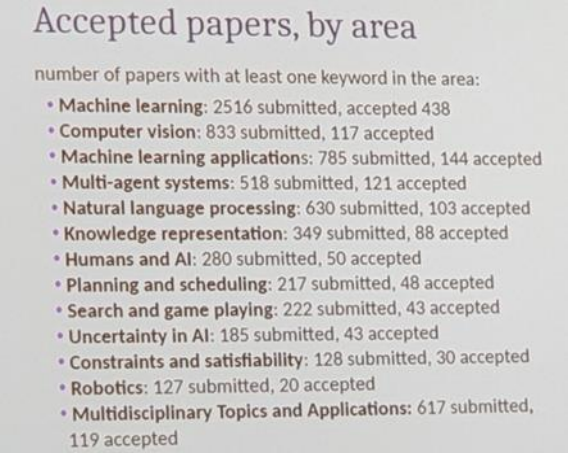

Figure 2: IJCAI 2019 submitted and accepted papers by area.

While IJCAI 2019 as a whole was undoubtedly a great success, some issues were observed in specific areas. For example, "AI in industry" presented several important AI applications. To name one, Xiaowei, a Chinese mobile platform with several AI modules, has around one billion users (Huaowei around 3 billion) and is constantly introducing new AI services. At the 2019 IJCAI conference they presented an AI assistant. When fully implemented and reaching all users, it will bypass Siri (0,5 billion), Google Home (0,4) and Alexa (0,1) users as current leading voice-controlled AI assistants. In the AI demonstration section, a fast growing and flourishing area of IJCAI, several systems deserved and often got world-wide appreciations. For example, one system improved distribution and placement of Uber drivers, enhancing the individual driver's gain and decreasing the user's waiting time. One rewarded demo presented an automatic creation of assistants from websites and the other fair use of workforce.

The industry AI award was given to a Microsoft team for an application of reinforcement learning to personalize news (28% increase in adaptation) and games (40%). These huge improvements were obtained by relatively small modifications of the previous systems, a lesion to be remembered. But surprisingly, the participation in the lecture hall was less than average. The explanation at hand is that most of the conference attendees were researchers listening to academic presentations that took place simultaneously in several parallel sections. The gap between academia and industry was highlighted once again. Researchers receive funding and fame according to academic criteria and it is not of great importance if their ideas find ways to actually help people and increase profits.

The fusion of real-live applications and academia at IJCAI was courageously attempted in many respects, such as the competition for care of the elderly instead of robot soccer (Figure 4).

The two major advances in 2019 compared to 2018 were probably the increase in massive AI applications, and secondly, new research orientations. The fact that the former was somehow accepted as an obvious fact is not very helpful for AI growth and fame, where an AI program beating humans in a particular game obtains overall attention, while major AI applications hardly ever. But it is precisely the dozens of industry presentations, demos, workshops, competitions such as the elderly-care competition (Figure 4) and practical AI presentations, often related to a particular branch such as robots, that have most impressed an impartial AI observer in 2019. AI is in the intense phase of transforming human society into an advanced, incremental, optimized and multi-objective civilization providing better foundations for long-term sustainable growth.

As usual, there were hundreds of incremental algorithm improvements, be it random forest, boosting or deep neural networks. In particular, the deep learning, where a random forest algorithm is placed instead of a neuron in a network, had shown quite important improvements. The problem, which is consistent with the principle of multiple knowledge [2], is that it quickly loses diversity with additional levels since the random forest consists of more or less all possible decision trees. Therefore, despite some interesting results the original idea of adding another algorithm such as RF instead of a neuron is still in progress. Overall, this incremental progress is quite impressive as AI is used for hundreds of trillions of decisions a day, and a few percent better decisions mean a lot in real life.

Figure 3: Competitions at IJCAI 2019.

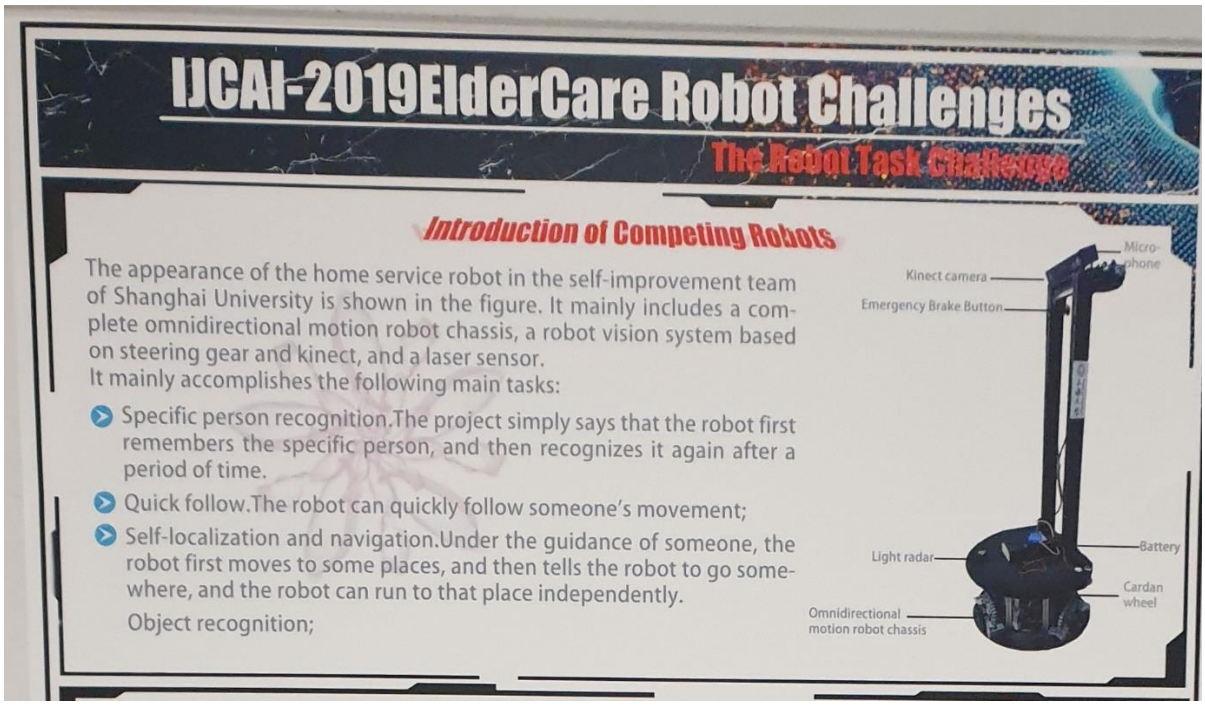

Figure 4: Elderly-care competition instructions.
The focus change from academic to real-life was noticeable at IJCAI 2019.

3 AI directions

As far as the new research orientation is concerned, at IJCAI 2019 it was carried out in a rather precise way, although not by all the invited speakers. But several lectures merged into a new research paradigm that was best presented at the conference last afternoon by Broeck, Domingos, and Shoham. It is not a switch from Decision Tress (DTs) to Deep Neural Networks (DNNs) because DTs (or decision graphs) are as accurate as DNNs in some areas and also provide explanations and understanding that are unprecedented for DNNs, regardless of the DNN advances outperforming any artificial system in several areas and often the best people. Nor is it very likely that DNNs will soon become truly intelligent, as Figure 5 shows - a boy standing on a chair hoping in vain to see the stars better with a telescope. It's also not a dilemma whether to use AI systems like GPT-2, HAIM, Grover or "Not Jordan Peterson" (the last one removed due to lawsuits) - why not use them for fun and get acquainted with the power of SOTA AI.

AI is a technology and like any technology it can be used for good or bad. At present, AI it is the one that contributes most to human progress, with applications ranging from robotics to web services and autonomous cars. According to practical statistics, a Tesla car, for example, is nine times safer in the autonomous driving mode than an average classical car. The progress can also be seen in the services openly available on the net - for example, a few years ago nobody could create a system like Not Jordan Peterson - fluently speaking input text that does not differ from the speech of original author.

The actual question / dilemma, according to the IJCAI presenters is the following: Are we on the path to developing truly intelligent systems or only AI applications capable of playing excellent chess, for example, where the specific algorithmic solutions are dedicated and successful only in a certain area, without explanation and without the impression that something inside resembles a real human intelligence? Since the attempts to solve the Turing test remain as unsuccessful as ever while the computer and AI progress is continuing with the exponential speed, something soberer seems to be hidden in this perplexity.

However, there are the good old strong AIers who claim that we are on the way to true intelligence and we just need to be patient a little more. And anyway, who says that intelligent AI systems need to have human-like intelligence to perform well, because airplanes fly in contrast to birds, while the direct applications of bird-like flight patterns is counterproductive. Why should an autonomous car write or understand sophisticated poems about ethics, mortality or love? Furthermore – consider the moral dilemma of autonomous cars: Who should a car hit - a child or a grandma, if it cannot stop in time? In practice, this is statistically an irrelevant question, since such a situation practically never occurs in an individual's life. Second, in some countries, such as Germany, there is a law that forbids taking preferences based on age - a car that prefers to run over grandma would therefore be illegal and subject to legal consequences. And thirdly, why is this dilemma imposed on the scientific engineering community, where 99% of activities are aimed at developing technical solutions that enable high-quality driving in all possible real circumstances from weather conditions to the reactions of other road users? Should we concentrate our energy on a hypothetical situation or rather design better systems to save thousands of lives

Figure 5: Probably, current deep neural networks, alike other existing AI approaches, will never achieve true intelligence on their own. New strategies are needed.

each year? It should also be noted that two decades ago autonomous cars were more of a joke than something people believed in - so amazing is the AI progress!

So why is a large part of all discussions dedicated to a philosophical dilemma of whom should a car strike first in more or less artificial situations? Why does a Tesla incident caused by an AI mistake attract a lot of media attention and the corresponding ten situations in which it avoided a crash with superhuman reflexes practically none at all? Not to mention that there are several benchmark domains where AI progress can be demonstrated explicitly in a scientific, repeatable and measurable way.

In reality, for a large part of the AI applications, no real human-level intelligence is required and the engineering AI already offers significant improvements. For example, DNNs in the ImageNet benchmark visual recognition test improved their accuracy from 71% to 93% from 2011 to 2014 and from 2014 to 2018 to 98%. To name some of the most important AI achievements in recent years: 2017 - skin cancer, poker; 2018 – SQUAD1.0, Chinese-English translation, Dota2, prostate cancer; 2019 - SQUAD2.0, Starcraft. DNN combined with reinforcement learning enabled a big step ahead. For example, Google's DeepMind played magnificently 50 Atari games. An example game would be hitting the ball from the bottom of the screen upwards to hit objects in several rows at the top of the screen to score points. But to demonstrate the strange nature of some recent AI achievements, when the racket was moved up a few pixels, the performance deteriorated significantly, which is highly unlikely for humans. Another example - when it was investigated how DNNs learned to distinguish cats from dogs, it turned out that their decisions were based on a small number of pixels and when these pixels were changed, with humans still clearly distinguishing between different animals, DNNs failed. These days, researchers are developing algorithms that compete in the search for the minimum number of pixels that need to be changed to mislead DNNs. Several experiments of this kind showed that DNNs learn significantly different than people do, that their knowledge is not general, but highly specialized and therefore brittle. The expectation that DNNs, like other existing AI technologies, will achieve true intelligence is rather an attempt shown in Figure 5, according to several distinguished AI researchers.

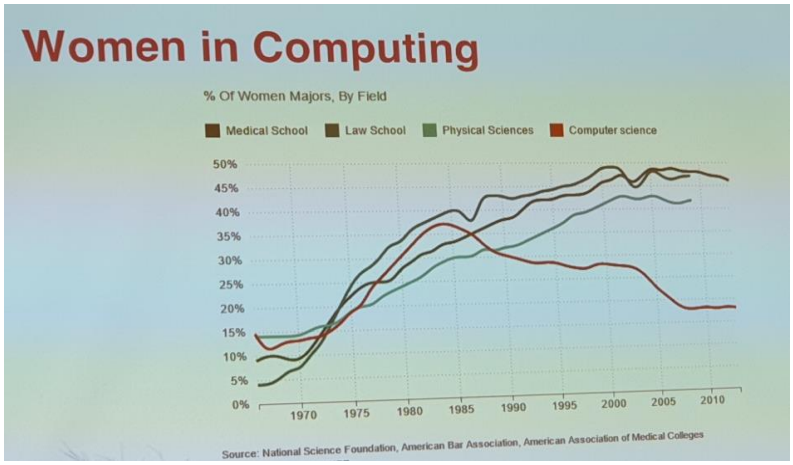

Figure 6: The issue of decreasing number of women in computing is a relevant and sound one, but the idea to use other criteria instead of research excellence for scientific publications is a threat to science.

members with specific personal characteristics, which

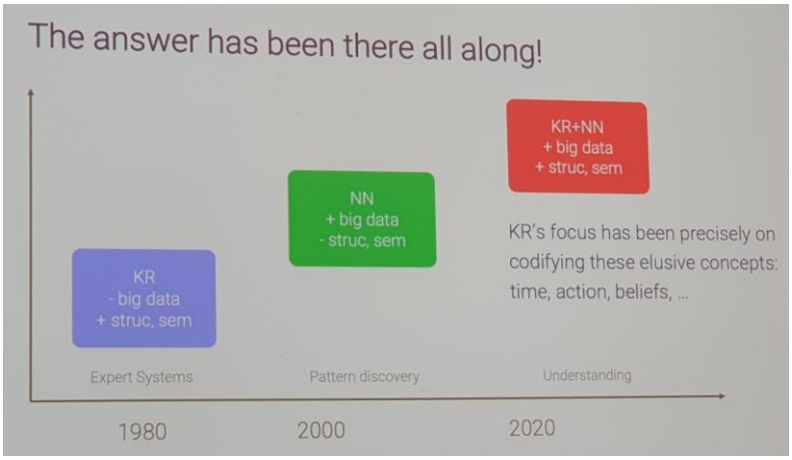

Figure 7: New strategic AI research direction on a path towards true intelligence, proposed by Shoham.

4 AI dangers

Among the dangers for AI, another one lurks in the shadows - the penetration of ideology, which is currently happening in all spheres of human activity, be it mass media or science. Indeed, in some AI areas like superintelligence [3,4], scientific objectivity, i.e. novelty, should not be the only criterion. A hostile superintelligence could harm human civilization, and therefore such attempts should be treated with appropriate supervision and caution[5]. For AI conferences and journals, the standard penetration of ideology is not a major problem, as all these activities are based on anonymous refereeing where authors based on personal characteristics such as position, country of origin, wealth, skin color, gender, age or similar cannot be preferred. In IJCAI 2019, however, there were some attempts to modify this standard approach. They all demanded a "fair" share of a certain section of the population - note that this paper will strictly avoid naming such criteria. Science and ideology do not walk along well, and it is disturbing for any true scientist to observe the growth of ideology in recent years. It might be too early to warn that virtually all civilizations have saturated and collapsed with the growth of harmful ideologies - harmful in the way they collided with the production of vital goods. In Western civilization, the negative effects of overwhelming neo-liberal globalization are quite obvious, from the overburdening of the planet by transporting industries to less developed countries with cheap labor and thus overloading the global environment, to the structure of important positions based on political orientations and personal categories such as gender or skin color, and not primarily on the ability to work well.

Be what it may, the declining number of women in IT technology (Figure 6) is indeed problematic. As a rule of thumb, at least 20% to 30% of the members of the opposite sex are needed to achieve good group performance and according to statistics this is already hard to achieve in some teams. In comparison - for boards of directors, CEOs or ministries, many Western countries require 40% of represents another extreme, and would be indeed unfortunate if such criteria were introduced into science, as softly advocated. But as long as the refereeing remains anonymous, there is no direct way for ideology to corrupt science too much.

At IJCAI, there wasn't much talk about media IT giants like Google or Facebook, but the way they affect human society to become more polarized, hostile and less open is becoming more and more evident. As an indicative example, suppose one observes a YouTube clip claiming that the Earth is flat. The recommendation system observes the area of interest and recommends more videos that the Earth is flat. Soon all one person will get are videos confirming the wrong belief. There are other stray effects related to the IT giants. Perhaps we should not discuss the penetration of ideology into say Google by deliberately providing the objective algorithms with false data in order to learn to eliminate politically undesirable persons from the media light (e.g. name modifications) as it is probably not a major phenomenon. However, the IT giants with all their positive novelties have also the sinister monopolistic side, influencing elections, and making people more stupid, as the Flynn effect shows with centuries of progress and a decline in the last decade.

At the same time, when used properly, fair and without ideological twists [5], AI will continue significantly improving the quality of the Web. For example, violent videos are removed from YouTube much faster and more efficiently than before with YouTube AI guards. From time to time there are still some failures, such as the elimination of robotic wars with the argument that cruelty to animals exists, but overall the improvement is indeed significant.

5 Conclusion and discussion

To summarize:

– Even without true AI, the incremental AI progress with rather engineering solutions already offers great improvements, and all attempts to discredit them or to shift the discussion outside the scientific, engineering

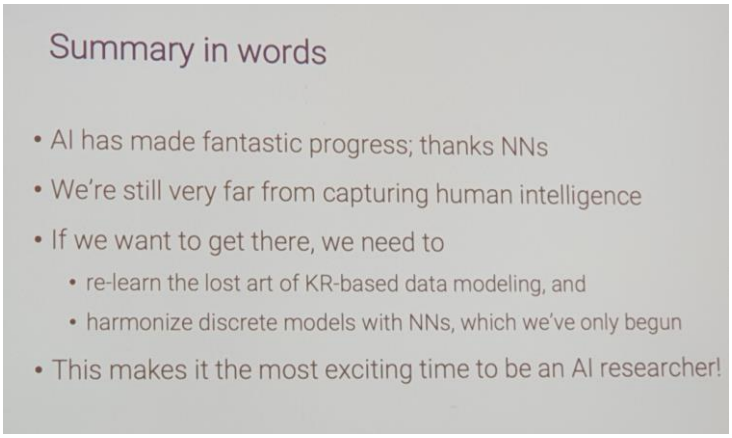

Figure 8: The last page of the IJCAI conference.

solutions are doomed to fail due to penetration of AI into our everyday lives.

– Different authors propose different recipes to achieve true intelligence, e.g., the author of this paper multiple computing and multiple knowledge [2]. In 2019, the IJCAI community proposed to merge deep ML technologies such as DNNs with models - Knowledge Representation (see Figure 7). It is therefore not primarily superintelligence or general intelligence, but the combination of DNNs with model-based (or rule-based) reasoning, that regardless of the upcoming problems at least in the near future will remain one of the dominant technologies and will persist as one of the most important technologies for the progress of human civilization. Believe it or not, even Google's responses to inquiries in recent years have been based on various AI methods. If AI stagnation should occur, then in the form of slower progress is expected, not of the winter type.
– On the other hand, there is no doubt that in a few years' time there will be another financial crisis, because on average crises occur in seven years, and in the last nine years we have been living in a series of steady growth. For the rich and clever, the crisis is an opportunity to enrich themselves more quickly, as history shows, but for the rest of the population, especially the middle and lower classes, there is nothing to cheer about. When and how deep the financial crisis will be - only time will tell.

For the finale of the IJCAI 2019 report and for the overall impression, the last sentence of the Shoham's lecture (Figure 8) was chosen: "**This makes it the most exciting time to be an AI researcher**."

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Consistency in Cloud-based Database Systems

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Cloud computing covers the large spectrum of services available on the internet. Cloud services use replication to ensure high availability. Within database replication, various copies of the same data item are stored in different sites, this situation requires managing the consistency of the multiple copies. In fact, the requirement for consistency level can be different according to application natures and other metrics; a delay of some minutes in visualizing latest posts in social networks can be tolerated, while some seconds can make a loss of a bid in an auction system. Wide variety of database management systems are used actually by cloud services, they support different levels of consistency to meet the diversity of needs.

This paper draws a presentation of the main characteristics of cloud computing and data management systems and describes different consistency models. Then it discusses the most famous cloud-based database management systems from the point of view of their data and consistency models.

Povzetek: Prispevek analizira podatkovna skladišča v oblakih predvsem s stališča konsistentnosti.

1 Introduction

Cloud computing refers to the large spectrum of services available on the internet. These services manage big quantities of data with high availability, scalability and elasticity. Providing availability requires databases replication. Replication permits the creation and the management of various copies of data items stored in different sites.

Consistency concerns the freshness of data and indicates if copies are the same in the different sites and witch version of data is returned by queries. In fact, consistency does not have the same importance for all the applications and the users. In social networks, a delay of minutes or even hours in visualizing the posts may not be a problem. Whilst for an auction system, a delay of few seconds can cause the loss of a bid.

Various systems are proposed to manage data for cloud services; they provide a variety of consistency models and use different data models which are based either on the classical relational model or on No-SQL models.

This paper discusses consistency in cloud-based database management systems. The reminder of this paper is organized as follows. Section 2 presents the main characteristics of cloud computing. Section 3 presents databases models in cloud. Section 4 explains the concept of consistency and the dilemma posed by the CAP theorem; it presents also the different levels and models of consistency. Section 5 presents some famous cloud systems and describes the implemented models of data and consistency. Section 6 concludes the paper.

2 Cloud computing

Cloud computing includes all forms of services available on the Internet; that are classified as software, platform or infrastructure as a service. Cloud services attract increasingly individuals, startups and big companies by the fascinating characteristics offered such as Availability, Scalability and Elasticity [1-4].

2.1 Availability

Queries must be answered within a reasonable time even there is a huge load of work or under any type of failures.

Availability is guaranteed by **replicating** databases, i.e. creating multiple replicas (copies) of the database and storing them at different sites. Replication can be full when it concerns the entire database or partial when it concerns just a part of the database (one or more tables, one or more partition) [5, 6].

Typically, Replicas are used to increase the **availability** of the system. They permit i) to decrease the latency by distributing queries on different replicas, ii) to cache site failure by accessing other sites, and iii) to recover site failure as backups [7].

Synchronous replication control algorithms assume that replicas are the same all the time. But this is not possible physically, so outdated replicas are made not

accessible until they are synchronized. In contrary, asynchronous algorithms allow accessing to divergent replicas that will finally converge [8, 9].

2.2 Scalability

This property is related to the capacity of providing large databases and managing their growing. Scalability is ensured by **partitioning** the database, i.e. devising the database into several disjoint partitions (fragments) that can be stored in different sites. Partitioning database offers the possibility of incrementing infinitely the capacity of storage by adding new hardware [6].

Partitioning has two general types: **Vertical** and **Horizontal**. In vertical type each partition contains a set of columns of the database; while in horizontal type (called communally sharding) the database is divided into sets of rows. The two types of partitioning can be combined to obtain a better strategy [10].

2.3 Elasticity

Elasticity called also elastic scalability refers to the flexibility of scaling up and down quickly in order to support the change of the requirements. Elasticity is the most important property that attracts companies to the cloud as it permits to pay accurately according to use.

3 Database models in cloud computing

Data storage in the cloud uses both of the classical relational model and the new No-SQL architectures.

Relational Databases: These databases respect the classical relational model proposed by E.F.Codd [11]. Relational databases structure data into tables composed of columns and rows, with a unique primary key and possible foreign keys. They provide the CRUD (**C**reate, **R**ead, **U**pdate and **D**elete) basic operations, and also operations across several tables.

Relational databases dominate the market of databases for more than twenty years; this success is due to its stability and consistency. These characteristics are guaranteed via transactional mechanisms that are implemented by the ACID (Atomicity, Consistency, Isolation and Durability) properties [12].

SQL (Structured Query Language) is the most used for requesting and maintaining relational databases.

Database Management Systems (DBMS) are responsible to store, retrieve, secure, replicate and realize backups of databases. The most famous Relational Databases Management Systems (RDBMS) are: Oracle, MySQL, Microsoft SQL Server, Postgres.

No-SQL Databases:

No-SQL databases ('Not only SQL' or 'Not relational') is a family of databases or more appropriate data stores that support all schemas of data characterized as structured, semi-structured and unstructured. No-SQL databases provide a high level of availability, scalability and elasticity. These features make No-SQL databases increasingly used for big data and qualified as the databases for the next-generation of web applications [13, 14].

Unlike the relational databases, No-SQL databases do not have a unified data model. Also, the level of operations is different; some systems provide only simple read-write operations, while others support more advanced operations. These differences lead to more than one hundred No-SQL databases which are principally classified into four categories [2, 3, 15, 23]:

i. **Key-value Databases:** this model permits to store all schemas of data, as (key, value) pairs. A unique key is assigned to every value and permits to access the value. The value can be a simple data item, or a set of key-value pairs.
   Example of key-value databases are: App Engine Data Store, Redis, Riak, etc.
ii. **Column-oriented Databases:** this model holds structured data in tables that are organized in rows like in relational databases. The difference is that columns can be different from one row to another. Also, a column can also regroup a set of columns. In other hand, operations across tables are not supported.
   Examples of column-oriented databases are: Google BigTable, Cassandra, etc.
iii. **Document-based Databases:** this model is used to store unstructured data, where keys addressed generally XML (eXtensible Markup Language) or JSON (JavaScript Object Notation) documents. No restrictions on data type or documents length are imposed.
   Examples of Document-based stores are: CoucheDB, MongoDB, RavenDB, etc.
iv. **Graph Databases:** this model allows storing data and relationships between them using graphs; nodes store data and arcs store relationships. The support of dynamic relationship makes this model the most appropriate for social networks.
   Examples of graph databases are: Neo4j, HyperGraphDB, Infinite Graph, etc.

We stress that all No-SQL architectures are basically based on the key-value model.

4 Consistency

Mutual consistency or simply consistency refers how to propagate updates between the different copies of replicated items. It concerns the state of data items in different sites; if they are the same or not. Also, how users see data items, if they see the same value, or they are allowed to see different values [6, 22].

Figure 01 shows a cloud system where the item X is duplicated in three sites. In an ideal situation, all copies of X have the same value (V1=V2=V3), this classical level of consistency is the most suitable, but it is hard to implement in distributed systems as it is proved by the CAP theorem as explained below.

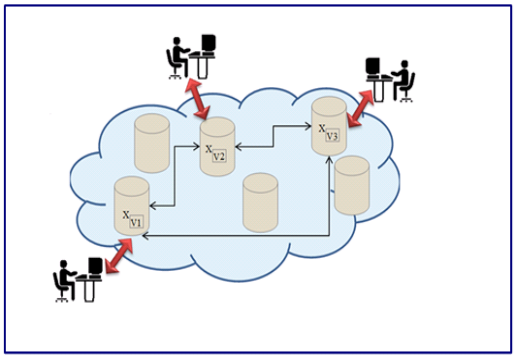

Figure 1: Distributed system with replication.

We mention here that the cloud is considered as a large geo-distributed system; data is largely replicated to ensure availability in the case of concurrent queries and recovery in case of failure. The different replicas can be located in the same datacenter or over different geo-distributed datacenters that can located in different continents; in this case the communication between replicas is very expensive.

4.1 CAP theorem

The CAP theorem (Figure 02) states that shared-data systems can ensure at most two of three properties: Consistency, Availability, and Partition tolerance at the same time [16, 17].

Figure 2: CAP theorem.

Choosing two properties between Availability, Partitioning tolerance and Consistency in the cloud is not easy; Availability and Partitioning are primordial and Consistency is vital for reliability. Cloud systems do not avoid absolutely one of the three properties, and propose generally a compromise between the three properties, which leads to support degraded levels of each one. A description of consistency levels is presented by the next section.

PACELC [18] extends CAP and states that the compromise is not all the time between Availability and Partitioning and Consistency; during network Partition (P) the compromise is between Availability (A) and Consistency (C). Else (E), the compromise is between Latency (L) and Consistency (C). The latency measures the delay of getting a reply.

4.2 Consistency levels

Consistency levels are influenced by the type of replication control protocol; i) Synchronous protocols propagate updates to all the replicas at the same time and in the same order. These protocols present strong consistency (immediate consistency). ii) Asynchronous protocols allow updating one replica while other outdated replicas are still accessible. iii) Hybrid protocols propagate updates synchronously between some replicas. Asynchronous and hybrid protocols present different levels of consistency according to which replicas are accessible, and the number of replicas that must be written and read before replying to queries [18, 19]. Quorum-based systems are proposed to achieve strong consistency by using the majority of replicas; Paxos is the most known protocol in this area [47].

The level of consistency is chosen according to the system nature and user's needs. Transactional systems like they proposed to book a flight ticket, buy an item, or send a bid are cases where data must be treated with strong consistency; an inconsistency of few seconds may make a loss. Social networks are examples of applications that tolerate weak consistency; a delay in visualizing the latest posts can be accepted.

4.3 Consistency models

A variety of consistency models degraded from strong to weak consistency are proposed in the literature, the main models are [19, 20, 21, 22, 40]:

Strict consistency (Atomic consistency, Linearizability), is the strictest model of consistency; updates are propagated between replicas at the same order according to the real time. Also, reads return the last written values.

Sequential consistency (Serializability): updates are ordered according to a logical order applied by all the replicas, this order can be different from the real order. Reads return the last values written according to the logical order.

The eventual consistency model ensures that all replicas will eventually become consistent even if requests can read inconsistent values. Different variants of this model are distinguished according to the techniques used to manage the inconsistent window:

Causal Consistency is a variation of the eventual consistency, where only causally related operations are ordered.

Read-your-writes consistency is a case of causal consistency where users access always his updates, or a newer version, and never access an older version.

Session consistency implements the read-your-writes consistency model during the session.

The bounded staleness consistency model tolerates reading stale values under some conditions such as bounding staleness by a specific period of time delta. This condition is satisfied by propagating updates within delta.

In Configurable consistency (Tunable consistency) the user configures the number of replicas accessed synchronously. Here, the consistency level depends on the percentage of the replicas requested synchronously; strong consistency is reached if the number of replicas for read (R) and write (W) overlap (R+W>=N), N is the total number of replicas.

5 Consistency levels in cloud systems

Wide variety of database management systems are used actually by cloud services. This section presents the most famous of them from the point of view of their data and consistency models [24].

5.1 Amazon propositions

Amazon has several propositions: Simple Storage Service (S3) [25,29], SimpleDB [26] and DynamoDB [27, 28] are No-SQL databases that provide high availability and scalability. Amazon Aurora [30, 31] is a relational databases management system that provides strong consistency.

S3 is designed to store large data in buckets: a bucket is organized as a key-value store, values are generally objects that represent data files or folders used to organize data files, folders can be arranged hierarchically. S3 offers simple operations to create, write, read and delete buckets, keys and objects. S3 uses automatic Cross-region replication that allows asynchronous copying of objects across buckets in different Regions. This strategy provides eventual consistency model.

SimpleDB arranges structured data in domains which consist of items; items are composed of pairs of (attribute, value); value can contain multiple data. SimpleDB offers operations for creating, writing, reading and deleting a domain or an attribute. Operations manipulate one or various items of the same domain. Eventual consistency is proposed by default; however it is possible to choose the strong consistency.

Dynamo uses tables of items, each item contains one or more attributes. An attribute is composed of (key, value) pairs. Dynamo provides several operations to create, write, read and dele table, item and attribute; which permit to manipulate one or various items of the same table. Initially, dynamo offers eventual consistency; a quorum that preserves availability and scalability is addressed to fulfill operations. However, dynamo makes it is possible to achieve strong consistency by configuring the number of requested replicas.

Data models in simpleDB and Dynamo have the structure of tables. Although, they are not classified as column-family store because they have simple columns and not super column families.

Amazon Aurora is a cloud-based relational databases management system proposed by Amazon Relational Database Service (RDS). Aurora is built on a MySQL engine and it is compatible with PostgreSQL. It provides better availability and scalability comparing to classical databases engines on RDS. Aurora guarantees strong consistency by supporting a quorum protocol.

5.2 Google propositions

In its turn, Google published several cloud-based systems [32] like BigTable [33], Megastore [34], Spanner [35], Cloud SQL [36], and Cloud datastore [37].

Bigtable stores data in massive tables. Each table is organized in rows that are accessed by primary keys and they contain a set of column-families which can differ from a row to another. A column-family regroups related columns and each column contains a single value for a row. This model allows storing versioned data in columns regrouped in a column family. Operations concern atomic single-row and a quorum protocol based on Paxos algorithm is implemented to provide strong consistency for write operations, read operations can get stale data if an update is on progress.

Bigtable is designed to store very large amounts of data; Google uses it in many applications like: Google Analytics, Earth, Map and Personalized Search.

Megastore uses schemas of tables to organize data; a table contains a set of entities that are characterized by a set of properties. Megastore defines entity groups that are sets of related tables based on Bigtable. Megastore provides transactions with full ACID semantics that can concern data through several tables of the same entity group, not just data of the same table like the majority of No-SQL databases. Like Bigtable, Megastore uses Paxos protocol to provide strong consistency; for each write operation, a majority of replicas across geographically distributed datacenters is requested; this strategy increases the system latency.

Megastore is proposed to build interactive applications; it is used by well-known Google applications as: AppEngine, Gmail, Calendar and Android Market.

Spanner is a key-value database created to fix the weaknesses of megastore in term of latency. Like megastore, spanner organizes data in schematized semi-relational tables, uses timestamp for versioning data and use a like SQL-based query language. Spanner propose an excellent support of transactions with full ACID properties, it provide strong consistency for distributed transactions across geographically replicated datacenters; this is achieved by executing a combination of the two-phase-commit protocol and Paxos protocol. Spanner is largely used within Google's datacenters infrastructures.

Cloud SQL is a RDBMS based on MySQL that provides classically immediate consistency.

Cloud Datastore is a Document store that organizes data on kinds of entities; each entity is accessed by a key and composed of a set of properties storing values that can have different types even for the same properties. Cloud Datastore use Multi-Master replication based on Paxos. Queries are configured to obtain immediate or eventual consistency.

5.3 Microsoft propositions

Microsoft has also several propositions: Microsoft Azure Table storage [38], Microsoft Azure DocumentDB [39] and Microsoft Azure SQL Database [41].

Microsoft Azure Table storage is a key-value store that stocks large amounts of data in tables. Each table contains a set of entities: an entity is composed of a primary key and a set of properties. Table storage provides strong consistency, and permits to achieve transactions with ACID properties across tables of the same partition.

Microsoft Azure Cosmos DB gathers multiple data models that include key-value, table, columnar, document and graph data models. It offers a configurable consistency model that presents five levels: strong, bounded-staleness, session, consistent prefix, and eventual. Strong consistency is associated only with one Azure region; it uses a linearizability based on a majority of replicas. The other levels are designed to reinforce avalability across different regions.

Microsoft Azure SQL Database is a RDBMS in the cloud built on the Microsoft SQL Server engine that supports full ACID properties of relational databases and uses a quorum-based algorithm that provides an acceptable consistency level with high availability.

5.4 Others solutions

5.4.1 Cassandra

Cassandra [42, 43] is an open source column family store proposed by Facebook for managing massive amounts of data. Cassandra is inspired from Google BigTable and Amazon DynamoDB.

The data model of Cassandra uses column families (tables) that regroup rows; each row in a table is composed of a key and a list of columns or super columns. A column is composed of a key, a value and a timestamp. A super column is a column family that regroups columns.

Cassandra proposes panoply of consistency models that can be configured at operation level. These levels are differentiated according to the requested replicas and theirs locations; the level ALL involves all the replicas of the cluster. The levels: One, TWO and THREE involve at least one, two and three replica (s), respectively. The level QUORUM involves a quorum of replicas of the cluster. According to the nodes locations, the following levels are defined: EACH_QUORUM requires a quorum of replicas in all data centers. LOCAL_QUORUM requires a quorum of replicas in the same data center. And, LOCAL_ONE requires one replica at least in the local data center. In addition, Cassandra proposes the SERIAL level that uses linearizable consistency for achieving lightweight transactions.

LOCAL_SERIAL concerns one datacenter. The levels listed above are common to read and write operations. The ANY level is specific only to write operations; it permits to execute a write operation even if no required replica is available; the operation writes hints for downed nodes on others nodes. The changes will be sent to downed nodes when they recovered.

The consistency level is determined by the number of replicas solicited for the read (R) and write (W) operations; if it overlaps the total number of replicas (N) the consistency is strong (R+W>=N), otherwise the consistency is weak.

5.4.2 PNUTS

PNUTS [44, 45] proposed by Yahoo! exposes a simple relational model with flexible schema. PNUTS organizes data into tables of records with attributes that can store any type of data. PNUTS offers various operations like Update, delete, selection of one or more items from a single table.

PNUTS proposes a per-record timeline consistency model that offers a consistent view of data to the user; a master replica is nominated to each record, this replica receives all the updates concerning the record and propagates the updates to other replicas in the same order.

This consistency can be configured; the weak level is ensured by the options: Read-any, Read-critical (required version), Test-and-set-write. However, the options: Read-latest ensures strong consistency.

5.4.3 Neo4j

Neo4j [46] is a graph based No-SQL databases that models data using nodes and relationships. Nodes are used to represent entities, they can be labeled and contain properties. Relationships present relations between nodes and can also contain properties.

Neo4j supports full ACID properties and implements causal consistency to provide an acceptable level of consistency.

6 Conclusion

Availability, scalability and elasticity are the success keys of cloud computing. At the storage level, these properties are guaranteed by partitioning and replicating databases.

Initially, cloud systems used the relational model that dominated the market of databases for more than twenty years. This model is known by its stability and consistency, which are guaranteed using transactional mechanisms. However, these mechanisms make the relational model very rigid and lack required availability and scalability. In order to meet the cloud needs, a new generation of relational cloud-based systems that supports more availability and scalability appeared. Several applications in cloud prefer No-SQL models that are proposed initially as simple key-value pairs that avoid all types of constraints. Bit by bit, No-SQL Databases use more organized models and integrate some transactional mechanism. Nevertheless, they still more flexible comparing to relational model.

In the consistency side and as it is difficult to ensure availability with strong consistency in large geo-distributed systems, cloud systems implement different consistency models to ensure the best compromise between availability and consistency. In addition, a lot of systems propose a tunable consistency that offers the possibility to choose between numerous proposed models.

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Output Analysis in Voice Interaction in AI Environment

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The future foreign language teaching will inevitably be combined with AI technology, and it is likely that the traditional foreign language teaching method of one teacher instructing a number of students will gradually be completely replaced by a new foreign language learning mode of each student's foreign language learning and most importantly acquisition being realized by interacting with AI interface customized for each student. The reason is rather simple. In spite of numerous repatching teaching method explorations, the traditional classroom-based foreign language teaching has been unable to solve the congenital problems, such as inadequacy of language input and interaction, insufficiency of real life sensory stimulation and violation of natural language acquisition sequence for the absence of language environment. The AI interface, in contrast, with the infinite, accurate and real language supply and human-computer interaction, and also with constant adjustment of ZPD (Zone of Proximal Development) according to each student's language development level, precisely sets up appropriate scaffolding for every language learner, thus revolutionarily creating a language environment close to or even beyond the real one and returning language learning to natural acquisition process. The first step to achieve this goal is to realize human-computer voice interaction. The realization of voice interaction needs many technical supports, among which voice interaction output analysis is an urgent part. By importing AI voice interactive output analysis algorithm, constructing output analysis model, and establishing the operation platform of the analysis model, the paper relies on the determination of the voice interactive output influence function, and takes the cultural elements of English language as an example to analyze the output.

Povzetek: V članku je objavljana analiza govorne komunikacije z upoštevanjem mehanizmov angleškega kulturnega okolja.

1 Introduction

Interaction based on mechanical one-way input have been giving way to the two-way voice interaction in numerous ways to satisfy human-computer communication needs especially in language learning. For instance, on the basis of Google search function, Google Now records the keywords searched by users, and provides users with relevant voice services through intelligent reading. This allows the machine to upgrade from "passive" answering user's questions to "active" alerting users to their needs, that is, the way the machine interacts with human beings in a service-oriented manner. Whether it's Apple AI or Google Now, it gives machines the ability to act on the basis of "independent thinking", thus opening a new era of language learning with two-way human-computer interaction. Conventional voice interactive output analysis method uses dynamic voice capture technology to realize voice interactive output analysis, which can greatly improve the efficiency of voice output. However, when applied to voice interactive output analysis in Artificial Intelligence (AI) environment, due to the high degree of strangeness in the field and the limited response of the operating environment, the problem of low accuracy of output analysis appears. This greatly reduces the frequency of AI environment use, resulting in incomplete output analysis of voice interaction in AI environment. In order to ensure the validity of the interactive output analysis method and simulate the language interaction environment in AI environment, two different methods of interactive output analysis are used to analyze the output accuracy simulation experiments. It is found that the method in this paper has higher analysis output accuracy [1].

2 Construction of AI voice interactive output analysis model

At present, the internationally recognized and accepted communicative teaching method aims to cultivate students' ability to express themselves in the target language. Interactive teaching method is a kind of communicative language teaching. Interactive teaching theory holds that language is the system of expressing ideological system, and the main function of language is interaction and communication. Interaction mainly refers to the interaction between teachers and students and also among students themselves in the classroom. Classroom activities should include real communication and enable students to perform meaningful tasks. Students'

communication includes sharing information and negotiating meanings with others.

The construction of AI voice interactive output analysis model mainly includes two parts: building the running platform of AI voice interactive output analysis model and importing AI voice interactive output analysis algorithm.

2.1 Establishment of AI voice interactive output analysis model platform

The model of *Multi-dimensional Input-interactive Output* is based on the premise of "language learning is technical training, not pure knowledge learning", and guided by Robert W. Blair's *Low Shielding Effect* in 1987 and Swain's *Output Hypothesis* in 1995. In the process of building this model, we will focus on the real language input mode and the learner's output mode which play decisive roles in the latter language output.

The running platform of AI voice interactive output analysis model is the basic platform to ensure the reasonable and safe operation of AI voice interactive output analysis model. The platform consists of four parts: data layer, operation layer, physical layer and display layer [2].

Data layer is the logical level for acquiring voice interactive information, which provides data support and data guarantee for operation layer. Under the premise of authorization, the security environment is guaranteed, the voice interaction status and voice interaction information are acquired, and the data supply is completed.

Operational layer is a logical level based on AI voice interaction output analysis algorithm, which provides direct and indirect evidence for output analysis in AI voice interaction.

The physical layer includes all external devices supporting the platform, such as processors, hosts, displays, network connections, etc. It provides a hardware platform for the platform and output analysis, in AI environment.

The display layer is the logical level through which the results are displayed by the display devices in the physical layer, so that the staff can read the results directly and realize the output analysis in the voice interaction in AI environment [3].

2.2 An interactive output analysis algorithm for importing AI speech

For the studying the output analysis of voice interaction in AI environment, the algorithm of AI voice interaction output analysis' main function is to analyze the speech interaction output of artificial intelligence. In the environment of voice interaction, taking the cultural elements of English language as an example, AI voice interactive output analysis algorithm can not only drive mathematical operations, but also complete the transforming voice into written language. In the process of data calculation, the conversion process from voice to language and the process of driving mathematical operation are analyzed in detail.

In the process of voice-to-language transformation, the parameters are generated and the results are output mainly through voice acquisition module and voice recognition module. With different results of the output, the command is written in the form of MySQL statement. The key program of the command is shown in Figure 1.

```
· int *q,*#include<stdio.h>
· Llist(size)S.base=(char*) malloc(1005* sizeoth)) return 0;
· Int *p,*q;(S.top==charfor(i=0;i<strlen(str);i++) f(char));if((i<1)||(i>L.leng
· New base=(int*)realloc(L.elem,(L.listsize+50)*sizeof(int))  ;elete(Sq List &L,int I,int
  &e)return  *S.top++=e;S.size=1005ile(
· If(!new base) ex it·  Lelem=neif(str[i]<='z(char));
· q=&L.el=fopen("test","w"))==NULL)char S.",&n)! get;(-2);wh
· *q=e;ifrintf("error: cannot open file!\n");=r)&&str[i]>='a')5*'sizeof
· L.length++;return 1n--) if((i<1)||(i>L.length)) return 0;base) ("%d
· end
```

Figure 1: Key program of AI voice interactive output analysis algorithm.

3 Output analysis in implementing voice interaction in AI environment

Based on the construction of AI voice interactive output analysis model, the influence function of voice interactive output is determined. Taking the cultural elements of English language as an example, the output analysis is carried out to realize the output analysis of voice interaction in AI environment.

To determine the influence function of voice interactive output, we need to determine the state equation of voice interaction and calculate the interaction coefficient of voice, so as to realize the determination of the influence function of voice interactive output.

The speech interaction state is real-time interaction, and is difficult to quantify, thus it is necessary to construct the speech interaction state equation. Different types of language interaction have different operational systems of equations and methods of constructing equations. This paper takes the voice interaction between English users as an example to construct the state equation of voice interaction.

Based on the relevant information acquisition module of AI voice interactive output analysis model operation platform, the AI voice interactive output analysis algorithm is imported for statistical analysis. Assuming that the amount of interactive information is M and the interaction coefficient q is 1.0, there is a state equation of inter-cell voice interaction, as is shown in formula (1)[4].

$$C=-\frac{q_x}{\left(\frac{\partial T}{\partial M}\right)} \quad (1)$$

In the formula, C represents the state equation of inter-cell voice interaction, and q_x represents the type of language, and T represents the time of voice output. When the interaction mode is more complex, the interaction coefficient q can be expressed by formula (2):

$$q = Q/(C \cdot VT) \quad (2)$$

In the formula, Q represents the ideal coefficient, C represents the state equation of inter-cell voice interaction, and △T represents the type of interaction mode.

Through the determination of the speech interaction state equation, the speech interaction coefficient is calculated relying on the variable relationship of the speech interaction state equation. The calculation of speech interaction coefficient is based on the interaction equation. The calculation process is as follows[5]:

$$\rho=q\lim_{\Delta V\to 0}\frac{F^2}{VD} \quad (3)$$

In the formula, D represents the interactive state, V represents the interactive output, and F represents the scope of language interaction[6]. When the speech interaction coefficient does not satisfy the interactive equation, the statistical calculation of the data is carried out, as is shown in formula (4).

$$\rho=\mathrm{C}\lim_{\Delta V\to 0}\frac{F^2}{D} \quad (4)$$

The condition that the speech interaction coefficient does not satisfy the interaction equation is as follows: Speech characters are less than 4 characters, there are uncommon words in the speech which cannot be recognized, and the speech discrimination is not high, making it difficult to recognize[7].

Based on the calculation of voice interaction coefficient, the influence function of voice interaction output is determined, which can be expressed by formula (5):

$$E=-\rho k\left(\frac{\partial g}{\partial f}\right)^2 \quad (5)$$

In the formula, g is an interactive way, such as English. f is running, and k represents the reliability of interactive running program[8].

The determination of the influence function of the speech interactive output analysis algorithm is realized by the formulas (1)~(5).

4 Example analysis

In order to ensure the output analysis in the speech interaction in AI environment proposed in this paper, the cultural elements in the English language are used as examples, and the English audio interaction in different AI environments is used as the test object to analyze the output precision simulation experiment[9]. Different cultural forms of English sound interaction in AI environment, speech types, dialects, etc. are simulated [10]. The simulation experiment was carried out by using the conventional interactive output analysis method as the experimental comparison object[11].

4.1 Test data preparation

In order to ensure the accuracy of the analysis output simulation test, the experimental data preparation is first carried out, and the SDH-214 simulation system is selected for the data operation platform [12]. On the two sets of identical computers, two different interactive output analysis methods were used to analyze the output precision simulation [13]. The experiment mainly consisted of English speech interaction, with different English customs and cultural characteristics for analysis[14].

4.2 Test results analysis

During the experiment, two different methods of interactive output analysis were used to analyze the change of output accuracy in the simulation environment. The simulation curves of analytical output accuracy are obtained, as is shown in Figure 2.

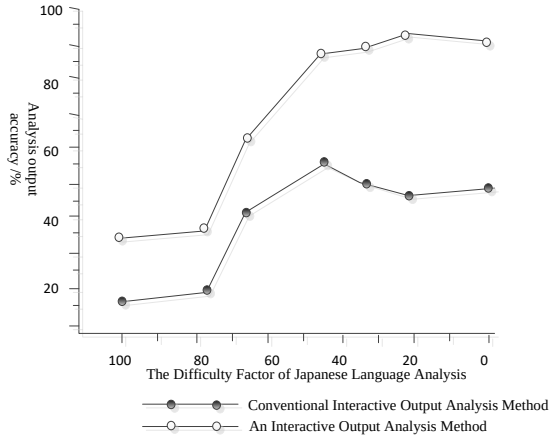

Figure 2: The output accuracy simulation curve.

According to the analysis of the test curve results, the output accuracy of the proposed interactive output analysis method is 73.45%, and that of the conventional interactive output analysis method is 39.24%. Compared with the conventional interactive output analysis method, the output accuracy of the proposed interactive output analysis method is 34.21%, which is suitable for the output analysis of voice interaction in AI environment [15].

5 Conclusion

This paper presents the output analysis of voice interaction in AI environment with examples of cultural elements in language. The research conducted on the base of the construction of AI voice interactive output analysis model and the determination of relevant parameters. The experimental data show that the proposed interactive output analysis method has high analysis output accuracy. This study provides a new idea for the interactive output analysis method, as well as a theoretical basis for the interactive output analysis method, and lays a foundation for the further study of voice interaction analysis. However, there are still some deficiencies in the practical application of this paper. The author hopes to further improve the output accuracy of voice interaction in the future research.

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Research on the Simulation Design of Humanistic Landscape Optimization in Urban Residential Area Based on Computer Technology

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With economic development, individuals are paying increasing attention to their surrounding living setting. They attach excellent significance to urban design coordination and the general natural environment, and follow a lifestyle that is easy and comfortable. In the past, scientists concentrated on the physical shape of residential areas and landscape design, and few quantitative research on ecological housing fields ' color modifications have been conducted. The human landscape optimization design of urban residential areas is performed on the basis of computer technology. The urban landscape design of residential urban landscapes was carried out from various stages. Comparison is made between the three-dimensional color and three-dimensional color rates of two distinct model plant color landscape models, and the fundamental requirements for rational landscape color plant distribution are acquired. A computer-based model of artificial landscape layout is suggested for urban residential areas. It offers a theoretical foundation for future design of urban landscape

Povzetek: Predstavljena je raziskava urbanega okolja v smislu optimizacije več parametrov.

1 Introduction

The residential areas in almost every city will have more or less humanistic landscape. These humanistic landscapes are the organic combination of the humanities and the landscape. Humane landscape is one of the indispensable conditions to improve the quality of urban life. It enables residents to enjoy the natural scenery and the aesthetic pleasure, feel the edification of culture and improve the taste of life in daily life. For example, some greening and water bodies in the city, as well as various facilities, not only have their basic material functions, for example, green landscaping can improve urban greening, absorb carbon dioxide, clean air, and reduce soil erosion, but also has the function of spirit in the shape and design, they are more artistic, which can give people bring aesthetic pleasure enjoy. Through humanistic landscape design, the material and spiritual functions of these landscapes can be maximized. Because the humanities landscape design not only can show the integrity and ecology of the landscape, but also fully display its artistic and comfortable. The design of humanistic landscape in urban residential area accords with the needs of modern people's living environment, improves people's living environment, and is also conducive to the protection of natural environment, so that people can get along well with the environment [1].

2 Literature review

IMcharg has ever put forward an important idea of the design of urban residential environment and humanistic landscape, namely the idea of comprehensive ecological planning. In the book “water landscape”, Rosemarie Mike Lily focuses on the design of the garden waterscape. In the book “ecological design and comprehensive treatment of urban waterscape” NARS: creating a clear and beautiful original waterscape system, JinyuanHuan focuses on the analysis of waterscape's ecological design concept and how to carry out water ecological design. He pointed out the shortage of modern urban waterscape, analyzed the reasons for the problems, and put forward the “NARS ecological waterscape system”. BaiYufang and Chen Wangqing discussed the application of the virtual Waterscape in the application of the waterscape of Hangzhou residential district [2].

In recent years, great achievements have been made in the construction of urban residential areas in China. However, it is also faced with the problems of large residential area, excessive consumption of resources and energy, and low ecological degree of residential areas. Therefore, while China is actively promoting the “low-carbon economy” growth mode, increasing the proportion of ecotype residential areas is the inevitable direction of the development of residential areas. At present, the

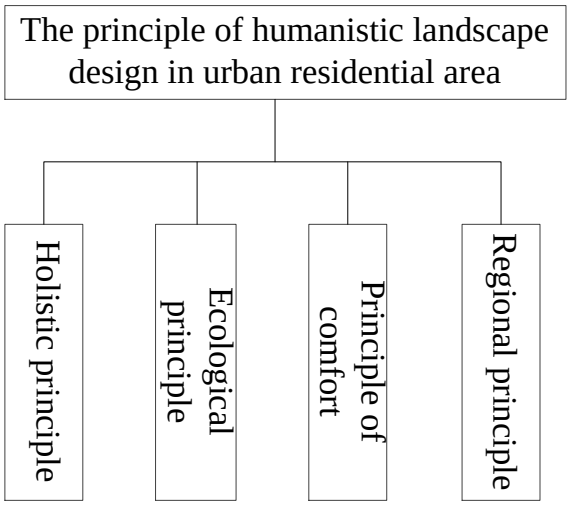

Figure 1: Principle of humanistic landscape design in urban residential area.

research on Eco residential area in China is not deep enough. Under the urgent task of building eco residential area, we need to strengthen the research on the theory of ecological residential area. Figure 1 is the principle of humanistic landscape design in urban residential areas.

3 Research methodology

Optimization simulation design of humanistic landscape in urban residential area based on computer technology

3.1 Design principle

In the process of three-dimensional image design of humanistic landscape in urban residential area, the urban landscape and landforms are obtained first, and the characteristics of humanistic landscape plant configuration are obtained. The stereoscopic index of plant colorization in urban residential area is set up, and the three-dimensional image design of humanistic landscape in urban residential area is completed based on this. The detailed steps are as follows:

CI represents the environmental factors of the humanistic landscape before the design. Hp represents the ecological factors before the design of city residential landscape. M_F represents the natural factors. ϑ_v represents human factors. [3] Formula (1) is used to obtain the characteristics of humanistic landscape configuration.

$$df''' = \frac{(CI \cdot H_p)}{\tilde{\omega} \times \Psi} M_\Gamma \quad (1)$$

In the formula, $\tilde{\omega}$ represents the function of humanistic landscape in urban residential area, and ψ represents the physiological and ecological characteristics of color plants.

Assuming that $K_{(\xi)}$ represents the equal number of color plants, C(i,t) represents the physical form of urban road landscape.The formula (2) is used to give the three-dimensional index of the color of urban plants.

Figure 2: The rational collocation of color plants in the cultural landscape.

$$K_p(\varphi) = \frac{K_{(\xi)} \times C(i,t)}{\sum_{i,j}^{m} \omega(\gamma) \cdot \theta(\Im)} \otimes \beta(op) \quad (2)$$

In the formula, $\omega(\gamma)$ represents the physical effect of the color of urban landscape plants. $\theta(\mu)$ represents the greening level of the city. $\beta(\mathbf{op})$ is the characteristics of leaf color leafed plants.

h_j represents the color leafed plants leaves. $\tau(\mathbf{ll})$ represents the proportion of different colors of leaf plants to the whole. M_k represents the comprehensive evaluation of color leafed plants adaptability equation. The formula (3) is used to form a three-dimensional image design model of the urban landscape plant landscape.

$$P_\Sigma \quad (xy) = \frac{\lambda(iy)}{df''' \times K_p(\varphi)} \times \left[h_j \cdot \tau(ll)\right] M_k \quad (3)$$

In the formula, $\lambda(iy)$ represents the variety of color plants and their growth adaptability.

However, traditional methods do not consider the seasonal variation of color and the physiological and ecological characteristics of plants.

3.2 Three-dimensional image optimization design of humanistic landscape in urban residential area

(1) Rational collocation of color plants in the cultural landscape

Plants commonly used in urban greening plants contain various kinds of trees, herbs and shrubs. They are the basic elements of urban ecological and cultural environment, as shown in Figure 2. According to the current urban environmental conditions and existing plant resources and their Greening Status, color symbolization, color Psychological Association, the configuration is carried out in the process of establishing the optimization model of the humanistic landscape design. In the configuration of color plants, seasonal variation of plant biology characteristics and color are combined. And according to the constraint conditions of humanistic landscape design in the residential area of urban residents, the landscape elements of the landscaping of the plants are obtained. The detailed steps are as follows:

v(ol) represents the natural landscape elements of the city before the landscape design. φ_o^k represents the environmental conditions of the city. ku represents existing plant resources. $\mathbf{c}(\nabla)$ represents the main body of the urban green space system. The formula (4) is used

to obtain the basic conditions for the rational collocation of color plants in the landscape.

$$q(r,y)=\frac{c(\nabla)\cdot f(XC)}{\varphi_o^k\times HH_k}\oplus\frac{k(\omega)}{\varepsilon(o,p)}\iota(el) \quad (4)$$

In the formula, f(XC) represents the physical effect of plant color. HH_k represents the symbolization of plant color. k(w) represents the geographical latitude and terrain of the greening site. $\varepsilon(\mathbf{o},\mathbf{p})$ represents the coordination among plant populations, and $\tau(el)$ represents the species of color plants.

It is assumed that h(uy) represents the basic principles of rational collocation of plants. m(l) represents the seasonal variation rule of color plants. The formula (5) is used to get the elements of landscaping.

$$F^l(C,X)=\frac{m(l)\times h(uy)}{\zeta(\vartheta)\cdot r(l)} \quad (5)$$

In the formula, $\zeta(\vartheta)$ represents the mutual coordination between the color plant population, and $\gamma(l)$ represents all the features of the landscape.

It is assumed that fr is the form of plant color expression. *kl* represents the effect of color patches in urban humanistic landscape, and the color and vegetation characteristics of color plants are obtained by using formula 6.

$$\theta(x)^*=\frac{\xi(i)\times jk^*(v)\overline{\omega}_k}{fr\times bn(lp)kl}\cdot q(r,y)\otimes\frac{E(kk)}{F^l(C,X)} \quad (6)$$

In the formula, $\xi(i)$ represents the urban green space system. *jk* represents the color leafed plants adaptability. $\widetilde{\omega_k}$ is the city lottery leaf plant resources. *v* represents the principle of urban characteristics. bn(lp) represents plant planting requirements.

The above analysis can show that in the process of establishing the optimization model of the urban humanistic landscape plant color design, the basic conditions for reasonable collocation of plants in the landscape are obtained by the principle of highlighting the urban characteristics and ecology. According to the needs of the landscape theme, the colorful landscape elements of the landscape plants are obtained, and the seasonal variation of color plants is obtained. The physiological and ecological characteristics of the color plants are given, which lays the foundation for the optimization design of the three-dimensional image of the urban landscape plant landscape [4].

(2) Optimization design of three-dimensional image of humanistic landscape in urban residential area

Based on the physiological and ecological characteristics of color plants obtained above, the three-dimensional color quantity concept is proposed based on the three-dimensional image optimization design of plant landscape in urban cultural landscape, and the three-dimensional color amount of urban humanistic landscape is calculated. The three-dimensional color quantity is used to optimize the three-dimensional image of the urban landscape. The detailed steps are as follows:

It is assumed that $\gamma(\mathbf{nn})$ represents the color leafed plants. M(nk) represents the characteristics of landscape design as a whole and contour. Based on the physiological and ecological characteristics of color plants obtained above, we use the formula (7) to describe the three dimensional spatial structure index of urban humanistic landscape.

$$(nk)_{kk}^{(M)}=\frac{\sum(\kappa j)\otimes\zeta(\mathrm{km})}{\gamma(nn)\oplus M(nk)}\times F^l(C,X) \quad (7)$$

In the formula, (kJ) represents the three dimensional Green amount, and the $\zeta(km)$ represents the crown diameter.

It is assumed that $\varphi(\mathbf{jl})$ represents the non three-dimensional color leafed plants. $\Psi(jl)$ represents three-dimensional color leafed plants. The formula (8) is used to calculate the amount of color leafed plants:

$$CG(H)=\frac{\varphi(jl)*\psi(jl)}{(nk)_{kk}^{(M)}}\times R(k,l)\otimes v(i,l) \quad (8)$$

In the formula, R(k,l) represents the color of the actual plant, v(i,l) represents the classification of color leafed plants by leaf color characteristics of the situation.

It is assumed that l_τ stands for the three dimensional color sum of common leaf, bicolor and spotted leaves. m(k,l) represents the crown of color plants, and $\delta(\mathbf{k},\mathbf{o})$ represents the three dimensional color sum of autumn leaf, new leaf color, common leaf, bicolor, and leaf color. The m(k,l) is defined as the amount of color leafed plants in spring, and the $\delta(\mathbf{k},\mathbf{o})$ is defined as the color leafed plants in summer and winter. The formula (9) was used to calculate the three-dimensional color conversion rate of urban landscape plants.

$$\varphi_l{}^o(n,j)=\frac{m(k,l)\cdot l_\tau}{\delta(k,o)}CG(H)\cdot\frac{nf(b)}{\xi(vv)} \quad (9)$$

In the formula, nf(b) represents all the colorful plants of the urban humanistic landscape, and $\xi(vv)$ represents the sum of the three-dimensional color of all the colorful plants of the city's humanistic landscape [5].

It is assumed that l(b,m) represents the sum of the three dimensional Green quantities of non-colored plants. $\lambda(m,n)$ represents the difference in the contrast of three dimensional coloring rate in spring. The model of the three-dimensional image optimization of the urban landscape plant landscape was established by using the type (10).

$$A(CB)=\frac{\lambda(m,n)}{l(b,m)}\times\varphi_l{}^o(n,j)M^* \quad (10)$$

In the formula, M* represents the number of different phase accumulation value of colorful plants.

4 Simulation results and analysis

In order to prove the validity of the proposed 3D image optimization design model of urban humanities landscape, an experiment is needed. In the environment of Matlab, a simulation platform for three-dimensional image optimization of urban humanities landscape is built. The data of humanistic landscape resources in urban residential areas from May 2016 to October 2017 are the experimental data [6].

4.1 Different models of landscape design color and three-dimensional color comparison

This paper uses the model proposed in this paper and the literature model to carry out the experiment of the landscape design of urban landscape plants. The three-dimensional color and three-dimensional color rate of plant color landscape design were compared between the 2 different models. The comparison results are shown in figures 2 and 3.

From the analysis of figures 3 and 4, it can be concluded that the color and rate of color rendering of urban humanistic landscape plants is better than that of the literature model. This is mainly because that when we use this model to design the 3D image of plant landscape in urban landscape, we first get the basic conditions of rational collocation of plants in landscape based on the principle of highlighting urban characteristics and ecology. According to the needs of the landscape theme, the colorful landscape elements of the landscape plants are obtained, and the seasonal variation of color plants is obtained. The physiological and ecological characteristics of the color plants are given, which ensures the color rate and three-dimensional color of the three-dimensional image design of the urban landscape plant landscape [7].

4.2 Comparison of the effectiveness of different models for landscape design

The model in this paper and literature model were used to design the experiment respectively. The stability(%) and efficiency(%) of the 2 different models for the rational allocation of urban cultural landscape were compared [8]. The comparison results were used to measure the overall effectiveness of the 2 different models of urban humanistic landscape design. The results were shown as figure 5 and figure 6.

From the analysis of Figure 5 and figure 6, it can be concluded that the overall superiority of the urban humanistic landscape design using this model is better than the model in the literature. In this paper, the three-dimensional color quantity concept of the urban humanistic landscape is designed, and the three-dimensional color quantity of the urban humanistic landscape is calculated. The three-dimensional image of urban humanistic landscape is optimized by three-dimensional color, which ensures the overall superiority of the landscape design.

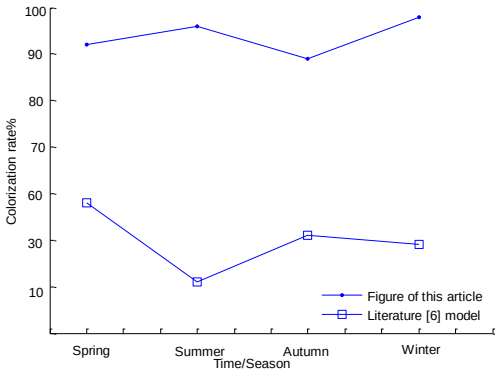

Figure 3: Color comparison of different models of landscape design.

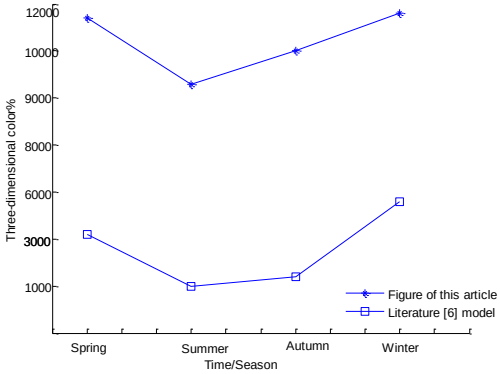

Figure 4: Three dimensional color comparison of different models of landscape design.

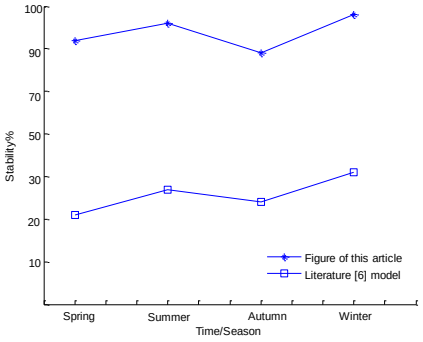

Figure 5: Comparison of the stability of different models of landscape design.

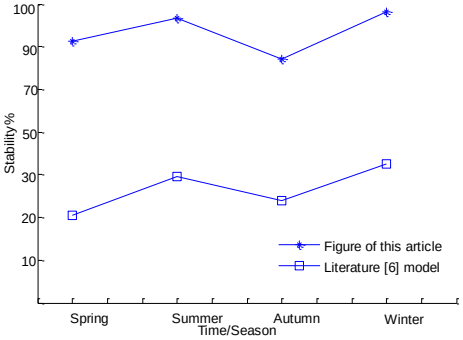

Figure 6: Comparison of the efficiency of different models of landscape design.

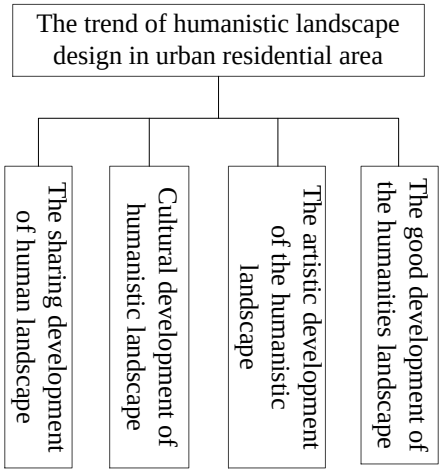

Figure 7: The trend of humanistic landscape design in urban residential areas.

5 The trend of humanistic landscape design in urban residential areas

With the accelerated process of urbanization in China, the design of humanistic landscape in urban residential areas is also developing. City residential area cultural landscape is more geared towards life, which meets the needs of the residents in the direction of development. It tries to improve the quality of the entire urban residential area with the most shared, cultural and artistic humanistic landscape. As shown in Figure 7.

(1) The development of the shared cultural landscape

When designing the residential landscape, we should take into account the needs of all users, and design a shared cultural landscape, so that every resident can enjoy and enjoy these cultural landscapes together.

(2) Cultural development of the humanistic landscape

In the design of the humanistic landscape, it is necessary to integrate more history and culture on the basis of the natural environment, so as to make the cultural landscape richer. Natural landscapes are naturally formed, while humanistic landscapes are designed by human beings, and human history and cultural development are the source and foundation of design. Therefore, humanistic landscape is actually a human cultural landscape. Because of the unique cultural background and historical background, the residents can feel the edification of art and historical culture when they appreciate the cultural landscape. Therefore, in the process of development, the pursuit of culture is an important direction in the development of humanistic landscape.

(3) The artistic development of the humanistic landscape

(4) The good development of the humanities landscape

In order to attract household occupancy to a greater extent, many residential areas introduce the water system to the construction of humanistic landscape. It can realize the scientific and rational arrangement of each layout, which can realize the harmonious development of human, environment and society.

With the development of social economy, people's pursuit of art is higher. Therefore, in the process of design, humanistic landscape needs to satisfy people's artistic pursuit and aesthetic need. The humanistic landscape not only maintains the natural ecology, but also has the artistic beauty [9].

6 Conclusion

With the continuous improvement of people's living standards, the demand for the living environment is becoming higher and higher. Therefore, the design of the green landscape in the residential area can not only meet the needs of the residents for the green space, but also improve the beauty and landscape culture of the residential area. More importantly, it can play a very important role in the greening of the city and the improvement of the ecological environment. We should pay attention to the ancient and emerging disciplines of the cultural landscape. This design accords with the modern and practical function of the poetic urban garden new space, and creates the beautiful landscape human settlement ecological environment. This should be the goal of all planners.

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Research on Dance Teaching Mode Based on Flipped Classroom in the Internet +Age

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The development of Internet technology has injected new impetus into the reform of education, and also posed new challenges to the traditional teaching mode. In recent years, as an extension of educational informationization, the flipped classroom has developed rapidly, and academic attention has increased year by year. At present, the flipped classroom in Colleges and universities in China has penetrated into many disciplines. Dance teaching should conform to the development of the times, optimize the teaching mode of dance education, open up innovative consciousness, and form a multi-channel teaching pattern. On the basis of discussing the theoretical and practical research on the mode of flipping classroom teaching in the dance teaching, this paper puts forward and designs the structure map of the pattern of the teaching mode of the flipped class in the ordinary university, and carries out a 4 month teaching experiment for the dance students. Through the analysis and verification of the data from the investigation and feedback, the conclusion is that the teaching mode of the dance flipping classroom has significant effect on improving the students' basic dance quality, dance performance and autonomous learning ability.

Povzetek: V prispevku je opisana uporaba umetne inteligence za izboljšanje učenja plesa.

1 Introduction

In twenty-first century, the rapid development of the information technology revolution and the continuous upgrading of the technology are slowly changing people's life, work and communication ways. It also brings opportunities for a series of changes in education and provides technical feasibility for the wide spread of classroom teaching. The current digital campus and the Internet of things have laid the material foundation for the flipping classroom. Mobile terminals provide technical tools for flipped classroom learning. At present, the advanced educational resources, such as micro video, Khan College and electronic desk, have provided convenient access to the implementation of the overturned classroom. With the continuous upgrade of technology, more and more information tools and methods will emerge to make learning easier and faster. To sum up, the development of modern information technology is the necessary condition for the smooth expansion of the flipped class, and the implementation of the information technology course cannot be separated from digital equipment. The development of technology has promoted the development of information technology courses and flip-flop classes, and the research on the teaching mode of junior dance based on flip-flop classes is essential. In the application of the overturned classroom teaching mode in the dance class in college sports, Zhang Qin (2016) concludes that the flipped classroom teaching mode is applied to the teaching of dance and dance courses in colleges and universities. It needs to be carried out in four aspects: the review of the content of video teaching before class + basic dance skills + effective autonomy and cooperation Learning + effective evaluation and careful ending design [1].

2 The construction of dance teaching mode based on flipped classroom in the Internet age

2.1 The application of the flipped class in the Internet age

From the implementation to the operation, the overturned class can be divided into four parts. The first is the preparatory stage of teaching, the second is the teaching memory and the understanding, the third is the implementation and the analysis stage, the last one is the comprehensive evaluation stage. The most important feature of this model is the reversal of roles. At the preparatory stage, the teacher is the protagonist, and in the understanding stage, the student becomes the protagonist in the classroom. At the stage of application analysis, students and teachers are both the protagonists. The last

stage is mainly teachers scoring, which can be done by group [2].

2.2 Design of dance teaching mode based on flipped classroom

Because of the specialty of dance teaching, body movement is the expression form of the practitioner [3]. The practitioner needs to master the technical movements and practice a lot under the guidance of the teacher to form the dance skills. In the construction of the reversed classroom teaching mode in dance education, it is necessary to focus on the needs of students, so as to construct a more suitable dance education teaching mode in Colleges and universities. The structure diagram consists of three stages (Figure 1). They are pre-class preparation of classroom resources, in-class knowledge internalization and content upgrade, and after-class consolidation and improvement. According to the curriculum requirements of dance discipline, theoretical knowledge is understood and mastered. The process of the design of the structure drawing emphasizes the importance of communication. The process of communication and feedback is highlighted at the beginning of class. It breaks through innovation in the way of evaluation, and makes full use of teaching resources and communication platform. It highlights the advantages of the flipped classroom and combines the characteristics of dance education to provide reference for the reform of dance education [4].

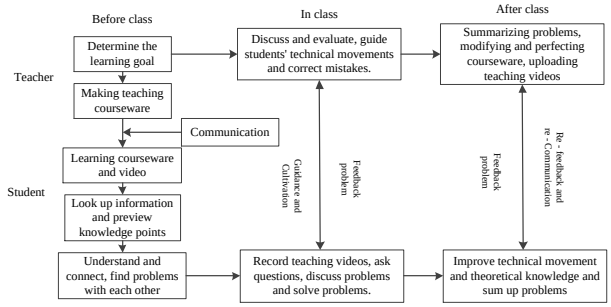

Figure 1: Structure of college dance teaching mode based on flipped classroom.

In the implementation steps of dance flipping classroom, it is designed in three stages (Figure 2).In the pre class stage, the teaching content should be cut in modules to set up the resources in various forms. It should be intuitionistic and effective. Students should conduct self-identification in the form of online testing or feedback. In this structure, the importance of feedback communication is emphasized, and new ideas are provided in the production of teaching content. The division of labor between teachers and students is clear and effective, and the design of teaching platform is more humanized. The way of online evaluation helps teachers and students to summarize and reflect, to further optimize the teaching plan and to support the students' learning and practice [5].

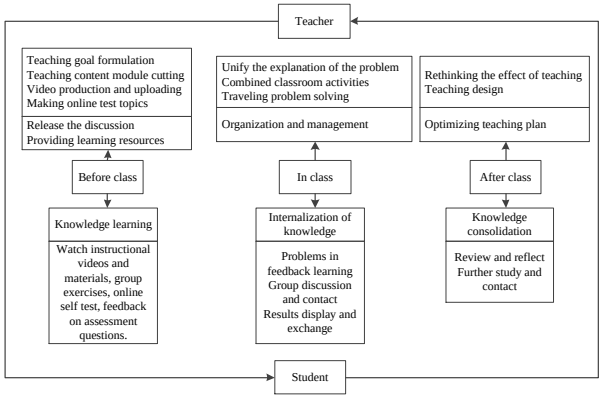

Figure 2: The steps of the dance flipping class.

The role of the teaching mode is mainly embodied in the teaching effect, which also reflects the current situation of teaching in China. The biggest feature of the flipping class is that it can improve the students' interest in learning and attract the attention of the students in class so as to improve their achievements and improve the teaching efficiency [6].

3 Practice research of dance teaching based on flipped classroom

3.1 Research objects and methods

In this paper, the application effect of flipped class in the teaching of dance in Colleges and universities is studied. A total of 120 students in the last semester of 2017-2018 year's dance courses were tested for a total of nine weeks of teaching experiments. The experimental class and the control class had a weekly class of 90 minutes each. The two classes consist mainly of two parts. One is the basic pace of dance, and the other is a small group of teachers. According to different teaching methods and reasonable arrangement order, the key points and difficulties are noted [7].

Evaluation method	Account for the proportion of achievements	Evaluation subject
Attendance and feedback video frequency	30%	Teacher evaluation
Classroom participation performance	20%	Teacher evaluation, group evaluation, self-evaluation
Group presentation	20%	Teacher evaluation, group evaluation, self-evaluation

Table 1: Flipped classroom process evaluation.

As can be seen from the evaluation table, the main evaluation methods are the number of students in class and

the number of feedback videos, classroom performance and group presentation. The number of classes and the frequency of feedback are evaluated by teachers. Class participation is mainly evaluated by students, groups and teachers.

Grading project	Scoring index	Scoring body
Basic posture (20 points)	Stance (5 points) grip (5 points) back (5 points) head (5 points)	Teacher
Combined action (40 points)	Integrity (10 points) fluency (10 points) direction (10 points) trajectory (10 points)	
Music performance (30 points)	Music rhythm (30 points)	
Facial expression and clothing (10 points)	Facial expression (5 points) Clothing (5 points)	

Table 2: Flipping class final skill test score.

The result of the evaluation is mainly the skill test at the end of the term, and the content of the examination is also the proportion of the score. It is mainly obtained by experts through questionnaires and data analysis. The main contents of the grading are basic posture, combined movements, music rhythm, facial expressions and clothing. The full score is one hundred points. The basic position is twenty points, while standing and holding posture and back and head are five points separately. The composition movement was forty points, the movement integrity, fluency, direction, track accounted for the ten points separately [8]. Musical rhythm has thirty points, facial expressions and clothing account for ten points. At the end of the final assessment, we invited three dance teachers from our school to carry out the score, which was carried out with a fair and strict attitude. The average score of three teachers are taken as the final result.

3.2 Pre-test and post test data analysis

3.2.1 Pre-test results and analysis

Before the experiment, the level of dance technology is measured. A basic step in dance is the main content of the test. At the same time, the basic situation of dance has also been investigated through questionnaires. In this way, we can get the cognition of the control class and experimental class to the dance.

According to table 3, the students in the two classes have not been trained professionally. Only 3.3% of the students have been in contact with the dance before, and the other students have not been in contact with them. Therefore, the cognition of the two classes is zero. So the two classes have professional knowledge and technical mastery is relatively low, both classes are on the same starting line [9].

		Is there any professional training before		Have you ever been in contact with a dance before	
		Yes	No	Yes	No
Experimental class	Number of people	0	60	2	58
	Percentage	0	100%	3.3%	96.7%
Control class	Number of people	0	60	2	58
	Percentage	0	100%	3.3%	96.7%

Table 3: Investigation and statistics on basic situation of dance in experimental class and control class.

This article mainly takes the exercise attitude scale as the main weighing work. This table is mainly for young students, and there are eight main indicators. They are behavior attitude, behavior cognition, behavior habit, behavior intention, objective attitude, emotional experience, behavior control and subjective standard. Each index is formed by a different number of items. There are seventy entries, and the higher the score is, the better it is. In order to get a better understanding of the attitude of the two classes, the two classes were measured before the experiment, and the results of the measurements were found through table 4.

Through table 4, we can learn that the two classes have more than 0.05 P values in behavior attitude, target attitude, behavior cognition, habit, intention, emotional experience, behavior control and subjective standards. This shows that the two classes are not very different in these eight aspects. The exercises of the two classes are kept at the same level so as to meet the requirements of the experiment.

In order to get a detailed understanding of students' interest in dance lessons, a questionnaire survey was conducted before the experiment. According to the statistics, only 5% and 7% of the students in the two classes are very interested in learning dance, only 15% and 20% are interested. There are only 37% and 30% of the students with general interest. Those who were not interested accounted for 40% and 37%, while those who did not like it accounted for 3% and 5% respectively. This also means that students are not interested in learning dance [10].

	Experimental class (n=60)	Control class (n=60)		
	X±S	X±S	t value	P value
Behavior attitude	28.36±6.59	27.19±4.20	0.914	0.361
Objective attitude	40.01±7.36	41.02±5.38	0.775	0.436
Behavior cognition	24.49±4.76	25.48±5.08	1.084	0.282
Behavior habits	35.54±8.73	33.59±5.91	1.152	0.253
Behavioral intention	24.34±5.43	25.51±5.34	1.106	0.324
Emotional experience	33.35±6.32	34.88±6.27	1.102	0.264
Behavioral control	23.03±5.46	21.47±4.52	1.421	0.164
Subjective criteria	20.45±5.38	22.01±6.32	1.153	0.253

Table 4: Independent sample T test results of exercise attitude before and after test class.

In order to investigate the abilities of the two classes, a questionnaire survey was conducted before the experiment. According to the survey, it is found that the two classes have very little study before class, and most of them do not have to consolidate their study after class. Only a few students choose to listen to the teacher when they encounter something they don't understand in class. This also indicates that the students' learning situation is not very good.

3.2.2 Post test results and analysis

The degree of acceptance is mainly observed from the object being carried out, and whether the students can accept the dance class in the flipped class, mainly based on the degree of the students' preference. In order to get a clear understanding of students' acceptance, especially after the end of the experiment, a questionnaire survey was conducted among the students in the experimental class [11].

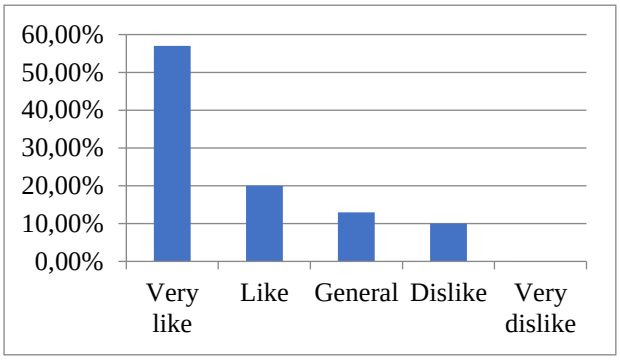

Figure 3: An analysis of the acceptance of the flipped classroom teaching.

According to figure 3, it can be found that the person who likes it occupies 57%, more than half of the people like it. People who like it occupy 20%, and those who have the general interests have 13%.There are 10% people who don't like it. The people who like to dance still occupy the vast majority. For the form of flip classroom teaching, students are still willing to accept it, especially the dance teaching under the flipped classroom [12].

First, a simple analysis of the results of the two classes is made from the basic positions, the movements of the combination, the rhythm of the music and the facial expression. According to table 5, we can learn that a=0.05 is a basic test standard, while the students in the two classes have certain differences in the basic posture, the combination of the movements and the rhythm of the music, which also represents a certain effect in the flipped class at this time. The students in the two classes did not change in facial expression and clothing. According to table 6, it can be found that the average values of the students in the two classes are quite different, and the P value is less than 0.05.The result of the comparison between the two classes shows that the students in the experimental class are better than those in the control class.

During the period after the end of the teaching experiment, we conducted an independent sample T test on two classes (Table 7).

According to table 7, we can well observe the behavior attitude of the students in the experimental class and the control class, as well as the target attitude and the behavior habits. The six aspects of the P value are less than 0.05, and this also represents the gap between the students of the two classes in these six aspects. The P value was higher than 0.05 in cognition and behavior control, which also showed that there was no significant difference between the two classes.

	Experimental class (score)	Control class (score)	P value
	X±S	X±S	
Basic attitude achievement	17.6±1.605	15.01±2.492	0.005
Combined action	36.05±2.182	32.98±3.267	0003
rhythm of music	30.02±1.237	26.47±2.684	0.004
Facial expression and clothing	9.41±0.482	9.16±0.369	0.250

Table 5: Analysis of four indicators of technical performance in the experimental class and the control class

	Experimental class (score)	Control class (score)	P value
	X±S	X±S	
Technical test results	93±4.602	86.42±6.387	0.008

Table 6: Total score analysis of final examination in experimental class and control class

After a period of learning, the dance learning in flipped classroom has achieved certain results. At the same time, there were questionnaires for students in the experimental class as well as in the control class. In the experimental class, about 60% of the students were interested in dance, and 19% of them had increased interest. Only 10% of them were only generally improved, and 5% still felt no interest. While 5% of the control class showed a significant improvement in their interest in dancing, 10% showed a general improvement, and 79% showed no change. Through these data, we can also know that flipped classroom has played a very positive role in enhancing students' learning [13].

3.3 Implementation effect analysis

Through the experimental data, we can see that the dance skills of the experimental class are higher than those of the control class. And the exercise attitude of the experimental class is better than the control class, and this also shows that the effect of the teaching in the flipped class has already achieved certain effect, so it is still very applicable in the University.

	Experimental class (n=60)	Control class (n=60)		
	X±S	X±S	t value	P value
Behavior attitude	26.01±5.08	25.53±5.29	1.326	0.043
Objective attitude	44.89±5.98	41.69±5.79	2.302	0.026
Behavior cognition	24.72±4.35	26.01±5.31	3.379	0.538
Behavior habits	37.01±5.68	33.29±5.36	2.702	0.009
Behavioral intention	37.06±6.06	33.06±8.32	2.245	0.017
Emotional experience	25.58±6.70	28.87±6.72	-2.226	0.011
Behavioral control	22.98±5.51	21.43±4.64	1.412	0.164
Subjective criteria	25.25±5.23	22.72±5.31	2.134	0.034

Table 7: Independent sample T test results of exercise attitude of experimental class and control class

Before class, teachers can make some micro-videos for teaching, which helps students consolidate their knowledge points after class. And students can do exercises repeatedly after class. In addition, students can learn in groups in the classroom, which is also conducive to improving students' learning ability [14].

The arrival of flipped classes makes students feel very fresh, which to a certain extent also increases students' interest in learning. The students' self-learning ability and cooperative learning ability are all exercised in all aspects. Their subjectivity has been brought into play, and the efficiency and quality of the teaching have been improved.

4 Conclusion

Based on the exploration and research of the new education model, the author recognizes that the new education mode in the overturning classroom is the trend of future development. The mode of flipping class extends the students' learning process to the class. The students get the information they need quickly through the network means. Compared with the traditional class, the flipping classroom teaching mode is more helpful to stimulate the students' interest in learning and mobilize the enthusiasm, initiative and creativity of the students' study. But this is not the only teaching mode. Because the educational situation in some places may not be appropriate, it cannot be implemented in a comprehensive way. Some developed areas can be decided according to the actual situation. For

some areas with relatively backward economic conditions, careful consideration should be given.

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Research on Development Mode of Intelligent Rural Tourism under Digital Background

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Intelligent rural tourism rapidly emerged under the digital background in China after the reform and development. Driven by the theme of China tourism administration's smart rural tourism year under digital background, the digital background smart rural tourism market has entered a period of vigorous development, accelerating the integration of tourism and agriculture, with forestry and other related industries. Since the late 1990s, China's rural areas have experienced four stages of spontaneous development, quantity expansion, standardized development and quality improvement. After more than 20 years' active exploration, China has established a development path with Chinese characteristics and a smart rural tourism model under digital background.

Povzetek: Opisan je razvoj inteligentnega kmečkega turizma na Kitajskem z metodami UI.

1 Introduction

Intelligent rural tourism rapidly emerged under the digital background in China after the reform and development. Driven by the theme of China tourism administration's smart rural tourism year under digital background, the digital background smart rural tourism market has entered a period of vigorous development, accelerating the integration of tourism and agriculture, with forestry and other related industries and industries. Since the late 1990s, China's rural areas have experienced four stages of spontaneous development, quantity expansion, standardized development and quality improvement [1] [2]. After more than 20 years' active exploration, China has established a development path with Chinese characteristics and a smart rural tourism model under digital background.

2 Research on the development mode of intelligent rural tourism under digital background

2.1 Analysis of the development status of digital rural intelligent tourism in China

In 2009, in order to upgrade China's smart rural tourism under digital background, the National Tourism Administration introduced a variety of new digital background smart rural tourism on the basis of provincial smart rural tourism with the digital background. The new concept of smart rural tourism is of great significance for enhancing the scale and quality of digital rural tourism [3]. In recent years, the digitized background of smart rural tourism reception capacity and income in China as shown in Table 1.

Time	Smart rural tourism reception (ten	Smart rural tourism employees (ten	Smart rural tourism income
2010	1404	62	251
2011	157	64	304
2012	162	68	359
2013	168	78	376

Table 1: Intelligent rural tourism recipients, employees and income in China.

An investigation into the smart rural tourism in China found that the digital background smart rural tourism products presented traditional singleness and lack of diversity. The overall level stayed at a low level of offering accommodation, agricultural products, parties and souvenirs [4]. The number of smart rural tourism and

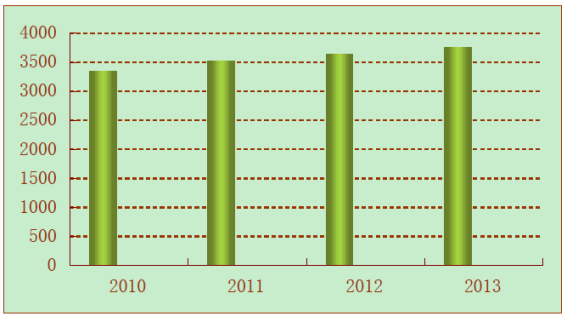

Figure 1: Number of intelligent rural tourism receptionists in China (Unit: 100,000).

the number of receptionists in China in recent years is shown in Figure 1.

2.2 Digital background definition of intelligent rural tourism development model

This paper defines the digital background smart rural tourism development model as the chain-type relationship formed by certain departments supporting digital rural intelligence tourism activities through certain economic relationships [5]. The smart rural tourism development model comprises of a horizontal extension, vertical associated function chain, product chain and cultural value chain. It appears as a network structure consisting of horizontal cooperation and vertical supply and demand. Its expression is as follows:

$$T = H(i, j, s, b) \tag{1}$$

In this concept, there are the two points to be explained. For one thing, some departments on the digital background smart rural tourism development model are horizontally cooperative. Each industry in the smart rural tourism development model can directly provide tourism products for tourists, but they need to work together to provide tourists with complete tourism product. For another, if the collaboration is not effective, the poor performance of one of the industries will weaken the development pattern of the entire digital background smart rural tourism [6]. The change relationship is as shown in formula (2) as follows:

$$\mu A_i(x) = e^{-\frac{(x-a)^2}{2b^2}} \tag{2}$$

2.3 Digital background characteristics of intelligent rural tourism development model

(1) Reticulation structure

The traditional mode of manufacturing rural tourism development is based on the vertical industrial linkage of the product process division. Products are processed through upstream, middle, and downstream enterprises and finally presented to consumers [7]. The background of the digital background smart rural tourism development model includes not only the vertical supply and demand relationship, but also the horizontal collaboration relationship. Its mathematical expression is as follows:

$$C = (Q, F_1, F_2, F_r) \tag{3}$$

Digital background intelligent rural tourism products have comprehensive features [8]. Tourists enjoy a range of tourism services from the time they leave their place of residence for the digital background smart rural tourism destinations. In other words, different from the final products of the rural tourism development model for the consumer, the various departments on the digital background smart rural tourism development model can directly provide tourism consumers with tourism products. However, each department can only provide part of the product [9]. If tourists are to be able to experience the full digital background smart rural tourism products, they need effective collaboration and cooperation among all sectors of the rural tourism development model. The main coordination method is shown in formula (4) as follows:

$$P(A_{l+s}|o_l) = \prod_{s=1}^{s} \left(\frac{k_{l+s}}{n_{l+s}}\right) \tag{4}$$

(2) The characteristics of digital background intelligent rural tourism

The rural nature is the essential attribute of the digital background intelligent rural tourism. The reality includes the rural nature of tourism resources, tourism products, tourism market and tourism benefits; the rural nature can be divided into rural culture and rural landscape [10]. The digital background essence of the rural tourism is the rural culture. The rural culture with nationality, history and region is the essential attribute of the digital background intelligent rural tourism. Rural culture as a concrete description is the property of the digital background intelligent rural tourism. Its mathematical expression is as follows:

$$g = \sum_{i,j} b_{ij}\, q_i q_j \tag{5}$$

The determination of core value of the digital background smart rural tourism development model is conducive to a clear direction for development. As to the core of the general tourism rural tourism development model, the traditional view is that travel agencies are the hubs linking the six major elements of tourism, while under the digital background, the reconstruction of the value chain of the tourism industry aims at reconfirming the core node of the chain, and that is, establishing a tourism industry value chain model with tourism sites and tourist attractions as the core [11]. The core of tourism and rural tourism development model is tourism and tourist attractions, and the tour experience of tourism sites and tourist attractions. The core value is tourism and rural tourism development model. However, the digital background smart rural tourism is a more special form of tourism. the mathematical expressions of the four traditional forms of digital rural tourism in China and eight new forms of business are as follows:

$$MSK = (f, w) \tag{6}$$

People choose smart rural tourism for various reasons, some to taste rural food, some to experience agricultural activities, and some to enjoy the rural scenery. That is to say, people choose smart rural tourism for the specific rural cultural atmosphere. It is a kind of cultural yearning for rural food culture, agricultural culture, and rural landscape culture. Therefore, this paper holds that the core value of the digitalized background intelligent rural tourism development model should be rural cultural experience. The value system centering on the intelligent rural tourism cultural experience is the basis for realizing the value-added rural tourism development model [12]. Culture is a description of a special way of life, and then the digital background smart rural tourism is a description of the special rural lifestyle. The rural culture includes

rural food culture, rural living culture, rural landscape culture, agricultural culture, rural product culture, rural entertainment in terms of culture and so on, and these aspects are all examples of rural special lifestyles as shown in Table 2:

Rural cultural experience manifestation	Performance description
Rural food culture experience	Including rural eating habits, methods, and allegorical relations with literature and art
Rural characteristic folk customs experience	Including the selection of rural residential sites, construction techniques, architectural structures, spatial layout, and aesthetic ideas, religious concepts, etc.
Rural landscape / pastoral scenery experience	Different from the comprehensive performance of various phenomena such as the humanities, society, and nature of
Rural entertainment culture / farming activities experience	Including picking, fishing and other farming or recreational activities.

Table 2: Multi-dimensional performance of core values of smart rural tourism development model with digital background.

(3) The characteristics of China's intelligent rural tourism evaluation

There are many perspectives on intelligent rural tourism evaluation. For example, the stability of rural tourism development model can be evaluated from the government's point of view. The cooperation of rural tourism development model can be evaluated from the perspective of the enterprise [13]. With tourism development model for performance evaluation, this paper chooses to evaluate the rural tourism development model of China's digital background smart rural tourism from the perspective of tourists. There are two main advantages in selecting tourist perspectives: firstly, assessing the advantages and disadvantages of the rural tourism development model from the tourists' perspective is closer to the target market; secondly, the use of questionnaires on the tourists is for the measurement of rural tourism development model, and the result is more objective and easier to measure. This paper selected digital background smart rural tourism catering, digital background smart rural tourism accommodation, digital background smart rural tourism products, digital background smart rural tourism scenic spots, digital background smart rural tourism traffic, digital background smart rural tourism entertainment activities for the project indicator layer, and there are several factor layers under the indicator layer, as shown in formula (7) as follows:

$$\Pi(a_i) = Y\left(a_i | \, Pr\, e\,(a_i)\right) \tag{7}$$

2.4 Data analysis of smart rural tourism development model under digital background

(1) Questionnaire design

The questionnaire in this paper is divided into two parts: firstly, the demographics and travel characteristics of tourists, including the demographic characteristics of tourists and tourists' travel characteristics. Secondly, the development model and importance. Development model survey factors use the five-point scale as the evaluation criteria for index evaluation. The survey objectives are: development model and importance. This paper focuses on field surveys of smart rural tourism sites with digital backgrounds in China. 288 questionnaires were distributed and 268 valid questionnaires were collected.

(2) Reliability analysis

A questionnaire with good reliability shows good stability and consistency. Reliability analysis is the analysis method that obtains the reliability of the questionnaire through the evaluation method, and uses the reliability to evaluate whether the questionnaire has good reliability and stability [14]. In general, the same question in the questionnaires of different subjects tends to be consistent, indicating that there is no large sample-to-sample error in the questionnaire survey and the reliability of the questionnaire is higher, and the reliability is lower. Reliability generally uses α coefficient as its evaluation index. The coefficient is generally between 0 and 1 [15]. The higher the reliability, the closer of α coefficient is to 1, which means that the more stable the questionnaire, and the mathematical expression is as follows:

$$p = (\alpha, v, h, h^{w}, \ldots, h^{w_n}) \tag{8}$$

Under normal circumstances, α coefficient is above 0.70, which indicates that the questionnaire is of good reliability and can be used for the next analysis. If α coefficient is lower than 0.35, and the reliability is low, the stability of the questionnaire is insufficient, and it cannot be used. Among them, the reliability of the questionnaire is acceptable [16]. In this study, SPSS tool was used to analyze the reliability of the questionnaires used, and their consistency was checked to ensure the quality and credibility of the questionnaires. After inspection, the overall reliability of the questionnaire used in this survey was α=0.956, and the reliability of development model α=0.954, and the importance of reliability α=0.961, all in line with Cronbach's standards, showing good reliability of the questionnaire.

(3) Development model result analysis

In this survey, men accounted for 45% of the total number of samples, and women accounted for 55%, and the gender ratio is more balanced. In terms of age structure, the proportion of tourists aged 22-38 is the highest. From the point of education, undergraduates and college graduates accounted for the most. In view of residence, the majority of the tourists are Chinese. We can calculate the mean and standard deviation of the development model of 20 evaluation indicators, and sort them according to the average size. Through observation,

Indicator layer	Factor layer	Very dissatisfied	Dissatisfied	General	Satisfaction	Very satisfied	Average
Rural Tourism Catering	Rural features	6	9	123	95	16	3.7
	Environmental hygiene	7	23	154	53	5	3.5
	Price	15	45	93	72	18	3.8
Rural tourism accommodation	Rural features	2	14	122	85	13	3.3
	Environmental hygiene	8	48	93	72	12	3.6
	Price	5	33	107	98	4	3.7
Rural tourism products Indicator layer Rural Tourism Catering	Rural features	5	27	122	74	16	3.5
	Price	8	64	103	53	3	2.2
	Quality	7	58	124	52	2	3.4

Table 3: Ranking of development patterns of evaluation factors for intelligent rural tourism in China.

it can be seen that among the three-level indicators, tourists are more satisfied with the rural characteristics of tourism accommodation, rural characteristics and tastes of tourism and catering. The secondary models of development are the quality, price, and prices of tourism and catering. Paired sample T-test is a statistical method to test whether there is a significant difference in the overall mean of two paired samples. Paired samples can be two sets of sampled data for the same variable, and can also be considered as two different aspects of a problem [17]. To conduct paired sample T test, firstly we need to find the difference between each pair of samples, and then compare the mean and the average value of the 0 relationship, with weak sample no difference and the mean value should be near 0, otherwise the sample is different [18]. In this study, the paired sample T test was used to analyze the difference between the importance of the questionnaire and the development model (the mutual comparison under the same indicator). If the difference was not significant, the importance of the indicator and the development model were examined. The performance of the entry is different, but conversely indicates significant, that is, and there is a certain distinction between the evaluation of the importance and the development model [19].

3 Conclusion

The rural tourism industry chain is different from the general manufacturing industry chain. This paper defines it as a chain-type relationship that supports various sectors of rural tourism activities through certain economic relationships. [20] In the rural tourism industry chain, there are horizontal links between industries, and various industries face consumers at the same time; any individual link in the rural tourism industry chain can directly provide tourism products for rural tourists, but they cannot provide complete tourism products. The rural tourism industry chain is different from the general industrial chain, and its chain core is diversified, and the core value of the rural tourism industry chain is the experience of rural culture. The digital background intelligent rural tourism development model core value should be rural cultural experience. [21]The value system of the rural tourism development model centering on the digital background intelligent rural tourism cultural experience is the basis for realizing the value-added of the rural tourism development model..

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Study on the Multivariant Interactive Teaching Modes of College English under the Information Technology Environment

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Teaching modes can achieve twice the result with half the effort for teaching effect. The multivariant interactive teaching modes based on constructivism theory are a new kind of teaching modes supported by information technology. The multivariant interactive College English teaching modes under the information technology environment has changed the relationship between teachers and students in the classroom teaching process and the relationship between teachers and students and the teaching content. It can improve the quality of English teaching to achieve the goal of effectively improving the teaching effect of the course and improving students' ability of using English language. Based on the background of the information technology environment, this research takes the college students as the object and the multivariant interactive teaching modes as the research method and analyzes the effectiveness of the multivariant interactive teaching modes through an example.

Povzetek: Opisana in testirana je multivariantna analiza učenja angleščine.

1 Introduction

The rapid development of information technology is gradually changing the traditional teaching environment and means. Foreign language educators should make full use of advanced digital technology to absorb and inherit the original teaching advantages to the maximum, making it easier for College English teaching to turn from the teacher centered to the "multivariant interactive" teaching mode between students and computers, students and students, students and teachers. Information-based "multivariant interactive" teaching is the development direction of College English teaching. Therefore, one of the main objectives of the reform of the current teaching mode is to construct a new teaching structure which can not only play the guiding role of teaching but also fully reflect the main role of the students. The multivariant interactive teaching modes under the digital technology environment have strong interactivity. It can realize interaction between students and computers, interaction between students and students, interaction between students and teachers, and interaction between students and learning content. The direction of interaction can also be one to one, one to many, or multivariant to many "multivariant interactive" [1].

2 Related research based on the multivariant interactive teaching modes

2.1 The connotation of multivariant interactive teaching modes

"Multivariate" is the meaning of multivariant elements and multivariant essential factors. "Multivariant interactive" is the process of interaction and interlinking of multivariant elements. In the course of teaching, "multivariate" refers to the teaching elements related to teaching activities, such as teachers' elements, students' elements, teaching environment elements, material conditions elements, and textbook elements and so on. Therefore, "multivariant interactive" can be defined as a process in which various elements related to teaching activities interact and influence each other. The multivariant interactive in the course of teaching is a series of teaching and learning activities, which can make use of the factors of teachers, students and teaching environment to improve the students' interest in learning actively, improve the students' learning state and effect, and achieve a high quality and efficient teaching effect [2].

2.2 The characteristics of multivariant teaching modes

(1) Integrating multivariant teaching methods. The multivariant interactive teaching modes intertwined the teaching method, teaching means, teaching content and teaching organization form into an interactive one. It changes the relatively abstract education idea into a

specific operational strategy, and encourages students to feel, judge and practice and adjust their learning behaviors in an all-round way [3].

(2) An open teaching environment. The multivariant interactive teaching modes are open, and the classroom under this mode is an activity class. Before and after class, students must read a lot and grasp certain vocabularies so that they can interact effectively in class. The information technology environment also increases the interaction between students and teachers, so that students can interact with others in the virtual social situation, which helps students to play the role of emotional factors in language learning [4].

(3) An equal relationship between teachers and students. The multivariant interactive teaching mode advocates the establishment of an equal interaction between teachers and students. It respects the students' personality and experience, encourages and trains the students' spirit of independent exploration, interaction and practice and innovation, and tries to create a relaxed and harmonious interactive teaching situation. Students choose different learning methods according to their special situations and learning requirements, and actively participate in the whole interactive teaching process.

(4) A variety of teaching forms. The multivariant interactive teaching modes are opposed to the stereotyped and traditional instilled teaching, which focuses on that students actively and collaboratively acquire knowledge.

3 Experimental designs of multivariant interactive teaching modes of college English under information technology environment

The experimental subjects were a comprehensive university, which includes both freshmen who have just entered the university and seniors of the sophomore year. Freshmen organize classes in administrative classes, and old students independently choose courses according to the credit system management system, so students in a class may come from different professional classes. There are mainly four teachers involved in experimental teaching work, all of whom are members of the research group of this project. They have not only division of labor, but also cooperation, and are involved in listening and speaking experimental teaching [5]. This chapter intends to elaborate on the design of listening and speaking experiment teaching and the survey of teachers' teaching beliefs.

(1) The research problem of the experiment

1) Whether the multivariant interactive teaching modes can play a positive role in the cultivation of students' awareness of oral communication strategic and the using frequency of communicative strategy;

2) Whether the multivariant interactive teaching modes can promote the formation of students' independent learning ability and cooperative ability;

3) Whether the multivariant interactive teaching modes can provide students with meaningful input and output environment.

(2) Experimental object

The object of this study is the first-grade students of grade 16 law school in our university. They are students of two natural classes whose majors are law. Before the experiment, we calculate the average score for statistics after converting subjects learning background and English college entrance examination results into percentile, and the results are shown as shown in Table 1. The two classes who participated in the experiment used the same listening and speaking teaching materials and the independent learning network platform, that is, the "Experiencing English College English learning system", which is newly developed in the first volume of College English listening and speaking course [6]. The system is installed on the server based on campus network, and students can log in and study at any time. From table 1 and Figure 1, it can be seen that the English foundation of the subjects is basically the same. The time distribution of their extracurricular English learning every week in middle school is basically the same. The 1 class was taken as the experimental class and the 2 class was taken as the control class.

	1 class (Experimental class)	2 class (control class)
The number of students	38	36
The number of girls	20	19
Entrance average achievement	78.21	79.79
The number of people from key middle schools	33	36
Extracurricular listening time every week (hours)	1.2	1.4
Extracurricular oral language time every week (hours)	1.1	1.2
Extracurricular reading time every week (hour)	3.3	3
Extracurricular writing time every week (hours)	2.1	1.9
Extracurricular translation time every week(hours)	0.5	0.5

Table 1: Learning background and College Entrance Examination Statistics

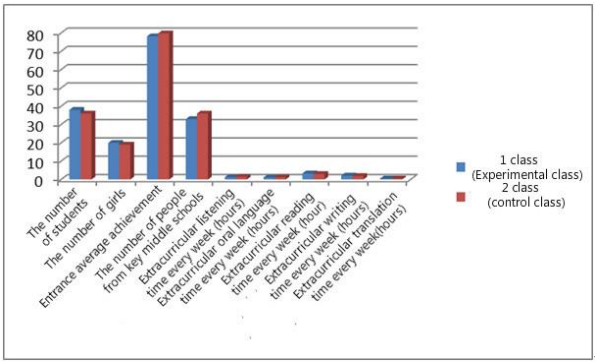

Figure 1: The comparison situation of the subjects being studied.

(3) Experimental scheme

The experimental scheme is:

1) Selecting the subjects, they were divided into experimental class and control class, and their oral learning strategies, communication strategies and metacognitive strategies were investigated.

2) Assigning tasks and goals of "teachers and students, students and students, students and machine" interactive teaching for students in experimental class and developing an autonomous learning plan.

3) After the end of the experiment, the change situation of the oral learning strategies and the use of communication strategies in the experimental class and the control class were investigated through questionnaires.

4) Listening and speaking tests were conducted in both the experimental class and the control class and comparing the differences between their achievements.

5) Through the learner's autonomous learning program, the feedback table is executed, and the students' subjective evaluation of "teachers and students, students and students, students and machine" interactive teaching is understood through the students' learning diary and the students' interview.

6) The differences between autonomous learning ability and cooperative ability of the experimental class and the control class were compared.

(4) Experimental tool

There are three kinds of research tools used in the experiment. The first is the questionnaire, including the English learning strategy questionnaire and the cooperative feeling questionnaire. The second is audio-visual test. The third is the students' own subjective evaluation, including study diary or weekly diary and interview, and the implementation feedback form of learner's independent learning plan [7]. This research uses SPSS13.0 statistics to process data.

4 Analysis of the Experimental Results of Multivariant Interactive Teaching in College English under Information Technology Environment

4.1 The experimental process of listening and speaking experimental teaching

Listening and speaking experimental teaching started from the end of September 2016 and ended at the end of January 2017, which lasted for 12 weeks. During the first week of freshmen, the using frequency of English learning strategies, audio-visual tests and oral English learning needs analysis were conducted in the experimental class and the control class. Then the teaching plan was introduced to the experimental class, emphasizing the importance of cooperative learning and autonomous learning. In addition, an experimental class was trained in oral learning strategy, oral communication strategy and independent learning, and the content and operation of oral communication strategy and metacognitive strategy were introduced gradually. From the beginning of the second week, combined with the teaching resources (the new edition of "College English audio-visual Speaking Course 1"), the "College English learning system" has carried out the teaching practice based on autonomous learning and cooperative learning in the experimental class, which requires the students to complete each specific learning task seriously. The control class also emphasizes the significance of cooperative ability and autonomous learning, and encourages students to develop autonomous learning, but it does not activate oral communication strategies and strategy training. When completing each specific learning task, we advocate cooperative learning and independent learning. In January 2017, the applied situation of oral communication strategies of two classes was surveyed again. Finally, two classes took part in the audio-visual speaking ability test [8].

4.2 Example description

College English listening and speaking "teachers and students, students and students, students and machine" interaction based on autonomous learning and cooperative learning is shown in Figure 2. The solid line is strong and the dotted line is weak.

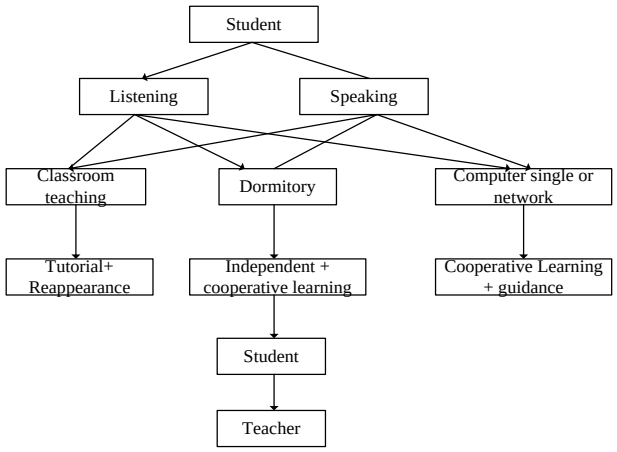

Figure 2: "Teachers and students, students and students, students and machine" interaction.

4.3 Experimental results and analysis

(1) Survey results of the use of oral strategy

Before and after the experiment, we made statistics and analysis on the pretest and posttest of the two oral tests in the control class and the experimental class, and the survey situation of oral communication strategy using. The results are shown in Table 2 and Figure 3.

		Mean value	Variance	Free of degree	t value	Probability
Pretest	Control class	0.63	0.45	74	1.237	0.22
	Experimental class	0.49	0.53			
Posttest	Control class	1.05	0.31	74	1.859	0.067
	Experimental class	0.9	0.38			

Table 2: Horizontal statistics of the strategy using in the control class and the experimental class.

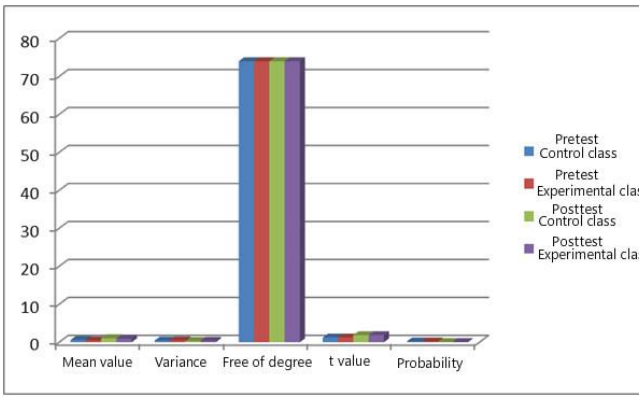

Figure 3: Lateral contrast diagram.

		Mean value	Variance	Free of degree	t value	Probability
Control class	Pretest	0.63	0.45	36	-4.947	0
	Posttest	1.05	0.31			
Experimental class	Pretest	0.49	0.53	38	-3.782	0.001
	Posttest	0.9	0.38			

Table 3: Longitudinal statistical table of the strategy using in the control class and the experimental class.

As can be seen from table 2 and figure 3, the mean values of the strategy using of the control class and the experimental class 12 weeks ago were 0.63 and 0.49 respectively, and the probability was 0.22, greater than 0.01 after the p-value test. This shows that the frequency of strategies using of the two classes is relatively low, and the use of oral strategies is almost no difference, and there is little correlation between the strategies using. After 12 weeks of training, the mean value of the strategies using of the control class and the experimental work was improved, while the average price of the control class was slightly higher than that of the experimental class. The probability was 0.067, more than 0.05, and less than 0.1 by the p-value test. It shows that the strategies using situation in the two classes has improved, which is gradually different, but the significance is not strong [9].

As can be seen from table 3, the frequency of using strategy is low in the control class and experimental work before 12 weeks. After 12 weeks of training, the frequency of using strategies increased. The probability of using the strategy before and after the experiment in the control class and the experimental class was 0 and 0.001 respectively, all lower than 0.05 by the p-value test. It shows that there are differences before and after the experiment, reaching statistical significance. The probability of irrelevance before and after experiment is almost zero.

(2) Results of listening and speaking tests

In the listening and speaking tests conducted 12 weeks ago and 12 weeks later, the results of the control class and the experimental class were shown in table 4 and table 5 respectively.

From the results of statistics of listening and speaking scores in Figure 4, table 4, table 5, the mean value of listening and speaking scores in pretest of the control class and the experimental class were 16.3, 25.03 and 14.74, 25.72 respectively. After p value test, the p value is 0.065

			Mean value	Variance	Free of degree	t value	Probability
Pretest	Listening	Control class	16.3	3.45	36	1.873	0.065
		Experimental class	14.74	3.76			
	Speaking	Control class	25.03	1.64	36	-1.958	0.054
		Experimental class	25.72	1.43			
Posttest	Listening	Control class	21.22	3.38	38	2.724	0.008
		Experimental class	18.9	2.99			
	Speaking	Control class	26.43	1.17	38	-2.201	0.031
		Experimental class	27.03	1.18			

Table 4: Horizontal statistics of listening and speaking scores in control class and experimental class.

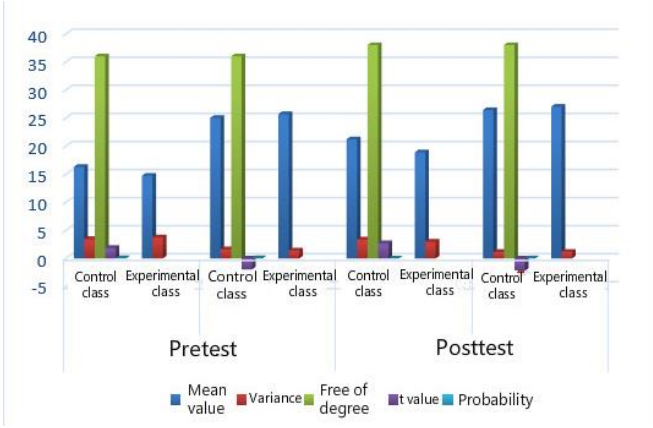

Figure 4: The result statistics of lateral contrast.

			Mean value	Variance	Free of degree	t value	Probability
Pretest	Listening	Control class	16.3	3.45	36	1.873	0.065
		Experimental class	14.74	3.76			
	Speaking	Control class	25.03	1.64	36	-1.958	0.054
		Experimental class	25.72	1.43			
Posttest	Listening	Control class	21.22	3.38	38	2.724	0.008
		Experimental class	18.9	2.99			
	Speaking	Control class	26.43	1.17	38	-2.201	0.031
		Experimental class	27.03	1.18			

Table 5: Longitudinal statistics of listening and speaking scores in control class and experimental class.

			Mean value	Variance	Free of degree	t value	Probability
Control class	Listening	Pretest	16.3	3.45	74	-10.055	0
		Posttest	21.22	3.38			
	Speaking	Pretest	25.03	1.64	74	-7.653	0
		Posttest	26.43	1.17			
Experimental class	Listening	Pretest	14.74	3.76	74	-7.201	0
		Posttest	18.9	2.99			
	Speaking	Pretest	25.72	1.43	74	-7.563	0
		Posttest	27.02	1.18			

and 0.054, which are between 0.05 and 0.1. It shows that the achievement difference between the two classes is not very significant. After 12 weeks, the mean value of listening and speaking scores in the control class and the experimental class were 21.22, 26.43 and 18.9, 27.03 respectively. The value of p is less than 0.05 by the p value test. This indicates that the listening and speaking effects of the two classes are significantly different, and the listening and speaking effects of the experimental class are more significant [10].

(3) Subjective evaluation of students

The significance of changing the attitude of autonomous learning lies in accepting the mode of autonomous learning and consciously entering the state of autonomous learning. It is difficult to achieve the expected learning effect if the change of independent learning

attitude only stays in spoken or perfunctory teachers' task requirements. A student from the control class wrote an evaluation of the self-reading task: "medium! The sound quality or the pronunciation of some words is not very good. (Student 1) for the evaluation of the same task, one student from the experimental class wrote, "read the text aloud and read the courseware, so that it is beneficial to the pure pronunciation, correct errors, cultivate the sense of language, and cultivate the ability of self-study." (Student 2) comparing the activities evaluation of two students, we found that the former student was very general. Perhaps he did not know how to improve the level of reading and lacked motivation to insist on reading aloud. Comparatively speaking, the latter student has a deep understanding of reading aloud. In short, the language accumulated through listening and reading can become students' Internalization knowledge and can also become a bridge for them to understand target language. As students become able to learn and learn in the language environment, their chances of leaving teachers for autonomous learning will increase.

5 Conclusion

Today, with the rapid development of science and technology and the acceleration of global integration, the demand of society for human resource literacy has changed accordingly. It is a new requirement for the quality of talent in the age of information technology to master and use foreign languages, especially English, to communicate and communicate and to master and use information technology to obtain; process and deal with information. The traditional teaching mode of College English with the goal of acquiring language skills has not been able to meet the needs of the ability of foreign language talents to use foreign languages comprehensively in the development of the times. With students as the center, task as the link and information technology as the means, the goal is to cultivate communicative competence, collaboration ability and improve language skills. The original intention of this research is to build a multi interactive College English teaching mode under the information technology environment and to combine the classroom teaching with autonomous learning. This research takes a university as the research object, and makes an example proving of English listening and speaking. The experimental results show that under the background of information technology, multivariant interactive teaching is conducive to College students' learning and application.

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Modeling the Negotiation of Agents in MAS and Predicting the Performance – an SPE Approach

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Software performance engineering(SPE) process starts at the early stages of software development life cycle which helps to develop software that meets the performance requirements on time and budget. Multi-Agent Systems(MAS) are comprised of one or more agents who coordinate each other to accomplish some task. The coordination can be achieved through cooperation and negotiation. In the early development stages measuring the negotiation workload and predicting the performance remains an important but largely unsolved problem. The problem of uncertainty regarding the negotiation workload is required to be addressed by estimation techniques. Hence, in this research we developed a probabilistic model for the negotiation scenario among the agents in a given time horizon. The negotiation workload obtained from the probabilistic model is integrated with the representative workload of the agents for predicting the performance of agents in MAS. The tool SMTQA is used for obtaining the performance metrics. Analysis of the execution environment is done by considering various configurations in the hardware resources based on the dynamic workload of the negotiation agents over a time horizon. From the sensitivity analysis, the bottleneck resources are identified and suggestions for improvement are proposed.

Povzetek: Predstavljena je izvirna metoda za ocenjevanje in napovedovanje delovanja večagentnih sistemov.

1 Introduction

A Multi-Agent System (MAS) is usually understood as a system composed of interacting autonomous agents. MAS have been employed successfully in a number of scenarios. The important characteristics of the agents which distinguish it from an object are Autonomous, Cooperation, Goal oriented, Adaptability, Mobility, Negotiation etc. Many articles on MAS have been mainly concerned with functional characteristics such as coordination, rationality and knowledge modeling. The nonfunctional characteristics also have the equal importance as the functional characteristics for any software system [1-5].

This research aims at making a contribution towards the non-functional characteristics Performance of agents in a MAS by considering the negotiation character of agents. Software Performance Engineering (SPE) is a method for constructing software systems to meet the performance objectives at the early stages of Software Development Life Cycle (SDLC). In SPE, system does not exist so it is not possible to develop the work load parameters from measurement data. Therefore, models of the system are used to collect the data required to predict the performance. The different data required for the SPE approach are Workload scenarios, Performance goals, Software Design concepts, Execution environment and Resource usage estimates [5-7].

The performance prediction of agents by considering the cooperation character of agent the authors have published different articles in [8-11]. In the early development stages measuring the negotiation workload and predicting the performance remains an important but largely unsolved problem. The problem of uncertainty regarding the negotiation workload is required to be addressed by estimation techniques. Hence, in this chapter a model for the negotiation scenario among the agents in a given time horizon is developed. The fitness function which represents the fitness of the agent in the negotiation scenario among 'n' agents in MAS is considered while framing the model. The negotiation workload obtained from the probabilistic model is integrated with the representative workload of the agents for predicting the performance of agents in MAS [12-14].

The tool SMTQA is used for obtaining the performance metrics. The execution environment is analyzed by considering various configurations in the hardware resources based on the dynamic workload of the negotiation agents over a time horizon. From the sensitivity analysis, the bottleneck resources are identified and suggestions for improvement of the software are made [15].

2 Methodology

A methodology is proposed to model the negotiation scenario of agents in a MAS using probabilistic approach. This is based on the methodology discussed for the

distributed systems in [15]. Let $t \in [t_0, T+ t_0-1]$ be the interval, where T be the number of intervals, t_o be the initial interval of the given time horizon. Let S_T be the negotiation services that are considered to be executed during the T intervals. With these assumptions, we have devised the methodology as follows,

- Developing a mathematical model for demand of negotiation services over a given time horizon
- Modeling the resources in the execution environment
- Modeling the variations (alternate designs) in the execution environment
- Identifying bottleneck resources and improving the performance by sensitivity analysis

2.1 Modeling of demand of negotiation services

Consider a MAS 'A' with 'n' number of agents. Let S_T be a set of negotiation services that to be executed during the T time intervals.

Let $S_T = \{S_1, S_2, S_3, \ldots\ldots S_m\}$ be the negotiation services.

Let W1, W2, W3,……..Wm be the size (representative workload) of the negotiation services.

Let Pijk (t) be the probability that agent 'i' communicates with the agent 'j' with the work load of Wk at the time interval t . The sum of these Pijk(t) over k equals 1.

Each negotiation service that can be occurred in the interval $t \in [t_0, T+ t_0-1]$, is characterized by:

- $P_{ijk(t),e}$ – probability of occurrence of the e^{th} negotiation primitive of those specified at time interval t
- $D^s_{t,e}$ – expected demand for each negotiation services $s \in S_T$, if the e^{th} primitive occurs among those specified at time interval t.

Based on such specification of expected primitives, s_t demand scenarios can be generated in each interval *t*, where $p_{ij,s}(t)$ be the probability that s^{th} scenario occurs at time *t* when agent '*i*' negotiates with the agent '*j'*.

In the first period t_0:

$$S_{t_0} = E_{t_0} \quad (1.1)$$

while in the following interval $t \in [t_0, T+ t_0-1]$, the number of scenarios can be recursively computed as:

$$S_t = E_t \,.\, S_{t-1} \quad (1.2)$$

Each workload scenario can be defined as the occurrence of one event at period *t* given one scenario in the previous period *t-1*. Definition of the demand scenarios based on the specification of six events over a time horizon constituted of three intervals is given in Table 1.

Period	Event	Probability	Demand
0	1	p_1	D_1
	2	p_2	D_2
1	3	p_3	D_3
	4	p_4	D_4
2	5	p_5	D_5
	6	p_6	D_6

Table 1: Definition of the demand scenarios.

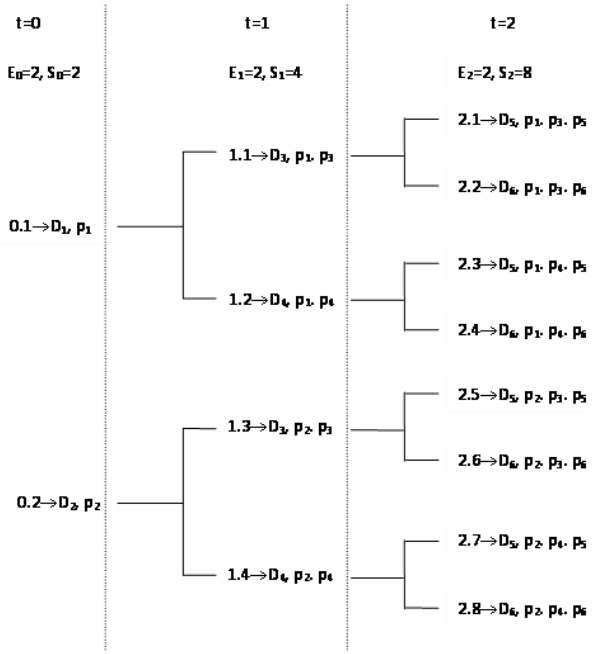

Figure 1: Conditional probability tree for the workload scenario.

2.2 Calculation of workload

The model is simulated by considering three time intervals such that for a given time interval t, $t \in [0, 2]$. The state (negotiation scenario) of the application in time t depends on the state (negotiation service scenario) at the time interval t-1 and the type of the request arrived at t. Hence the scenarios of the negotiation service are considered as states of the software application and the pattern of execution of negotiation services are modeled using the UML, State Chart Diagram. The Figure 2 to Figure 4 represent the workload to be executed during the different time duration. The negotiation services which are having a very less workload are executed during time t=0. During the time t=1 the negotiation services having a higher workload are executed. At time t=2, the negotiation services having an average workload are executed. From Figure 5, it is observed that agent a1 and agent a3 are negotiating more with agent a4. Also agent a2, agent a4, agent a5 are negotiating more with agent a3.

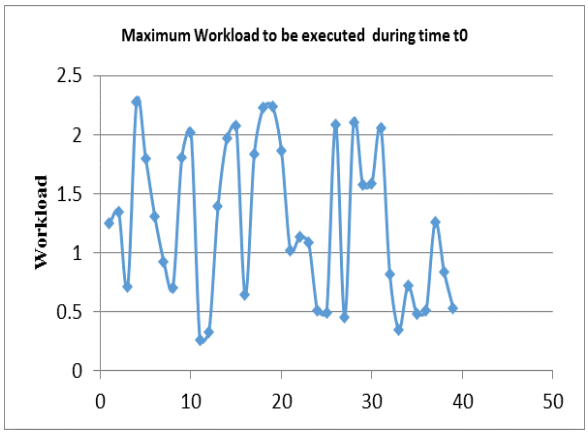

Figure 3: Work Load at Time t0.

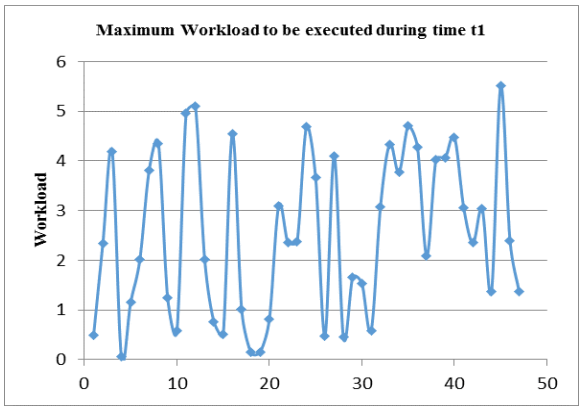

Figure 4: Work Load at Time t1.

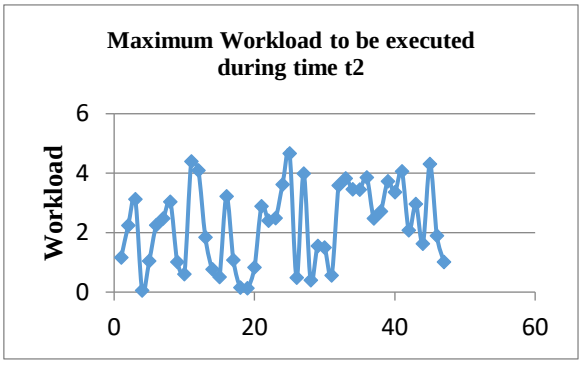

Figure 5: Work Load at Time t2.

2.3 Simulation results

The scenarios of the negotiation primitives are simulated using the tool SMTQA, and the performance metrics are obtained and tabulated in Table 2. The columns in the table represents average response time (Avg Resp Time), average service time (Avg Serv Time), average waiting time (Avg Wait Time), probability of idle time (Prob Idle) and average dropping of requests (Avg Drop). The rows represent the five agents and the internet. (IntN). From the values it is observed that the number of negotiation services dropped is high in Agent 2 and in the Internet. Hence these two resources are identified as the bottleneck resources. To solve this problem, we conducted the

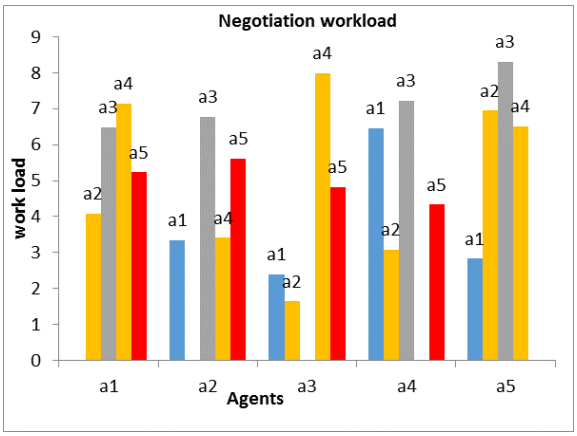

Figure 2: Agents V/S Workloads.

	Avg Resp Time	Avg Serv Time	Avg Wait Time	Prob Idle	Avg Drop
Agt 1	0.003	0.003	0.0	0.342	0.0
Agt 2	0.607	0.021	0.586	0.047	0.830
Agt 3	0.006	0.006	0.0	0.196	0.0
Agt 4	0.008	0.007	0.001	0.181	0.004
Agt 5	0.016	0.013	0.002	0.218	0.005
IntN	0.060	0.021	0.586	0.047	0.830

Table 2: Simulation Result for the configuration C1.

sensitivity analysis by considering different configurations and are presented in the next section.

2.4 Sensitivity analysis

Simulation of the behavior of the resources is carried out by considering the configurations C1 to C6 is as follows.
C1:-Processing speed of CPU is 2000, and the Internet speed assumed is 96.
C2:-Processing speed of CPU is 3000, and the Internet speed assumed is 96.
C3:-Processing speed of CPU is 4000, and the Internet speed assumed is 96.
C4:-Processing speed of CPU is 2000, and the Internet speed assumed is 146.
C5:-Processing speed of CPU is 3000, and the Internet speed assumed is 146.
C6:-Processing speed of CPU is 4000, and the Internet speed assumed is 146.

The results of the different simulation runs are presented in the form of tables. The results obtained for Agent 1 for the different configurations considered is presented in Table 3. The maximum time taken by the Agent 1 to respond is 0.036 in the configuration C4 and minimum time taken to respond is 0.003 with configuration C1. The waiting time in Agent1 is also maximum for the configuration C4. This is due to the configuration of C1; the number of negotiation services dropped is more due to the low configuration of the

Internet. Hence the number of negotiation services that are processed by Agent 1 is less compared to other configurations. In configuration C4, the processing speed of the Internet is increased so that the negotiation services by Agent 1 are more.

Agent 1					
	Avg Res Time	Avg Serv Time	Avg Wait Time	Pro Idle	Avg drop
C1	0.003	0.003	0	0.342	0
C2	0.02	0.019	0.001	0.196	0
C3	0.013	0.012	0	0.132	0
C4	0.036	0.032	0.004	0.135	0
C5	0.017	0.017	0	0.271	0
C6	0.016	0.015	0.001	0.137	0.003

Table 3: Simulation results obtained for Agent 1 with different Configuration.

The results obtained for Agent 2 for the configurations considered are tabulated in the Table 4. Agent 2 has taken the maximum time 0.607 to respond under Configuration C1 and the minimum time to respond is 0.009 with configuration C5. Figure 21 presents the average dropping of requests and probability of idle time of Agent 2. The maximum number of requests is dropped in configuration C1. The maximum waiting time for the requests is observed with configuration C1. This has happened because Agent2 has received more requests.

Agent 2					
	Avg Res Time	Avg Serv Time	Avg Wait Time	Pro Idle	Avg drop
C1	0.607	0.021	0.586	0.047	0.83
C2	0.02	0.15	0.004	0.108	0.005
C3	0.01	0.009	0.001	0.123	0
C4	0.023	0.018	0.005	0.115	0.005
C5	0.009	0.008	0.001	0.159	0
C6	0.01	0.009	0.001	0.133	0

Table 4: Simulation results obtained for Agent 2 with different Configuration

The results obtained for Agent 3 for the configurations considered are presented in Table 9.5. Agent 3 has taken the maximum time 0.118 to respond under Configuration C4 and the minimum time to respond is 0.003 with configuration C5. The average dropping of requests and probability of idle time of the Agent 3 is plotted in Figure 23. The maximum number of requests is dropped in configuration C4. The maximum waiting time for the requests is observed in configuration C4 for Agent 3.

Agent 3					
	Avg Res Time	Avg Serv Time	Avg Wait Time	Pro Idle	Avg drop
C1	0.006	0.006	0	0.196	0
C2	0.008	0.008	0.001	0.14	0
C3	0.094	0.052	0.042	0.083	0.073
C4	0.118	0.06	0.059	0.082	0.102
C5	0.003	0.003	0	0.255	0
C6	0.055	0.033	0.022	0.099	0.044

Table 5 Simulation results obtained for Agent 3 with different Configuration.

The Table 6 presents the results obtained for Agent 4 for the different configurations considered Agent 4 has taken the maximum time 0.033 to respond under Configuration C3 and the minimum time to respond is 0.008 with configuration C1. The maximum number of requests is dropped in the configuration C3. The maximum waiting time for the requests is observed with configuration C3.

Agent 4					
	Avg Res Time	Avg Serv Time	Avg Wait Time	Pro Idle	Avg drop
C1	0.008	0.007	0.001	0.181	0.004
C2	0.018	0.016	0.002	0.125	0
C3	0.033	0.025	0.008	0.116	0.011
C4	0.032	0.025	0.007	0.116	0.009
C5	0.014	0.013	0.001	0.179	0.004
C6	0.015	0.013	0.002	0.118	0

Table 6: Simulation results obtained for Agent 4 with different Configuration.

The Table 7 presents the results obtained for Agent 5 for the different configurations considered. Agent 5 has taken the maximum time 0.07 to respond under Configuration C4 and the minimum time to respond is 0.016 with configuration C1 and C5. The maximum number of requests is dropped in the configuration C4. The maximum waiting time for the requests is observed with configuration C4.

It is observed that the response times of Agent 3, Agent 4 and Agent 5 in the considered configuration are closer to each other and only a few numbers of negotiation services are dropped. Maximum response time is experienced with Configuration C3 and C4 and observed that the dropping of requests in the Internet is the least for the configurationC3 and C4. Lowest Response time is in C1 for Agents A1, A3, A4, A5 but experienced highest number of dropping in the requests. The behavior of Agent 2 is observed different compared to all the other agents' behavior. The reason can be that the average workload of Agent 2 is less compared to the workload of other agents, because of that Agent 2 could execute all the negotiation

Agent 5					
	Avg Res Time	Avg Serv Time	Avg Wait Time	Pro Idle	Avg drop
C1	0.016	0.013	0.002	0.218	0.005
C2	0.022	0.018	0.004	0.211	0.004
C3	0.025	0.02	0.005	0.107	0.002
C4	0.07	0.045	0.026	0.091	0.03
C5	0.016	0.013	0.003	0.128	0.008
C6	0.025	0.021	0.004	0.126	0

Table 7: Simulation results obtained for Agent 5 with different Configuration.

INTERNET					
	Avg Res Time	Avg Serv Time	Avg Wait Time	Pro Idle	Avg drop
C1	0.0607	0.021	0.586	0.047	0.83
C2	0.088	0.001	0.087	0.051	0.413
C3	0.025	0.021	0.004	0.033	0.068
C4	0.07	0.004	0.066	0.048	0.22
C5	0.163	0.004	0.159	0.05	0.674
C6	0.068	0.004	0.064	0.048	0.198

Table 8: Simulation results obtained for Internet with different Configuration.

requests it received. Also we observed that when the Internet speed is increased the dropping of requests reduced which gives the inference that many negotiation requests are executed by the agents successfully.

3 Summary

In this work, we presented a methodology to model the negotiation between the agents and predicting the performance of the system. We presented methodology to: i) develop a mathematical model for the workload of negotiation scenarios over a time horizon, ii) modeling the execution environment, iii) and iv) analyzing the execution environment for variations in resource configurations. The sensitivity analysis is done by considering modification in the resource configuration one at a time, and it also describes bottleneck resources. The output showed that how the different configurations of resources affect the response time of the agents.

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A Novel Agent Based Load Balancing Model for Maximizing Resource Utilization in Grid Computing

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Grid is the collection of geographically distributed computing resources. For effective management of these resources, the manager must maximize its utilization, which can be achieved by efficient load balancing algorithm, The objective of load balancing algorithms is to assign the load on resources to optimize resource use while reducing total jobs execution time. The proposed agent based load balancing model aims to take advantage of the agent characteristics to generate an autonomous system. It also addresses similar systems drawbacks such as instability, scalability or adaptability. The performance of the proposed algorithms were tested in Alea 2 simulator by using different parameters such as response time, resources utilization and overall queue time. The performance evaluation suggests that the proposed algorithm can enhance the overall performance of grid computing.

Povzetek: Predstavljena in s simulatorjem analizirana je agentna metoda razporejanja obremenitev v omrežju.

1 Introduction

Due to the emergence of grid computing on the Internet, a hybrid load balancing algorithm, which takes into account various factors such as grid architecture, computer heterogeneity, communication delays, network bandwidth, resource availability, unpredictability and job characteristics, is now required.

For grids, scalability and adaptability are two major issues. As for the centralized resource scheduling problem, the limitation of scalability and computational performance is inevitable. Moreover, due to resource heterogeneity, resource variations, application diversity and grid environments are dynamic. Therefore, adaptive and robust scheduling techniques are preferred [1][2].

Multi-agent systems offer promising features for resource managers. The reactivity, proactivity, scalability, cooperation, robustness, flexibility and autonomy that characterize agents can help in the complex task of managing resources in dynamic and changing environments.

This paper presents a new Agent Based Load Balancing Algorithm, called ABLBA. A hierarchical architecture with coordination is designed to ensure scalability and efficiency. In addition, a multi-agent approach is applied to improve the adaptability. The proposed algorithm aims to reduce the average response time, as much as possible, of jobs submitted to the Grid, and to maximize throughput and resource utilization.

2 Related works

Authors in [3] proposed a multi-agent load balancing model by analyzing the load of compute nodes and the subsequent migration of virtual machines from overloaded nodes to underloaded nodes. The proposed system involves multiple nodes that interact to implement MapReduce jobs. The multi-agent system consists of a group of agents: node sensor agent, simulation model sensor agent, analysis agent, migration agent and distribution agent. Analysis and distribution agents are defined as reasoning agents.

In [4], a decentralized computing algorithm was proposed to assign and schedule jobs on a distributed grid. Using the properties of multi-agent systems, the proposed distributed resource allocation protocol (dRAP) is described as follows:

An agent in the system is simply a node. Each agent has a vector including the number of CPUs in its cluster and the residual time to complete the execution of its current process. Each agent is assured to be in exactly 1 out of 4 cases during the simulation.

A main feature of this algorithm is that nodes ask their neighbors to form clusters. This reduces waiting time and communication costs. One optimization to consider would be to delay the disconnection of the cluster in state 4, which would guide learning or memory in the system where the planner would be able to remember the requirements of the past process. The problem with this algorithm is its decentralized nature, it is neither a centralized control nor a precise synchronization on nodes (agents).

The study in [5] presented the development of an agent-based model for managing network resources with defined operations so that the user can perform jobs efficiently and effectively and thus significantly improve management by a gLite Grid middleware. The proposed solution provides a platform based on a collection of agents in a virtual organization. The key

aspects of this proposal architecture are: resource tracking, load balancing and agent hierarchy.

In [6] the authors proposed a new load balancing structure based on the moving agent and a technique for optimizing ant colonies. In the proposed structure, a dispatcher agent is involved in distributing the tasks received to the worker agents according to the right decisions to minimize the overall execution time (makespan). The proposed framework is constructed using three layers which are the producer of user tasks, the scheduling load balancing layer and the workers' layer. This study should be complemented by comparing their results with other methods, minimizing task movements and resulting in additional costs in the migration process.

Authors in [7] presented the design and implementation of a priority scheduling and fuzzy load balancing model in a computing grid. In this grid template, the user sends his jobs to the grid agent, after the grid scheduler uses the priority-based scheduling algorithm to schedule jobs from the grid agent to the available resource. Load balancing is done using the fuzzy logic technique Propose, in which a set of fuzzy rules are produced using the resource and the work parameter. As fuzzy control rules are collected using linguistic variables, perceptual knowledge and inspection are easily integrated into the control mechanism.

3 Proposed agent based load balancing model

A grid computing was modelled as a set of clusters. Each cluster was composed of nodes and belonged to a LAN local domain (Local Area Network). Every cluster was connected to the WAN global network (World Area Network) by a Switch [8].

The proposed Agent Based load balancing model was based on mapping the Grid architecture into a tree structure. This tree was built by aggreGAtion as follows: first, for each cluster, a two level subtree was created. The leaves of this sub-tree correspond to the cluster nodes, and its root, called cluster manager, represents a virtual node associated with the cluster. Secondly, sub-trees corresponding to all clusters were collected to generate a three level sub-tree whose root is a virtual node designated as a Grid manager. The concluding tree is referred to as C/N, where C is the number of clusters that constitute the Grid and N the number of worker nodes [8].

This study aims to develop a hierarchical load balancing model based on a multi-agent system. There are two key challenges for Grid computing: heterogeneity and scalability. The authors propose a three-layer architecture to address the scalability issue. Connecting or disconnecting resources (worker nodes or clusters) correspond to simple operations in a tree (adding or removing leaves or sub-trees). The proposed agent based load balancing model aims to take advantage of the agent's characteristics to create an autonomous system. It also addresses similar disadvantages such as instability, scalability, adaptability, etc., and other specific issues related to grid computing.

3.1 Model characteristic

The proposed model is characterized as hierarchical; this characteristic facilitates the circulation of information through the tree and defines the flow of messages in the proposed strategy.

Three types of load information movements can be identified:

- Ascending movement: this movement relates to the load information movement, to get current load state. from Level 2 (node Agents) towards Level 1 (Cluster Agents). or from Level 1(Cluster Agents) towards Level 0 (grid Agents). With this movement, the cluster manager can have a global view of the cluster load or the grid manager can have a glob view of the grid load.
- Horizontal movement: it concerns the useful parameters for the execution of load balancing operations. This movement relates to task assignment intra-cluster in Level 2.
- Descending movement: this movement allows to take decisions for task assignment or jobs migration, the decisions taken by cluster Agents at levels 1 to the Migration Agents at same level. And from Migration Agents at level 1 to Node Agents at level 2, also from Grid Agent at level 0 to Cluster Agents in level 1.

The proposed model:

- supports the scalability and heterogeneity of grids: insertion or elimination entities (processing elements, nodes or clusters) are very simple operations in the proposed model (insertion or elimination nodes, subtrees);
- is totally independent of any physical structure of a grid: the conversion of a grid into a tree is a unique conversion. Each grid corresponds to one and only one tree;
- is based on the exchange of information between Nodes and clusters through their respective agents.

Level 0: At this level, Grid Agent is located, the Grid users send their jobs to the Grid Agent, for which it is responsible:

- receiving jobs from Grid users
- sending jobs for Node Agents
- all Cluster Agents are started by Grid Agent
- initiating a global load balancing process

Level 1: At this level, Cluster Agent is associated with a physical grid cluster; this Agent is responsible for:

- the maintenance of the load information relating to each of its Node Agents.
- estimating the load of the associated cluster and sending this information to Grid Agent.
- the decision to start local load balancing
- sending load balancing decisions to Migration Agent

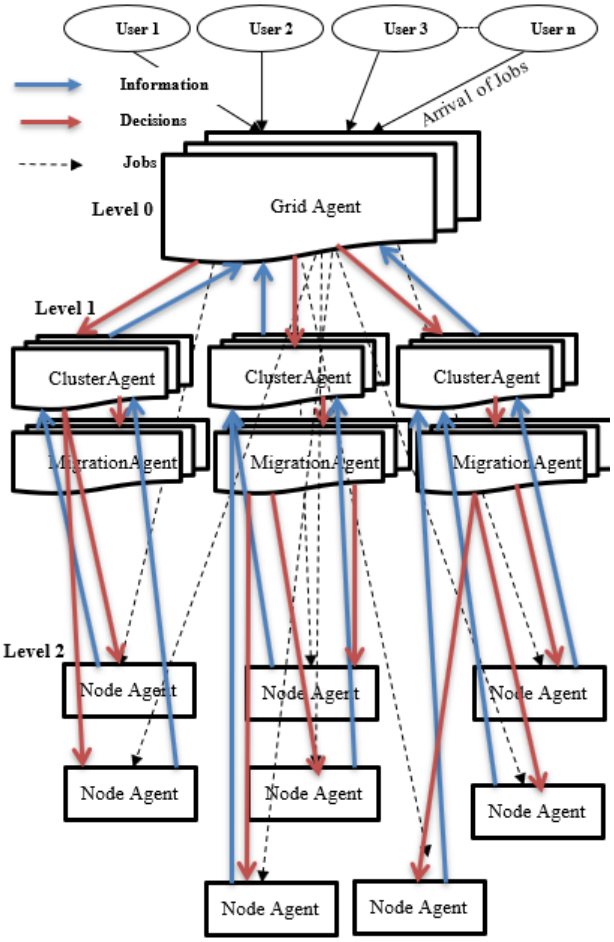

Figure 1: Agent based load balancing model in grid.

- Migration Agent is started by its associated cluster Agent
- all Node Agents are started by their corresponding Cluster Agent

Migration Agent is also present at this level, whose role is to:

- start the migration process
- send the migration decisions to the Node Agents.
- wait for an acknowledgement from receiver node and ensure that the migrated jobs are received and successfully resumed at the destination node

Level 2: At this level, Node Agent is present; it is necessary to have one Node Agent on each node; every Node Agent at this level is responsible for:

- maintaining its load information
- sending this information to its associated
- Cluster Agent
- working in cooperation with the Migration
- Agent to execute the migration process
- collect information about the jobs (number of jobs queued at node, arrival time, waiting time, submission time, start time, processing time and finish time of each job on the local node)
- remove the terminated, leaving or migrated jobs from queue of jobs
- calculate the total load of node
- receive jobs sent by Grid Agent

3.2 Proposed algorithms

According to the proposed model, two levels of load balancing are considered: Intra-cluster Agent based load balancing algorithm and Inter-Clusters Agent based load balancing algorithm.

There are certain specific events that change the load configuration in Grid computing and can be classified as follows:

- Any new job is arrived
- Accomplishment of execution of any job
- Any new node is arrived
- Any existing node is removed
- Failure of Machine at any node
- The node become overloaded

When any of these events happen, the local load value is changed. Table 1 summarizes the notations used in the proposed algorithms.

Parameter	Description
N	Node
$Load_N$	Load of Node
Qlength	Queue length
CPU-U	CPU utilization of Node
Mem	**Memory utilization of node**
TH_H	The higher threshold
TH_L	The lower threshold
OLD-list	Overloaded List
ULD-list	Underloaded List
BLD-list	Balanced List
$Load_{avg}$	Average Load
NBR_N	Number of Nodes of cluster
C	Cluster

Table 1: Notations used in the proposed algorithms.

3.2.1 Intra-cluster agent based load balancing algorithm

Depending on its current load, each Cluster Agent decides to start a Job Migration operation. In this case, the Cluster Agent tries, in priority, to balance its load among its nodes.

Load estimation

The node load at a given time was simply described by the CPU queue length. It indicates the number of processes awaiting execution. The proposed algorithm considers CPU-U (CPU Utilization), Q length (Queue length) and Mem (memory utilization) as load information parameters to measure the load of a node.

These parameters are calculated as follows:

Load (CPU-U)= (U1+U2+……+UT)/T, where: U1+U2+……+UT is the value of CPU-U in a previous one second interval.

Load (Qlength) = (Q1+Q2+…...+QT)/T, where: Q1,Q2,……...,QT is the value of Qlength in a previous one second interval.

Load(Mem)=(M1+M2+……...+MT)/T Where: M1,M2,……...,MT is the value of Mem in a previous one second interval. T is the number of time intervals.

The averaged information of CPU-U, Qlength and Mem are the load parameters used to describe the node load.

Algorithm 1. An algorithm for Node Agent

1: T←5 seconds
2: Waiting for jobs;
3: Create jobs queue for related node;
4: In each one second of T intervals do
5: Calculate (CPU-U);
6: Calculate (Qlength);
7: Calculate (Mem);
8: End do
9: Load (CPU-U) = $(U_0+U_1+…..U_T)/T$;
10: Load (Qlength) = $(Q_0+Q_1+…..Q_T)/T$;
11: Load (Mem) = $(M_0+M_1+…..M_T)/T$;
12: Send load information for related Cluster Agent
13: Wait for load change // happening of any of defined events
14: If (events_happens ()=1 or events_happens ()=4) then // Termination or migration of job
15: Remove terminated or migrated job from the waiting queue
16: Subtract their load value from the total local load of node.
17: Send new load to its Cluster Agent associated;
18: End if
19: If (events_happens ()=2 or events_happens ()=3) then // new or incoming job
20: Add the newly created or incoming job for the waiting queue
21: Add their load value for the total local load of node
22: Send new load to its Cluster Agent associated;
23: End if

Function events_happens ()

output Type: integer
1: If (Job.state=Termination) then events_happens () =1; End If
2: If (Job.state=Start) then events_happens () =2; End If
3:If (Job.state=Incoming Migrating) then events_happens ()=3; End If
4: If (Job.state = migrated) then events_happens ()=4; End If
5:If (Arrival of any new resource) then events_happens ()=5; End If
6: If (Cluster.state=saturated)then events_happens ()=8; End If
7:If (Cluster.state=unbalanced) then events_happens ()=9; End If

Location policy

In the next step, the nodes must be classified according to their load. Three states were used for classification: overloaded, underloaded and balanced. First, Cluster Agent must calculate two threshold values, which are calculated as follows:

- cluster Agent calculates load average of each parameter (CPU-U and Qlength) over all related nodes.
- $Load_{avg}(Qlength)=(load_1+load_2+….load_{NBRN})/NBRN$, where $Load_{avg}(Qlength)$ is the average load of Qlength over all related nodes.
- $load_1,load_2,….load_n$ are the current Qlength of each node calculated by Node Agent.
- $Load_{avg}$ (CPU-U) $=(load_1+load_2+….load_{NBRN})/NBRN$, where $Load_{avg}$ (CPU-U) is the average load of CPU-U over all related nodes.
- $load_1,load_2,….load_{NBRN}$ are the current load of CPU-U of each node calculated by Node Agent.

Calculation of threshold values

The higher and lower threshold values of Qlength and CPU-U of parameters are calculated by multiplying the average load of (Qlength or CPU-U) and a constant value.

- THH(Qlength) =H*Loadavg(Qlength)
- THL(Qlength) =L* Loadavg(Qlength)
- THH(CPU-U) =H*Loadavg(CPU-U)
- THL(CPU-U) =L* Loadavg(CPU-U)

where, TH_H is the high threshold and TH_L is the low threshold. H and L are constants. The next step is to divide the nodes for balanced, overloaded and underloaded nodes using the threshold values as follows:

- Overloaded: the node will be added for overloaded list if queue length is high, or CPU utilization is high, or memory usage is greater than 85%, then the node is classified as overloaded node.
- Underloaded: the node will be added for underloaded list if queue length is low, or CPU utilization is low.
- Balanced: the node is not into the overloaded list or the underloaded list. The node is in a balanced load state. They are considered to be more loaded than the low state and less loaded than the high state.

Algorithm 2. An algorithm for Cluster Agent

1: Startup its related Node Agent
2: Startup its related Migration Agent
3: Receive load information($Load_N(Qlength)$, $Load_N(CPU-U)$) from its related nodes.
4: Calculate and send its load information for Grid Agent.
5: somme ←0; somme1←0;
6: For every Node N of cluster C do
7: Somme← Somme+ LoadN(Qlength);
8: Somme1← Somme1+ LoadN(CPU-U);
9: End For
10: $Load_{avg}(Qlength)$= somme1/NBR-N;
11: $Load_{avg}(CPU-U)$= somme/NBR-N;
12: $TH_H(Qlength)= Load_{avg}(Qlength)*H$;
13: $TH_L(Qlength)= Load_{avg}(Qlength)*L$;
14: $TH_H(CPU-U)= Load_{avg}(CPU-U)*H$;
15: $TH_L(CPU-U)= Load_{avg}(CPU-U)*L$;
16: Partition Nodes into overloaded list OLD-

list, underloaded list ULD-list and balanced list BLD-list
OLD-list←∅; ULD-list←∅; BLD-list←∅;
For every Node N of cluster C do
If (($Load_N$(Qlength)>TH_H(Qlength)) or ($Load_N$(CPU-U)>TH_H(CPU-U))or (Load(Mem)>85%)) then
OLD-list ←OLD-list ∪ N;
End If
Else If (($Load_N$(Qlength))< TH_L(Qlength))or($Load_N$(CPU-U)<TH_L(CPU-U))) then
ULD-list← ULD-list ∪ N;
Else BLD-list← BLD-list ∪ N;
End If
End For
Sort OLD_list by descending order relative to their $Load_N$(Qlength).
Sort ULD_list by ascending order relative to Their $Load_N$(Qlength).
If (events_happens ()=7) then //cluster is unbalanced
While (OLD-list ≠ ∅.AND. ULD-list ≠ ∅) do
For i = 1 To ULD-list. Size() do
send the decision of migration for AgentMigration (with address of first sender node of OLD List and its receiver node of ULD-list);
If an Acknowledgment received from Migration Agent
Update the current $Load_N$ of receiver and sender nodes
Update OLD-list, ULD-list and BLD-list;
Sort OLD-list by descending order of their $Load_N$(Qlength).;
End For

Job Migration Decision

After classifying the nodes, in the next step Cluster Agent decide to transfer jobs from overloaded to underloaded nodes. It sends this decision for Migration Agent.

Algorithm 3. An algorithm for AgentMigration

1: Receive decision of migration from its related Cluster Agent.
2: Sending the migration decisions to the Node Agents of sender and receiver node.
3: Wait for an Acknowledgment from Node agent of receiver node.
4: Send an Acknowledgment for its related Cluster Agent

3.2.2 Inter-cluster agent based load balancing algorithm

This algorithm applies a global load balancing among all clusters of the Grid. The Inter-cluster load balancing at this level is made if Cluster Agent fails to balance its load among its associated nodes. In this case the cluster agent transfers jobs to under loaded clusters based on the Decision taken by Grid Agent. the following algorithms are proposed:

Algorithm 4. An algorithm for Grid Agent

1: Startup all Cluster Agents
2: Receive jobs from grid user
3: Send jobs for Node Agents
4: If (events_happens ()=6) then //one of cluster is saturated
5: Create underloaded_clusters_table;
6: Sort clusters Cr of underloaded _clusters_table by Ascending order of their Load
7: While (underloaded _clusters_table ≠ Φ) Do
8: Sort the clusters Cr of underloaded _clusters_table by ascending order of inter clusters(Ci-Cr) WAN bandwidth sizes.
9: Sort nodes of saturated cluster by descending order of their load
10: Sort Jobs of first node of saturated cluster by FCFS algorithm and communication cost
11: Migrate the selected job from the first node of saturated cluster to j_{th} cluster of underloaded_clusters_table
12: Update load of sender and reciever cluster
13: Update ULD_clusters_table.

The last algorithm is implemented in Grid Agent which determines the way a receiver cluster is selected for a job migrated from overloaded cluster. Grid Agent calculates the minimum communication cost of sending jobs from saturated cluster to receiver underloaded cluster based on the information collected in the last exchange interval. Grid Agent selects the cluster that gives minimum overall cost.

3.3 Agents interactions

The proposed agent based load balancing algorithm is intended to take advantage of the agent characteristic to create a self-adaptive and self-sustaining load balancing system. It consists of five types of agents, in unbalanced situations, and if the Cluster Agent finds that there is a load imbalance between the nodes under its control, it uses the gathering event information policy to receive the load information from each Node Agent. On the basis of this information and the estimated equilibrium threshold, it analyses the current load of the cluster.

Depending on the result of this analysis, it decides whether to start a local balancing in case of an unbalanced state, or simply inform Grid Agent of its current load. Node Agent sends the updated local load value to Cluster Agent, which updates its load information. The local node load is calculated by the Node agent residing at each calculation node. Node Agent creates the task queue at the local node and updates it if necessary, and sends it for Cluster Agent based on the defined events. Migration Agent is responsible for migrating jobs to the selected underloaded node.

There is a Migration Agent in each cluster, who expects an acknowledgement of receipt from the receiving node once it receives the migrated job. The Migration Agent ensures that the work is successfully received and resumed or started at the destination node. The last agent is Grid Agent, it is the role of the distribution of work between clusters, all Cluster Agents are started by this type of agent and it decides whether to start a global load balancing in case of a saturated state.

4 Experimental results

4.1 Experimental environment

An experimental environment using Alea 2 as a grid simulator and JADE (Java Agent DEvelopment Framework) for agent implementation was set up to evaluate the effectiveness of the proposed algorithms. In the proposed infrastructure, management agents can communicate in a Grid environment using the Jade agent platform. In addition to Alea 2, a class library was developed that simulates the activities of an agent platform. This library, called ABLB (Agent based load balancing), includes the classes: Grid Agent Cluster Agent, Migration Agent and Node Agent.

4.2 Workload

The complex data set was modelled from the national Grid of the Czech Republic's MetaCentrum, which allowed to carry out very realistic simulations. It also provides information on machine failures and specific work requirements and this information influences the - quality of solu tions generated by scheduling algorithms. The job description includes (job ID, user, queue, number processors used, etc.).

The cluster description also includes detailed information such as RAM size, CPU speed, CPU architecture , operating system and list of supported properties (allowed queue(s), cluster location, network interface, etc.). In addition, the information machines were under maintenance (failure/restart). Finally, the list of queues containing their time limits and priorities is provided. More details on the trace file used can be found at [9].

4.3 Performance evaluation

The important performance factors in estimating the proposed algorithm is maximizing resource utilization. the use of resources was the main focus (%). The number of clusters was assumed to be 14, and each cluster was considered to be composed of different numbers of resources. The number of jobs was 3000. Figure 3 shows the use of the cluster with and without the proposed algorithm. It can be noticed that the agent based load balancing algorithm is more effective in maximizing resource utilization.

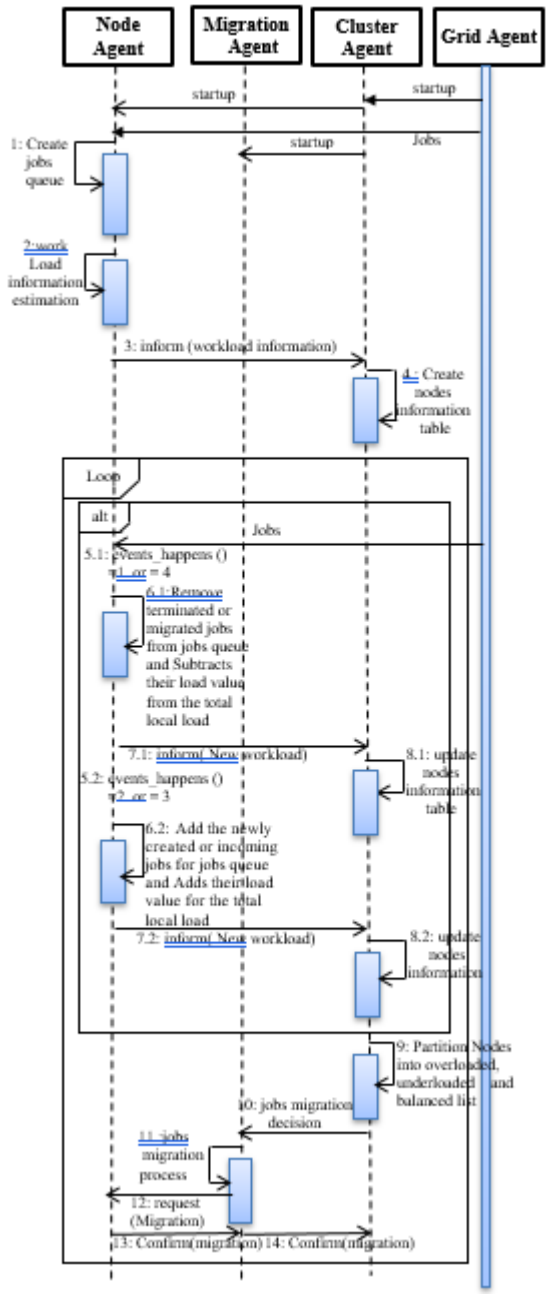

Figure 2: UML Sequence Diagram describes agent interactions in intra cluster load balancing process.

The proposed algorithm allows job to be scattered over the most available resources when there was no appropriate resource, unlike other traditional algorithms that try to select the best resource that resembles the work requirements; otherwise, the job will remain in the global queue, indicating an underutilization of those resources.

Figure 3: Comparison of cluster utilization (%) with and without Agent Based Load Balancing using 14 clusters.

5 Conclusion

The algorithms proposed under the Alea 2 simulator written in Java were developed to test and estimate the performance of the load balancing model based on the proposed agents. Experimental results showed that the proposed model allows a better balance of load and the correct use of resources. There are several approaches to improve resource utilization and reduce response time through coordination and cooperation among agents.

Therefore, the proposed model supports heterogeneity, scalability and dynamics of grids. In addition, a multi-agent architecture for grid load balancing was suggested, as well as a job migration technique to reduce the difference between overloaded and underloaded nodes. Finally, to estimate node load, the combination of CPU usage, memory usage and queue length was applied.

However, the problems of the model implemented included the reliability problem; there is no certainty that migrating work will resume in the reception node. The sender node does not keep a copy of the job until it is left at its new receiver node. Other solutions must be found to offer more reliability for migrating jobs. Moreover, the time required to complete a migration process is not explicitly calculated.

Hence, this study considered the comparison of the proposed algorithm with other agent-based load balancing algorithms, the cost of negotiation between agents, the use of a moving agent for load balancing, and the improvement and use of the proposed model in real grid environments.

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Machine Learning for Dengue Outbreak Prediction: A Performance Evaluation of Different Prominent Classifiers

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Dengue disease patients are increasing rapidly and actually dengue has recorded in every continent today according to the World Health Organization (WHO) record. By WHO report the number of dengue outbreak cases announced every year has expanded from 0.4 to 1.3 million during the period of 1996 to 2005 and then it has reached to 2.2 to 3.2 million during the year of 2010 to 2015 respectively. Consequently, it is fundamental to have a structure that can adequately perceive the pervasiveness of dengue outbreak in a large number of specimens momentarily. At this critical moment, the capability of seven prominent machine learning systems was assessed for the forecast of the dengue outbreak. These methods are evaluated by eight miscellaneous performance parameters. LogitBoost ensemble model is reported as the topmost classification accuracy of 92% with sensitivity and specificity of 90 and 94 % respectively.

Povzetek: Sedem algoritmov strojnega učenja je analiziranih na izbruhu mrzlice dengi in LogitBoost je dosegel najboljše rezultate.

1 Introduction

Dengue fever is the most well-known arboviral disease transmitted by female mosquitoes (Aedes Aegypti) in tropical and subtropical regions throughout the world [7]. Spanish word dengue is derived from dinga. Dengue fever also familiar as break-bone fever, break heart fever, and dandy fever. Dengue viral fever is originated by four concerned viruses known as DEN- (1 to 4). Now DEN-5 which is newly introduced in 2013 [13,3]. Dengue fever (DF), Dengue Hemorrhagic Fever (DHF), and Dengue Shock Syndrome (DSS) are the broad stages of dengue viral from normal to serious respectively [8,16].

According to WHO report the number of dengue outbreak cases announced every year has expanded from 0.4 to 1.3 million during the period of 1996 to 2005 and then it has reached to 2.2 to 3.2 million during the year of 2010 to 2015 respectively. Dengue outbreak is a champion among the most notable viral disease in human beings. Over 33% of the aggregate population of the world is under pitfall together with numerous urban communities of India. In due course, forecasting of dengue outbreak can protect the life of a human by alarming them to take appropriate treatment and care. Forecast of transmissible outbreaks like dengue disease is a challenging work and several prediction techniques are still in their early stages [10]. An Eco-bio-social framework for dengue vector breeding has been proposed by [2]. The researchers use six different Asian regions in their research work and as a gist, vector breeding and adult Aedes aegypti are determined by a complex interaction of the factor.

Souza et al, (2007) [19] shows the influence of dengue disease on liver activity. They found that liver damage is more frequent in ladies. So, the liver test is more important that calculates the level of liver damage.

Machine learning is state of the art technology to embolden machines to perform without being explicitly customized to streamline performance standard use of case data or previous observations. Machine Learning model is used for the collection of precious information from the data by the normalized dataset. At this critical moment, the capability of many prominent machine learning systems was assessed for the forecast of the dengue outbreak. For the sake of this, seven machine learning algorithms have been used like LogitBoost, Logistic regression, Decision tree, Naive Bayes, Artificial neural network, Sequential minimal optimization, and k-nearest neighbor. Additionally, the ROC curve is also used for performance measurement. In table 4, we have shown the comparison among accuracy rate, sensitivity and specificity of the prominent classifier with two ensemble models i.e. Random forest [5] and LogitBoost.

2 Related Work

There are few other works concerned with the prediction of dengue outbreaks. Althouse et al. (2011) [1] applied three models, Linear regression (Step-down), Generalize Boosted regression and negative binomial Regression, as well as two another methods, logistic regression, and artificial neural network, are also applied for dengue disease prediction. They have performed their experiments for two regions Singapore and Bangkok. Authors found that the linear model is superior to other models; also support vector machine (SVM) performs

better than logistic regression in both regions. The selected linear model achieves a correlation of 0.86 and 0.93 between fitted and observed for Bangkok and Singapore region, respectively.

Brasier et al. (2012) [3] performed dengue disease prediction using CART and Random forest methods based on symptoms. They are performed 10 trails with 10-fold cross-validation that shows 84.0% (for DF) & 84.6% (for DHF) average accuracy result.

Support vector classification is used by Fathima et al, (2012) [6] for the prediction of arbovirus dengue. In their analysis, SVM gives 90.42% accuracy with 47.23% sensitivity and 97.59% specificity.

Fathima et al, (2015) [5] has done their experiment on dengue infection prognosis using random forest (one of the ensemble model) classifier on clinical parameters. As a result, they found 92% accuracy.

Ibrahim et al. (2005) [9] experiments dengue viral on 252 patients (4 DF & 248 DHF) using ANN with 9 input neurons and 5 hidden neurons on MATLAB simulator and their result showed 90% accuracy.

Rachata et al. (2010) [14] applied ANN using climate parameters like temperature, rainfall and relative humidity for dengue outbreak prediction. 85.92% accuracy is found in their experiment; also, they suggested using another feature selection method such as the hidden Markov model.

Decision Tree (C4.5) classifier is applied by Tanner et al. (2008) [21] on 1200 dengue samples (364 dengue positive & 836 dengue negative) consisting of five clinical parameters. Their experiments found 84.7% accuracy and 15.7% overall error rate and claims decision tree could be a useful classifier.

Additional review on related literature can be found in [10], which explores around thirty literature published between the year 1995 to 2013.

3 Methods & material

Data mining is an act of analyzing and extraction of substantial previous databases consider in mind that the end target is to the prediction of unknown information of a novel example from observed examples.

Data mining phases are as follow:

- Phase 1: Problem identification
- Phase 2: Formulation of the hypothesis
- Phase 3: Data collection
- Phase 4: Data Pre-process (scaling, encoding, and selecting features and outlier detection or removal)
- Phase 5: Model estimation
- Phase 6: Model interpret and draw conjecture

In this experiment, we use dengue disease dataset in CSV file format for the prediction on the WEKA data mining tool. This dataset consists of 75 samples with 36 samples without dengue disease (Negative) and 39 samples with dengue disease (Positive) [12,17,20]. The dataset is collected from test reports of different discharged patients. After that performs data pre-processing for smoothing some missing values using ReplaceMissingValues technique under filter option of WEKA tool. In this experiment, 8 distinct clinical attributes have been taken into account for the prediction of dengue diseases (Table 1).

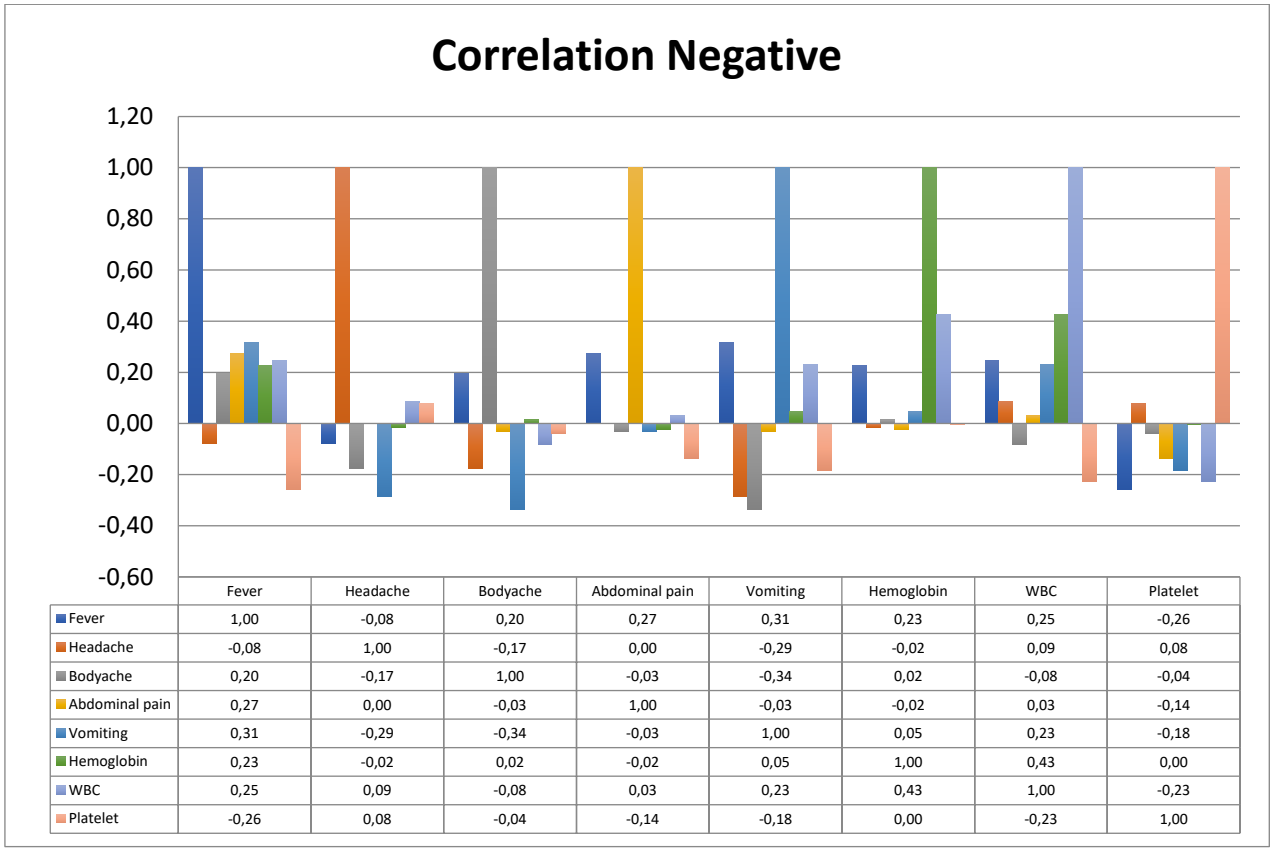
Attribute Name	Data type	Range
1. Fever	Binary	No/Yes
2. Headache	Binary	No/Yes
3. Body ache	Binary	No/Yes
4. Abdominal pain	Binary	No/Yes
5. Vomiting	Binary	No/Yes
6. Haemoglobin	Numeric	12.0-17.5 (g/dL)
7. WBC	Numeric	4000-11000(/cumm)
8. Platelet	Numeric	1.5-4.5 (Lakh/mm^3)
Dengue	**Binary**	**Negative/Positive**

Table 1: Clinical attributes for dengue outbreak.

Dataset samples incorporated of the total of 75 samples with 8 clinical attributes for each sample. Samples with the absence of dengue outbreak were treated as a negative class, and samples with the presence of dengue outbreak were treated as positive samples for purpose of analysis. The correlation between

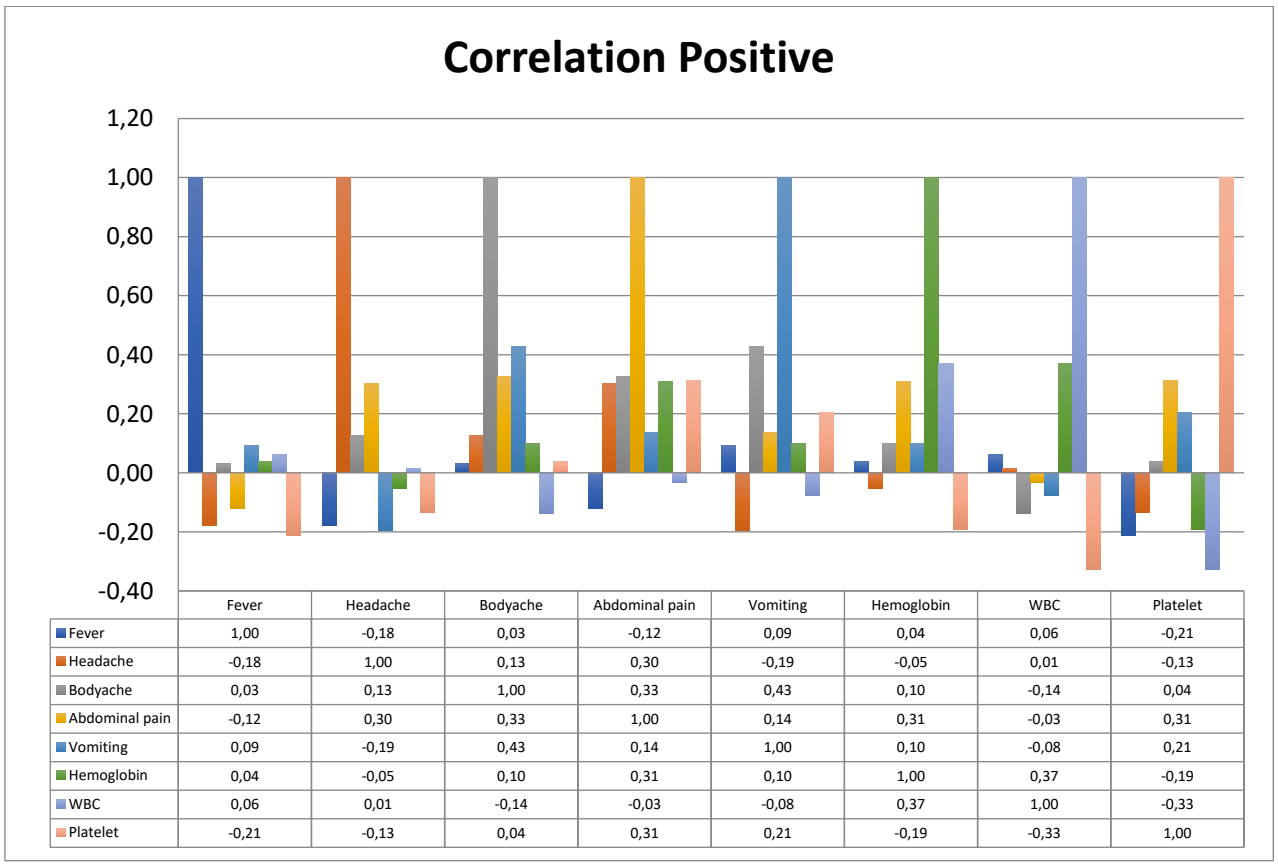
Eight attributes of negative and positive samples show the high correlation between the attributes of the two classes of samples as depicted in Figures 1 and 2. Figure 1 clearly shows that fever feature is positively correlated with all other parameters except a headache and platelet in samples without dengue outbreak (negative). Similarly, positively correlation between other parameters in negative class can be noticed in Figure 1.

Similarly, Figure 2 clearly demonstrates that the hemoglobin feature is positively correlated with all other parameters except a headache and platelet in samples with dengue outbreak (positive). Similarly, positively correlation between other parameters in positive class can be observed in Figure 2.



	Fever	Headache	Bodyache	Abdominal pain	Vomiting	Hemoglobin	WBC	Platelet
Fever	1,00	-0,08	0,20	0,27	0,31	0,23	0,25	-0,26
Headache	-0,08	1,00	-0,17	0,00	-0,29	-0,02	0,09	0,08
Bodyache	0,20	-0,17	1,00	-0,03	-0,34	0,02	-0,08	-0,04
Abdominal pain	0,27	0,00	-0,03	1,00	-0,03	-0,02	0,03	-0,14
Vomiting	0,31	-0,29	-0,34	-0,03	1,00	0,05	0,23	-0,18
Hemoglobin	0,23	-0,02	0,02	-0,02	0,05	1,00	0,43	0,00
WBC	0,25	0,09	-0,08	0,03	0,23	0,43	1,00	-0,23
Platelet	-0,26	0,08	-0,04	-0,14	-0,18	0,00	-0,23	1,00

Figure 1: Linear correlation of negative cases.



	Fever	Headache	Bodyache	Abdominal pain	Vomiting	Hemoglobin	WBC	Platelet
Fever	1,00	-0,18	0,03	-0,12	0,09	0,04	0,06	-0,21
Headache	-0,18	1,00	0,13	0,30	-0,19	-0,05	0,01	-0,13
Bodyache	0,03	0,13	1,00	0,33	0,43	0,10	-0,14	0,04
Abdominal pain	-0,12	0,30	0,33	1,00	0,14	0,31	-0,03	0,31
Vomiting	0,09	-0,19	0,43	0,14	1,00	0,10	-0,08	0,21
Hemoglobin	0,04	-0,05	0,10	0,31	0,10	1,00	0,37	-0,19
WBC	0,06	0,01	-0,14	-0,03	-0,08	0,37	1,00	-0,33
Platelet	-0,21	-0,13	0,04	0,31	0,21	-0,19	-0,33	1,00

Figure 2: Linear correlation of positive cases.

4 Machine learning algorithms

4.1 K-nearest neighbour (kNN)

K-nearest Neighbour classifier is based on instance learning approach that is influenced by the lazy learning technique. Instance-based method, alternatively known as memory-based learning. In this approach, it matches novel problem instances with previously picked instances at training, which is stored in the memory. It is most fruitful for huge datasets with fewer features and provides global approximation and less time in training.

The k-NN method can be applied to both classification and regression. In both situations, the input composed of the k nearest training instances in feature space. The outcome is dependent on the application of k-NN is applied for classification or regression [10].

In k-NN classification, the result is a class belonging. The classification of entity is decided on the basis of a majority vote of their neighbor. In contrast k-NN regression, the outcome is the merit significance for the object. The significance is the means of the values of their kNN.

The k-NN model for continuous-valued objective functions that compute the average estimation of the *k* nearest neighbors. kNN is strong to noisy data by calculating the mean of k-nearest neighbors. The gap between neighbors can be overwhelmed by unnecessary features that lead to the curse of dimensionality. To defeat it, dimension stretch or elimination of the less significant features.

4.2 Support vector machine (SVM)

Support Vector Machine, also alternatively known as Support Vector Network introduced by Vladimir Vapnik, that is used for both classification and prediction. SVM is a machine learning method for binary classification problem, despite the fact that executions of multi-class SVMs exist to guide enter vectors to a multi-dimensional feature space. A straight decision environment is worked with exclusive competence guaranteeing high generalization capability of a machine learning strategy [6].

SVM depends on the statistical learning theory that there is an infinite line known as hyperplanes, isolating the two classes. SVM approach endeavoring to search the best one, that reduce the classification error on unknown data. SVM finds for the hyperplane with the biggest margin i.e. maximum marginal hyperplane (MMH).

The thought behind the SVM has been widely actualized in biology with some strategy for the limited situation where training data can be isolated error-free, additionally extending this outcome to non-separable training data. SVM is a deterministic approach that generates effective generalization properties. SVM has a strong mathematical function that uses kernel for complex learning.

Sequential minimal optimization (SMO) is a method for resolving quadratic programming issue which appears at training time of support vector machine [12,18].

A separating hyperplane can be calculated as:

$$H = W.X + \mathrm{b} = 0$$

Where, H hyperplane, W weight, X input vector, and b bias.

4.3 Artificial neural network (ANN)

The artificial neural network is powerful processing machine, that can be an algorithm or real hardware device that has the ability to recognize experience or contemplation knowledge represented through intermediary unit collectively features, and can make such learning knowledge available for usage.

The weighted sum of product $x_i w_{kj}$ (for i=0 to m) is usually denoted as net_k:

$$net_k = x_0 w_0 \sum_{i=1}^{m} x_i w_{kj}$$

Finally, an artificial neuron computes the output y_k as a certain function of net_k value:

$$y_k = f(net_k)$$

Where x and y are input and output signals respectively, w_{kj} synaptic weight, j synapse, and f is activation function [10].

4.4 Naive Bayes classifier

Bayesian learning is referred to as methods in probability and statistics. Bayes theorem illustrates the possibility of an event on the basis of conditions which may be respective to the event. It has a homological performance with chosen neural network classifiers and classification tree.

Every training sample can gradually increment or decrement the probability that a hypothesis is accurate means that previous knowledge could be associated accompanied by observed outcome. Naive Bayes is computability intractable and optimal decision making. Naive Bayes classifiers are applied for extraction of the appropriate grouping for a dataset wherever explicit elemental applications are conjoined [18].

The mathematical equation for Bayes theorem is stated as:

$$P(X|Y) = \frac{P(X)P(Y|X)}{P(Y)}$$

Here X and Y represented as events, P(X) and P(Y) represents the ratios of X and Y without concern to each other. P(X|Y) is a conditional probability of observing occurrence X given that Y is correct. P(Y|X) is the ratio of observing occurrence Y specified that X is correct.

4.5 Decision tree

The decision tree is a hierarchical based prediction approach that sketches the observed attribute in the branches and the target value at their leaves. The predictions can be discrete values which is a classification decision tree or continuous values which is regression decision tree. The prominent algorithms have been developed e.g. ID3, C4.5, CART, CHAID and MARS for

decision tree prediction model. J48 decision tree [11] algorithm is a popular Java development under the C4.5 algorithm in WEKA tool that is applied as one of the experiments in this research.

Attribute selection measure by information gain is described as:

$$I(p,n) = -\frac{p}{p+n}log_2\frac{p}{p+n} - \frac{n}{p+n}log_2\frac{n}{p+n}$$

The entropy or requisite information required to the classification of objects in overall sub-trees is calculated as:

$$Entropy(A) = \sum_{i=1}^{v}\frac{p_i+n_i}{p+n}I(p_i+n_i)$$

The encoded information that can be obtained by divaricating on A:

$$Gain(A) = I(p,n) - E(A)$$

Where A and I represent Attribute and Information gain respectively; p and n are an element of class P and N respectively.

4.6 Logistic regression classifier

Logistic regression is based on the regression technique in which the dependent variable is categorical. Logistic regression is a way to the prediction of a dichotomous result. Logistic regression can be binomial, ordinal and multinomial. In multinomial, the results can have more than two possible types.

Univariate logistic regression was applied for continuous covariates, whereas logistic regression techniques give odds proportion of interest, that is not easy to use as a diagnostic device because a computer would be required to compute dengue fever prediction. Consequently, we readjusted the two selected logistic regression technique that substituting continuous attributes with binary counterparts [4].

4.7 LogitBoost: an ensemble classifier

Various application of a data mining process demonstrated the legitimacy of mentioned No-Free-Lunch theorem [22]. According to No-Free-Lunch, a single learning model cannot be the best and most appropriate with the whole domain of application. Ensemble learning is an encouraging perspective strategy that combines weak learners to make a powerful model with a specific end goal to enhance the prediction model [15].

Ensemble model is a new way to the mixture of numerous prominent models for enhancement of the precision rate of a novel model for better prediction. It is a combination of k-learned models (M1, M2, M3...Mk) with the purpose of making an upgraded model M* [10], shown in figure 3.

In this research, LogitBoost algorithm has applied as an ensemble classifier for the prediction of dengue outbreak. LogitBoost follows the boosting approach as an ensemble. Boosting approach is most strong learning that is applied for both classification and regression analysis. Boosting approach first builds a weak classifier and test inputs are given starting weights and more often it begins with identical weighting. During iteration, the test inputs are assigned with new weight value to center the systems that are not accurately classified with a newly learned classifier. At each progression of learning, increment weights of the input instance that are not accurately trained by the weak learner and reduction of weights of the input instance that are accurately trained by the weak learner. The ultimate classification model is built on a weighted vote of weak classifiers produced in the repetition.

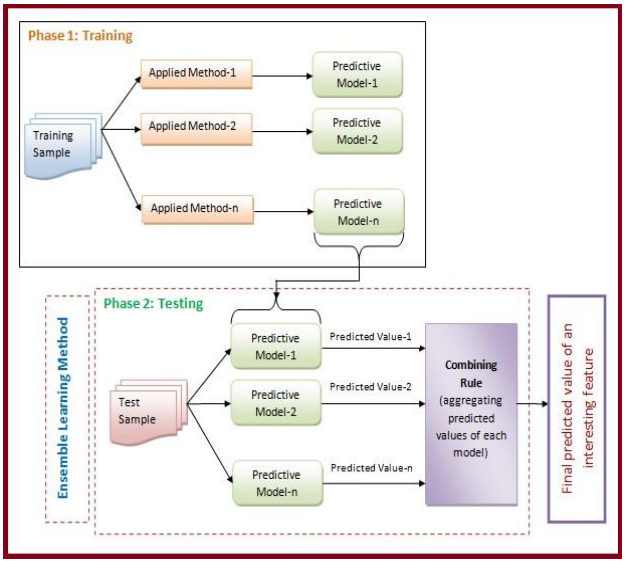


Figure 3: Ensemble model architecture [10].

In this comparative analysis, we found that LogitBoost performs better than another specific prominent classifier. LogitBoost ensemble model is reported as the topmost classification accuracy of 92% with sensitivity and specificity of 90 and 94 % respectively.

5 Classification performance metrics

In this research, seven supervised machine learning approaches were applied for the classification of dengue disease samples. Performance of the classification techniques was estimated on tenfold cross-validation. Eight quality parameters were taken into account for the assessment of classification models. Samples with the absence of dengue outbreak were treated as a negative class, and samples with the presence of dengue outbreak were treated as a positive class. Basic terminologies of confusion matrix as described here:

- **True Positive (TP)- a** number of records predicted as positive and it does have dengue outbreak.
- **True Negative (TN)- a** number of records predicted as negative and it doesn't have dengue outbreak.
- **False Positive (FP)-** a number of records predicted as positive but actually it doesn't have dengue outbreak. FP is also known as the *Type I Error.*
- **False Negative (FN)-** a number of records predicted as negative but actually it does have dengue outbreak. FN is also known as the *Type II Error.*

The quality measures on confusion matrix for binary classification are listed below as:

❖ **Classification Accuracy:**
The overall proportion of appropriately predicted samples to the total number of samples by the classifier model.

$$CA = (TP + TN)/(total\ sample)$$

❖ **True Positive Rate:**
The proportion of predicted positive sample to the total actually positive samples.
- Also known as *Sensitivity* or *Recall*

$$TPR = TP/(TP + FN)$$

❖ **False Positive Rate:**
The proportion of predicted positive sample to the total actually negative samples.

$$FPR = FP/(FP + TN)$$

❖ **True Negative Rate:**
The proportion of predicted negative sample to the total actually negative samples.
- Also known as *Specificity*

$$TNR = TN/(TN + FP)$$

❖ **Positive Predicted Value:**
The proportion of predicted positive sample to the total predicted positive samples.
- Also known as *Precision*

$$PPV = TP/(TP + FP)$$

❖ **Negative Predictive Value:**
The proportion of predicted negative sample to the total predicted negative samples.

$$NPV = \frac{TN}{TN + FN}$$

Rate of Misclassification:
The proportion of overall incorrectly samples to the total number of samples. It can be also defined as the proportion of gross error (Type I Error and Type II Error) to the total number of samples
- RMC=1-CA
- Also known as "**Error Rate**"

$$RMC = \frac{Type\ I\ Error + Type\ II\ Error}{total\ sample}$$

❖ **F1 Score:** It is a weighted average of the recall and precision.

$$F1 = \frac{2TP}{2TP + FP + FN}$$

6 Results and discussion

The performance measurement of dengue outbreak prediction by seven machine learning algorithms is evaluated based on eight attributes as mentioned in the methods and materials section.

There was a total of 75 samples taken into account with 36 negative cases and 39 positive cases of dengue outbreak. Dengue dataset samples were divided in tenfold, each fold was used in testing and rest folds were applied as training throughout cross-validation.

Confusion matrix of prediction result is tabulated in Table 2 for LogitBoost, and other classifications like, Logistic regression, Decision tree, Naive Bayes, Artificial neural network, Sequential minimal optimization, and k-nearest neighbor are shown in figure 4.

Figure 4 depicts the predictions of these machine learning models. It is declared from the results that LogitBoost predicts the topmost number of true positives (number of records predicted as positive and it does have dengue outbreak) and it also predicts the topmost number of true negatives (number of records predicted as negative and it doesn't have dengue outbreak (Table 2; Figure 4).

Decision tree confusion matrix shows that it has the second highest true positives and Logistic regression predicts the second-highest true negatives (Figure 4).

Logistic regression confusion matrix shows that it has the third highest true positives and SMO confusion matrix predicts third highest true negatives (Figure 4).

Naive Bayes and ANN confusion matrix depicts that both are the fourth highest true positives and true negatives (figure 4).

SMO confusion matrix indicates that it has the fifth highest true positives and Decision tree predicts the fifth highest true negatives (Figure 4).

k-NN confusion matrix shows the worst performer in the sense of the lowest true positives and true negatives (Figure 4).

LogitBoost:

		Predicted Class		Total Actual
		Negative	Positive	
Actual Class	Negative	34 (89.47%)	2 (5.40%)	36
	Positive	4 (10.53%)	35 (94.59%)	39
Total Predicted		38	37	75

Table 2: Confusion matrix for LogitBoost algorithm.

Table 3 explains various classification chronicle measurements especially classification accuracy, specificity, sensitivity, precision, False Positive Rate, Negative predictive value, the rate of misclassification and F1 score.

Table 3 declared that LogitBoost outperformed over all other machine learning methods with the topmost classification accuracy of 92% while the second highest classification accuracy is achieved by Logistic regression of 85%. In addition, LogitBoost has found the highest sensitivity of 90% and Decision tree has got the second highest sensitivity of 87%. Logitboost also acquires topmost specificity of 94% and precision of 95% which declared that LogitBoost ensemble model is most appropriate for the prediction of patients with dengue outbreak (positive class).

Table 3 also shows other parameters like False Positive Rate, Negative predictive value, the rate of misclassification and F1 score of these machine learning methods. The table undoubtedly shows that LogitBoost

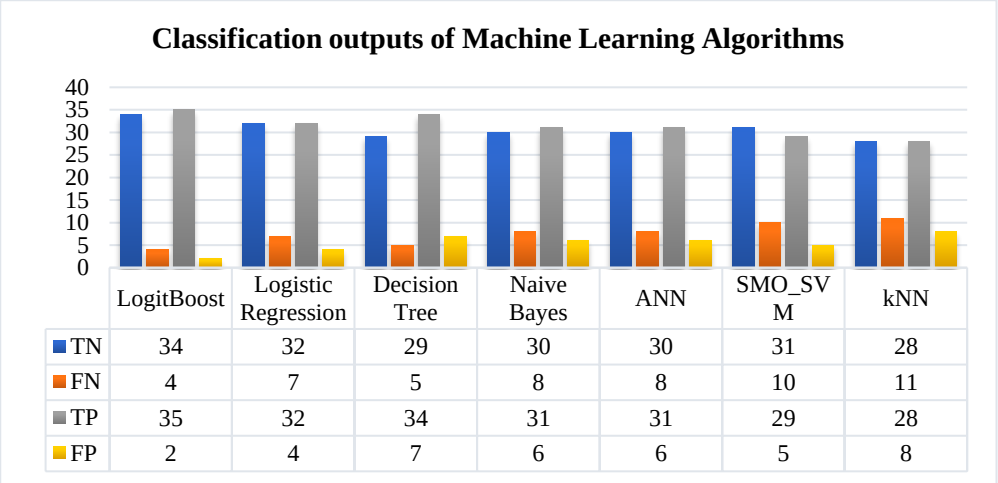


Figure 4: Classification output of machine learning algorithms

	CA	*Sens.*	*Spec.*	*Prec.*	*FPR*	*NPV*	*RMC*	*F1*
LogitBoost	0.92	0.90	0.94	0.95	0.06	0.89	0.08	0.92
Logistic Regression	0.85	0.82	0.89	0.89	0.11	0.82	0.15	0.85
Decision Tree	0.84	0.87	0.81	0.83	0.19	0.85	0.16	0.85
Naïve Bayes	0.81	0.79	0.83	0.84	0.17	0.79	0.19	0.82
ANN	0.81	0.79	0.83	0.84	0.17	0.79	0.19	0.82
SMO	0.80	0.74	0.86	0.85	0.14	0.76	0.20	0.79
kNN	0.75	0.72	0.78	0.78	0.22	0.72	0.25	0.75

Table 3: Classification performance metrics of machine learning algorithms.

MODEL	ACCURACY (%)	Sensitivity	Specificity	REFERENCE
Support Vector Machine	90.42%	47.23%	97.59%	[6]
Random Forest (Ensemble)	**92%**	**94%**	**92%**	**[5]**
Artificial Neural Network	90%	-	-	[9]
Artificial Neural Network	85.92%	-	-	[14]
Decision Tree (C4.5)	84.7%	78.2%	80.2%	[21]
Alternative Decision Tree	89%	89.2%	47.6%	[11]
LogitBoost (Ensemble)	**92%**	**90%**	**94%**	**In this experiment**

Table 4: Comparison of accuracy result of LogitBoost ensemble model among other experiments.

has the highest negative predictive value of 89% whereas it also defeats all other methods on the F1 score with 92%. LogitBoost also achieves the lowest FP rate of 6%, and also the lowest Rate of misclassification (8%).

6.1 ROC curve for performance evaluation

Receiver Operating Characteristic (ROC) curve is a generally employed diagrammatical representation which estimates the performance of the classification models over all feasible thresholds. ROC curve is generated by tracing the FPR on the x-axis with contrary to the TPR on the y-axis. ROC is impartial of both classes and important when the number of instances of both classes mutates at training. Range under ROC must be close to 1 for the best classifier.

Figure 5 enlighten that LogitBoost defeats all other methods in the prediction of negative dengue outbreak case and Figure 6, LogitBoost beat other methods in the prediction of positive dengue outbreak case.

7 Limitation and future work

In this experimental work, we have used 8 clinical parameters with 75 dataset samples (36 dengue negative and 39 dengue positive samples) and performs classification tasks of data mining. After that, we applied seven prominent algorithms in which LogitBoost (one of the ensemble model) performs better than others. According to No-Free-Lunch [22], a single learning algorithm cannot be the best and at most appropriate with the whole domain of application. It may be the computing cost and processing time can increase due to ensemble model but subsequently, day by day the new technologies have come into existence like cloud computing services

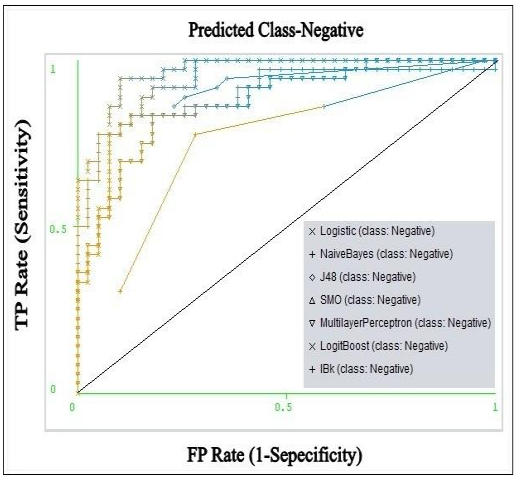


Figure 5: ROC for seven machine learning techniques tested for the negative case.

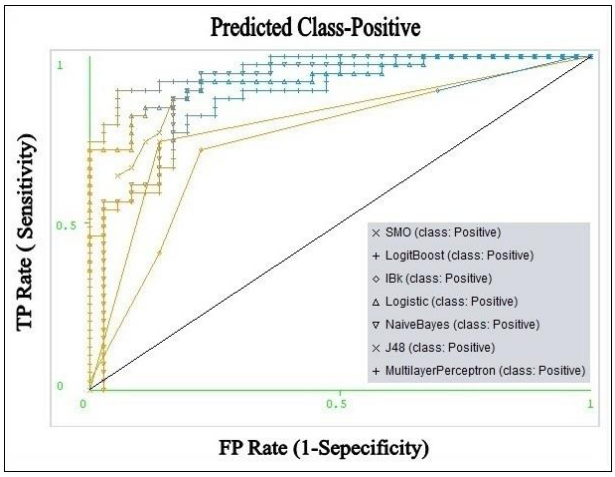


Figure 6: ROC for seven machine learning techniques tested for the positive case.

and distributed computing that reduced the computing cost and processing time.

In the future, one can use huge datasets with more related clinical parameters for their experiments and improvement of model accuracy as mention in the data classification section [10].

8 Conclusion

Dengue disease patients are increasing rapidly and actually, dengue has recorded in every continent today according to the World Health Organisation (WHO) record. Dengue outbreak prediction may save the life of people and can have valuable effectiveness on their diagnostic. This effort gives a work process established on machine learning techniques for the forecasting of the negative case or the positive case of dengue outbreak.

The prime focus of the research is toward prediction of dengue outbreak using WEKA tool. In this research article, seven prominent machine learning techniques have been applied and eight parameters are used for performance evaluation.

It has been concluded that LogitBoost ensemble model is the topmost performance classifier techniques that it has reached a classification accuracy of 92% with sensitivity and specificity of 90 and 94 % respectively and ROC area=0.967, and had the lowest error rate.

We have compared the accuracy rate of our analysis with other published results in Table 4. Based on our comparative analysis result using LogitBoost ensemble model as well as the Random forest classifier used by Fathima et al, (2015) [5] result concluded that ensemble model performs better than individual classifier (Table 4).

Furthermore, we are desirous to enhance the model accuracy with more related expressed and sensitive clinical features on a huge amount of dataset in future and as well as we are also interested to develop a web-based tool that helps doctors to take a decision with more accurate dengue outbreak.

List of abbreviations

DEN	: Dengue
DF	: Dengue Fever
DHF	: Dengue Haemorrhage Fever
DSS	: Dengue Shock Syndrome
CSV	: Comma Separated Values
WBC	: White Blood Count
ANN	: Artificial Neural Network
SVM	: Support Vector Machine
SMO	: Sequential Minimal Optimization
ADT	: Alternating Decision Tree
NB	: Naive Bayes
RF	: Random Forest
MNB	: Modified Naive Bayes
MFNN	: Multilayer Feedforward Neural Network
ROC	: Receiver Operative Characteristics

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Performance Analysis of Modified Shuffled Frog Leaping Algorithm for Multi-document Summarization Problem

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Due to massive growth of Web information, handling useful information has become a challenging issue in now-a-days. In the past few decades, text summarization is considered as one of the solution to obtained relevant information from extensive collection of information. In this paper, a novel approach using modified shuffled frog leaping algorithm (MSFLA) to extract the important sentence from multiple documents is presented. The effectiveness of MSFLA algorithm for summarization model is evaluated by comparing the ROUGE score and statistical analysis of the model with respect to results of other summarization models. The models are demonstrated by the simulation results over DUC datasets. In the present work, it elucidates that MSFLA based model improves the results and find advisable solution for summary extraction.

Povzetek: Na bazah dokumentov je bil uporabljen nov algoritem MSFLA za generiranje povzetkov dokumentov.

1 Introduction

Present days, growing of information exponentially in Web initiates information overload problem. As a result automatic text summarization (TS) has increasing value to various real-world applications. TS summarize information from single or multiple documents which share an explicit or implicit main topic. It facilitates users to quickly catch the most relevant and important information through large text data collections. Shortening of a large text document or documents into a concise form is called as single or multi document summarization respectively. As multi-document summarization processes multiple documents, therefore search space of multi-document summarization is large and considered as an enlargement of single document summarization. Hence it makes more challenging for selection of important sentences. In that context, summarization of multiple documents can be recognized as an optimization problem with the objective of producing optimal summary containing relevant and informative sentences of the original input documents [1].

As a challenging issue for text mining, automatic document summarization had been well-studied during half a century years [2]. The great majority of numerous approaches developed are extraction-based, which produce a summary using only existing sentences (or text fragments) extracted from the original text, so they are conceptually simple and more practicable compared to abstractive methods, which attempt to reproduce sentence by using complicated natural language generation techniques such as sentence compression [3] information fusion [4] and reformulation [5].

In literature, many evolutionary computation based contributions have been suggested for sentence selection from huge collection of information. The domain is already rich with the proposal of many evolutionary based summarization models development such as (GA),differentia evolution(DE), particle swarm optimization(PSO), harmony search (HS), cat swarm optimization(CSO), cuckoo search (CS) etc. In few cases these techniques suffers from premature convergence and gets trapped into its local optima. The focuses have to be exploitation and exploration abilities of these evolutionary algorithms. Further to improve the performance motivations have to be made on population diversity in the progressive procedure and a sophisticated approach for information sharing among each participant in the distribution. To overcome these issues an evolutionary approach called Shuffled frog leaping algorithm (SFLA) is proposed.

There are many applications in which shuffle frog leaping algorithm is applied. A detail description is highlighted as follows.

Tarun et.al. [6] applied opposition based leaning to improve the global search of SFL algorithm. It not only improves the local search but also improves its diversity. This technique is experimented on 10 benchmark optimization function, 10 shifted function (from CEC2005) and on cost management problem in cellular network.

Dalavi et.al [7] proposed a modified SFL algorithm for hole making operation in plate of ejector mould. Many kinds of machining operations are required for hole making operation. Implementing this technique the optimal sequence of operation is identified minimizing cost for hole making operation.

An improved SFL algorithm (ISFL) is proposed by Dash et.al. [8] for currency rate prediction problem. In this technique the author has tried to improve the local and global search process. This technique introduces a new frog leaping rule with the acceleration factor and leaping inertia components. The experimental result is compared with simple SFL algorithm and based PSO and the result shows the superiority of ISFL algorithm in terms of both convergence rate and predictor accuracy.

In [9], Kaur et.al. applied an augmented shuffle frog leaping (ASFLA) approach for resources provisioning work flow scheduling infrastructure as service cloud computing environment. For task scheduling ASFLA tries to minimize the execution time and transfer time among dependent task. This approach is compared with simple SFL and PSO and a significant improvement is observed using ASFLA.

A simulated shuffle frog leaping algorithm (SSFLA) is suggested by Amirian et.al [10] for grey scale project selection scheduling in tri-objective grey environment. Implementing time limit, budget constraint and multiple objectives, a modified grey shuffle frog leaping algorithm is proposed. This technique is compared with non-dominated sorting genetic algorithm (NSGA-II) and multi objective PSO to solve this NP hard problem.

In [11], the author has stated that SFLA is a novel meta-heuristic approach, applied in many combination problem. However in continuous optimization problem the algorithm falls in local optima. Thus author has proposed a variant of SFL called levy flight based shuffle frog leaping algorithm. The effectiveness of this technique is explored using 30 benchmark function and six continuous optimization functions. As a stochastic search based learning technique, Sharma et.al.[12], has suggested a varient of shuffle frog leaping algorithm called as centroid mutated SFLA for both discrete and continuous optimization problem.

Bhattacharjee et.al.[13] proposed a modified discrete shuffle frog leaping algorithm for 01 knapsack problem. This technique is extensively investigated taking considering large number of experimental studies. Due to its discretization property, performance shows a remarkable growth for small as well as medium sized knapsack problem and as an alternative solution for large knapsack problem.

Inspired from the successful implementation of SFLA in many application areas as an optimization approach, in this study a novel Modified Shuffled frog leaping algorithm based multi document summarizer is presented. MSFLA aims to maximize content coverage criteria while reducing redundancy and preserving length of the summary. The effectiveness of the proposed model has been evaluated with respect to particle swarm optimization (PSO), cuckoo search (CS) and standard shuffled frog leaping algorithm over DUC datasets. From the experimental results, it is clearly observed that MSFLA based multi document summarizer outperforms than conventional PSO, CS and SFLA based summarizer.

The rest of the paper is organized as follows. The detail of Shuffled frog leaping algorithm is presented in Section 2. In Section 3, Modified Shuffled frog leaping algorithm has been discussed. A detail framework for multi-document extractive summarization using MSFLA is presented in Section 4. The summary evaluation criteria and empirical study for performance analysis are discussed in Section 5 and 6 respectively. Finally conclusion is highlighted in Section 6.

2 Shuffled frog leaping algorithm

The Shuffled Frog Leaping Algorithm (SFLA) is a recent population based meta-heuristic algorithm. It incorporates both the benefits of memetic algorithm and social behavior of particle swarm optimization (PSO) algorithm. In SFLA (Figure 1), the population is a group of frogs, which are seeking for best available foods using search guidelines related to PSO algorithm. With the aim to search for food, the entire search process can be carried out by alternating communication of frogs in intra-cluster and inter-cluster. The intra-cluster communication performs within a memeplex for local invention and the inter-cluster communication performs between the frogs belongs to different memeplexes for global exploration. In traditional SFLA, assume that the initial population is generated randomly of P solutions (frogs). For each individual frog, evaluate fitness value. Afterward, sort the P in descending order of their fitness value. Then entire frogs are distributed into M number of memeplexes and each memeplex contains N frogs. In this process, the distribution of frogs is done in such a way that the first frog goes to first memeplex, second goes to first memeplex, frog M goes to M^{th} memeplex, and frog M+1 goes to first memeplex, and so on till the last frog [14,15].

Within each memeplex, the best and the worst frog according to their fitness are represented as X_b and X_w. The frog having global fitness is denoted as X_g. The location of worst frog is updated either based on location of local best frog or global best frog or randomly to a position, so that the frogs can move towards the optimal solution. The updating measure is as follows:

$$X_w(new) = X_w + Stp \quad (1)$$

$$Stp = rand() \times (X_b - X_w) \quad -Stp_{\max} \le Stp \le Stp_{\max} \quad (2)$$

Where Stp is frog leaping step size of range [-1, 1]. $rand()$ is a random number between [0, 1]. If $X_w(new)$ produced a better solution, it replaces X_w. Otherwise, the calculation in Equation (1) and (2) are repeated by replacing X_b with X_g. If there is no improvement in such situation, then a randomly generated new solution is replaces to X_w. Thereafter all the memeplexes are shuffled together to exchange information and generate new population for next search space.

3 Modified SFLA

Even though the advantage of traditional SFLA such as its simple structure, fewer number of controlling parameters and simple realization of algorithm, the algorithm have some limitations. In traditional SFLA, initial generated population is not uniform. Due to that reason diversity and searching ability of population decreases, and in local

searching process only it updates worst solution without updating the best solution. Therefore it has a negative influence on convergence speed of algorithm and solving precision. Hence to improve the performance of SFLA, a modified version of SFLA (MSFLA) is suggested in this work [8,16-18]. In MSFLA, the frog leaping step size is controlled by inserting search learning coefficient S with inertia component to change present movement status of frog during local search. The leaping rule discussed in equation 1 and 2 is modified and presented in equation 3 and 4.

$$X_w(new) = X_w + Stp \tag{3}$$

$$Stp = \phi \times Stp^{t-1} + S \times rand() \times (X_b - X_w) - Stpmax_{max} \tag{4}$$

Where, S is search learning coefficient (i.e. *S* is any constant but greater than one) to scale the frog's step size during local search process. If *S* contains a big value, leads premature convergence or results in missing of the local search producing only random search with little improvement. In equation 3 and 4, the leaping step size *Stp* at any instance t depends on frog's leaping step size with worst position in previous iteration. The objective of introducing inertia weight φ is to balance in the search process. It assumes that the greater inertia weight offers exploration while a smaller one raises the local exploration. Instead of considering a fixed inertia weight value, it is decreased repeatedly from a greater to smaller specified value [19, 20].

4 MSFLA framework for multi-document extractive summarization

4.1 Modeling the summarization problem as MSFLA problem

In order to model the summarization problem as MSFLA problem, each sentence is represented as a frog. Originally the source input *SI* contain number of individual documents i.e., $SI = \{DC_1, DC_2, \text{K}, DC_m\}$ and each individual document *DC* is segmented separately as $DC = \{S_1, S_2, \text{K}, S_n\}$, where m and n represents the number of documents and sentences in each document respectively. The number of currently available resources or sentences in the input document to the optimization problem determines the search space that allowed the frog to move in search of food or important sentence selection. In this problem, the weight of each sentence is represented

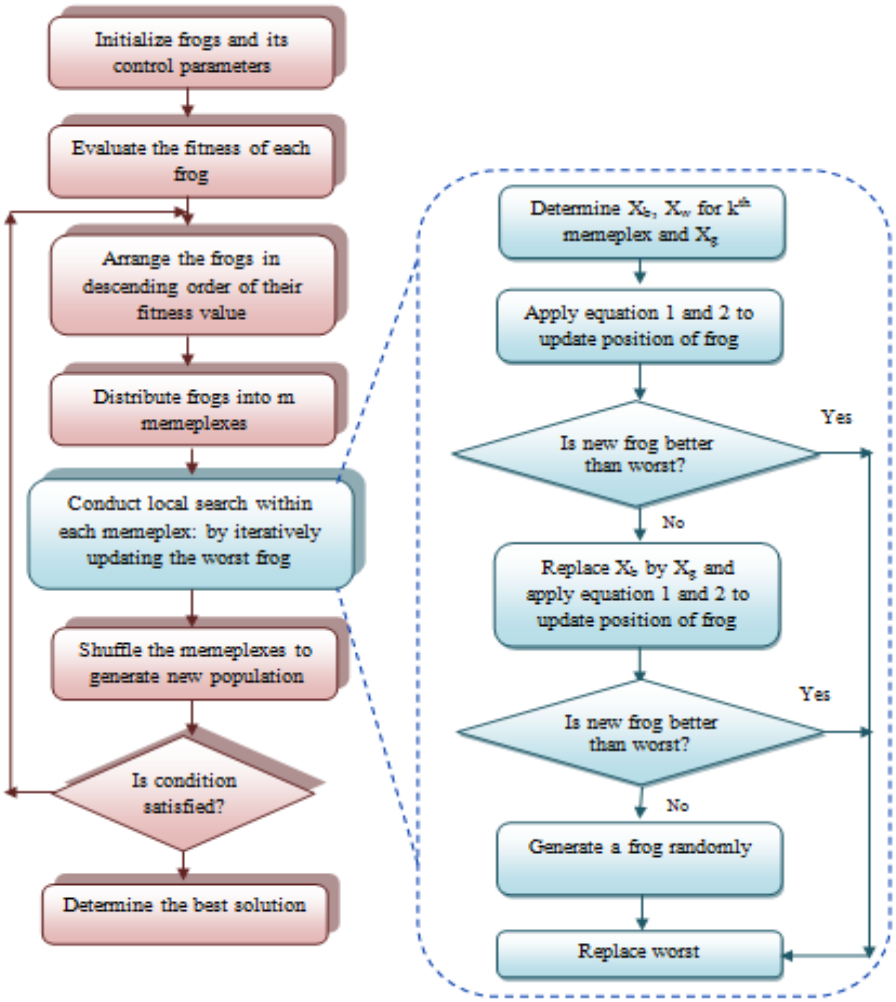

Figure 1: Flow chart of SFLA.

as the position of frog and it needs to be optimized to improve the searching process.

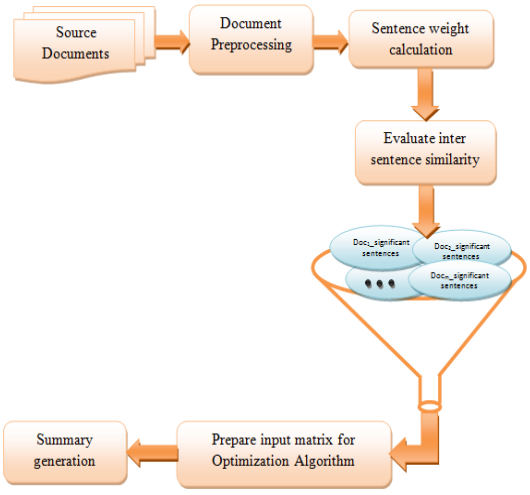

Figure 2: Proposed document summarization framework.

4.2 Overview of proposed summarization approach

The proposed framework of document summarization is illustrated in Figure 2. Primary objective of this approach is to generate a document in summarized form, from a set of input documents. First of all, for each document, sentences are segmented and each term of that sentence is tokenized followed by removal of stop word and stemming. Next, modified term frequency and inverse document frequency $(MTfIdf)$ is applied to compute weight of each sentence (Wtsen). For evaluation of inter sentence similarity, the most widely used cosine similarity metric is used. Once the similarity matrix is created, a similarity threshold is employed to select significant sentences from each document. Thereafter all significant sentences are merged into a document and their respective sentence weights are used to prepare input matrix for optimization algorithm. Finally, by comparing with summary threshold the top weighted sentences are selected to generate summary.

4.3 Detailed steps of proposed approach using MSFLA

Step 1: Set input documents SI, where $SI = \{DC_1, DC_2, \text{K}, DC_m\}$. *Each* DC_i *represents individual document of set SI. Each* DC_i *is represented in terms of number of sentences.*

Step 2: Preprocess each text document DC_i *through the following sub-process.*

Sentence segmentation: Read the text document and represent as segmented sentence S individually.

Tokenization: Read the sentence and terms of each sentence are tokenized as $TM = \{tm_1, tm_2, \text{K}, tm_p\}$, *where* tm_k *for k=1,2, …, p.*

Stop word removal: The word which has less important significance with respect to the document is removed such as 'a', 'an', 'the' etc.

Stemming: Eliminate suffix part of the word into its common base form.

Step 3: Calculate the sentence weight (Wt_{sen}) *for each sentence* S_j *of the preprocessed document* DC_i *using weighted sum of modified weighting scheme of term frequency and inverse document frequency* [21], *illustrated in equation* (5).

$$Wt_{sen} = MTfIdf_{tm,DC} = MTf_{tm,DC} \times Idf_{tm} \tag{5}$$

$$MTf_{tm,DC} = \frac{Tf_{tm,DC} \times \log\frac{\sqrt{Tc}}{Tt}}{\log\left[\left(\sum_{tm=1}^{p} Tf_{tm,DC}^2\right) \times \left(\frac{DC_{len}^2}{\sqrt{Tc}}\right)\right]} \tag{6}$$

$$Where \quad Tt = \sum_{DC=1}^{SI} Tf_{tm,DC} \qquad Tf_{tm,DC} > 0$$

$$and \quad Tc = \sum_{DC=1}^{SI} \sum_{tm} Tf_{tm,DC}$$

$Where \quad Tf_{tm,DC} - occurances of \ term tm \ in \ document DC$

$Tt - raw \ frequency of \ term tm \ with \ respect to \ all \ document collection$

$Tc - number of \ distinct terms \ in \ the \ document collection$

$DC_{len} - length of \ the \ document DC$

$$Idf_{tm} = \log\left(\frac{SI}{DF_{tm}}\right) + 1 \tag{7}$$

$$DF_{tm} = \sum_{DC=1}^{SI} \begin{cases} 1 & tm \in DC \\ 0 & tm \notin DC \end{cases}$$

$where \quad SI = Total \ number of \ documents$

Step 4: Evaluate sentence-sentence similarity for the preprocessed document DC_i *using cosine similarity metric.*

Step 5: For each DC_i, *select least similar sentences based on a similarity threshold value.*

Step 6: Select all least similar sentences of each DC_i *and merge to represent as a single document* DC_{input}.

Step 7: Set sentence weight of DC_{input} *as frog information to the MSFLA.*

Step 8: Evaluate fitness value of each frog.

Step 9: Arrange the frogs in decreasing order of their fitness value.

Step 10: Distribute entire frogs into M number of memeplexes and each memeplex contains N frogs such that $P = M \times N$. *In this process, the distribution of frogs is done in such a way that the first frog goes to first memeplex, second goes to first memeplex, frog M goes to* M^{th} *memeplex, and frog M+1 goes to first memeplex, and so on.*

Step 11: For each memeplex, do step 12.

Step 12: Local search (until iterative steps for each memeplex is not reached):

Step 12.1: Within each memeplex, determine the frog with best and worst position such as X_b *and* X_w. *determine the frog with global best position* X_g *with respect to entire frog population.*

Step 12.2: Evaluate new position of the worst frog by exchanging information within memeplex by using equation (1).

Step 12.3: If fitness value of $X_w(new)$ *is better than current one,* X_w *is replaced by the new one. Go to step 12.*

Step 12.4: Otherwise, evaluate new position of the worst frog by exchanging information between memeplex using equation (1). But in this case, X_b *is replaced by* X_g *in equation (1).*

Step 12.5: If fitness value of $X_w(new)$ *is better than current one,* X_w *is replaced by the new one. Go to step 12.*

Step 12.6: Otherwise, if resulting leap does not produced any improvement of the worst frog, then new position is generated randomly. Go to step 12.

Step 13: Shuffle the frogs of all memeplexes as new frog population.

Step 14: The parameters S *and* φ *are adapted at t number iteration as follows:*

$$S(t) = S_{low} + (S_{high} - S_{low}) \times t / total\ number\ of\ iteration \quad (8)$$

$$\varphi(t) = \varphi_{low} + (\varphi_{high} - \varphi_{low}) \times t / total\ number\ of\ iteration \quad (9)$$

Step 15: Finally, the frog with best fitness value is considered as candidate summary sentences.

Step 16: Select summary sentences chronologically from the document set based on their threshold by comparing with candidate summary sentences.

5 Summary evaluation criteria

The objective function *f* of proposed model is prepared in such a way that it maximizes coverage criteria while reducing redundancy and preserving length of the summary. Therefore, the authors have tried to form a summary from a set of documents with the objective of content coverage, non-redundancy and length. The summarization problem can be formalized as follows:

$$f = \sum_{i=1}^{m-1} \sum_{j=i+1}^{m} \begin{bmatrix} Sim(DC, S_i) + Sim(DC, S_j) \\ - Sim(S_i, S_j) \end{bmatrix} x_{ij}, \quad (10)$$

$$such\ that\ len(S_i)\ and\ len(S_j) \le L, \quad (11)$$

$$x_{ij} \in [0,1] \quad \forall i, j$$

$$Sim(S_i, S_j) = \frac{\sum_{k=1}^{p} w_{ik} w_{jk}}{\sqrt{\sum_{k=1}^{p} w_{ik}^2 \cdot \sum_{k=1}^{p} w_{jk}^2}}, \quad (12)$$

$$i, j = 1, 2, \mathrm{K}, n$$

$$where\ w_{ik}\ or\ w_{jk}\ is\ weighting scheme\ assign to\ a\ term$$

In equation (10), the first two term guarantees that relevance of the summary and it covers main content of the document set. Whereas, the third term avoid multiple textual units, that convey the same information. The length of the summary is bounded by cardinality constraint, is discussed in equation (11).

6 Empirical study

This section introduces: 1) detail of benchmark dataset for evaluation of summary; 2) setting of controlling parameters during simulation; 3) describe the metrics to assess performance of the summary; 4) performance analysis.

6.1 Evaluation setup on the benchmark dataset

For the evaluation of proposed framework, the datasets from Document Understanding Conference (DUC) is used [22]. It is a benchmark data corpus for text summarization problem. This contains input documents along with few reference summaries. The DUC datasets i.e., DUC2006 and DUC2007 are distributed through ACQUINT, and used for this experimental study. DUC2006 and DUC2007 contains 50 and 45 different document clusters, each cluster contains 25 independent documents respectively. Each document cluster contains reference summaries of 250 words, which answers the question(s) in the topic statement.

6.2 Parameter setup

The setup of control parameters of any optimization algorithm is application oriented and no fixed value is assign to these parameters. Therefore derivation of parameters is obtained through number of simulations. In this study, the experimentation has been conducted taking the population size 50 to 200 and fixing the number of memeplex 10. Initially the memeplex are upgraded with 10 number of iteration. However, after 8 iterations no such remarkable upgradation has been observed. Here the author has added the optimal environment setup for considered application. The controlling parameters of MSFLA algorithm such as: size of population (SP) is 160, memeplex size (m) is 10, iterative steps for memeplex (im) are 8, number of iteration (it) is 50,search learning coefficient and inertia weight are decreasing value of range [1,1+rand()] and [0,1] respectively.

6.3 Performance evaluation metrics

The comprehensive performance study of MSFLA based summarizer has been conducted over DUC dataset and evaluated by ROUGE [23, 24]. ROUGE stands for Recall-Oriented Understudy for Gisting Evaluation. It is used as the official evaluation metric for text summarization. A set of metrics such as ROUGE-L, ROUGE-N, ROUGE-S, ROUGE-W and ROUGE-SU are available in ROUGE to evaluate system generated summary against a set of reference summaries. In this study, ROUGE-N metric is used to match between system generated summaries and reference summaries.

$$ROUGE - N = \frac{\sum_{Sen \in Reference_{summary}} \sum_{N-gram \in Sen} Count_{match}(N-gram)}{\sum_{Sen \in Reference_{summary}} \sum_{N-gram \in Sen} Count(N-gram)} \quad (13)$$

Where N is contiguous sequence of terms, count match is the highest number of N-grams co-occurring in

system summary and reference-summaries. Count is the number of contiguous sequence of N-terms in the reference summaries.

6.4 Result analysis

The summary result has been evaluated by ROUGE-N score with N is 1 and 2 i.e. ROUGE-1 (R1) and ROUGE-2 (R2) metrics. ROUGE-1 and ROUGE-2 refers to word wise comparison and two words comparison at a time between the system summary and the reference summaries. Based on content coverage, anti-redundancy and length of summary ROUGE-N is calculated. A model producing higher ROUGE score reveals higher similarity of the system generated summary with respect to the original input document sets. Table 2 shows the ROUGE score obtained by proposed summarization model. ROUGE-1 score of all summarizer are falling within the range 0.41 to 0.44 and with respect to ROUGE-2 it is within the range 0.07 to 0.16 for DUC 2006 and DUC2007 dataset respectively. The statistical analysis in term of min (Min), average (Avg) and standard deviation (Std) are observed in Table 2 and Table 3 out of 20 independent runs for the MSFLA, SFLA, CS and PSO algorithm on DUC 2006 and DUC 2007 dataset respectively. In comparison with models illustrated in Table 1, it can be

Methods	DUC 2006		DUC 2007	
	ROUGE-1	ROUGE-2	ROUGE-1	ROUGE-2
PSO	0.4112	0.0784	0.4096	0.0762
CS	0.4311	0.1398	0.4243	0.1034
SFL	0.4320	0.1503	0.4317	0.1223
MSFLA	0.4408	0.1610	0.4358	0.1412

Table 1: ROUGE score of proposed summarizers on DUC2006 and DUC2007 datasets.

ROUGE metric		PSO	CS	SFL	MSFLA
ROUGE 1	Min	0.3908	0.4042	0.4016	0.4119
	Avg	0.4029	0.4142	0.4133	0.4228
	Std	0.0076	0.0087	0.0091	0.0096
ROUGE 2	Min	0.0487	0.0701	0.0811	0.1094
	Avg	0.0602	0.0890	0.1163	0.1305
	Std	0.0106	0.0210	0.0282	0.0186

Table 2: Performance comparison of proposed summarizers on DUC2006.

ROUGE metric		PSO	CS	SFL	MSFLA
ROUGE 1	Min	0.3916	0.4000	0.4053	0.4162
	Avg	0.3996	0.4119	0.4219	0.4270
	Std	0.0060	0.0074	0.0097	0.0061
ROUGE 2	Min	0.0643	0.0803	0.1011	0.1211
	Avg	0.0704	0.0944	0.1134	0.1337
	Std	0.0046	0.0082	0.0077	0.0073

Table 3: Performance comparison of proposed summarizers on DUC2007.

Methods	DUC 2006		DUC 2007	
	ROUGE-1	ROUGE-2	ROUGE-1	ROUGE-2
PSO	7.19	105.35	6.39	85.30
CS	2.25	15.16	2.71	36.55
SFL	2.03	7.11	0.94	15.45

Table 4: Relative Improvement comparison of MSFLA based summarizer and other summarizer with respect to ROUGE-1 and ROUGE-2.

realized that MSFLA based summarizer reveals the result based multi-document summarizer outperforms than other

Methods	DUC 2006		DUC 2007	
	Avg	95% CI	Avg	95% CI
PSO	0.4029	[0.399569, 0.406231]	0.3996	[0.396748, 0.402452]
CS	0.4142	[0.410387, 0.418013]	0.4119	[0.408382, 0.415418]
SFL	0.4133	[0.409312, 0.417288]	0.4219	[0.417289, 0.426511]
MSFLA	0.4228	[0.418593, 0.427007]	0.4270	[0.4241, 0.4299]

Table 5: Average (Avg) values of ROUGE-1 scores and confidential interval of methods.

Methods	DUC 2006		DUC 2007	
	Avg	95% CI	Avg	95% CI
PSO	0.0602	[0.0555, 0.0648]	0.0704	[0.068213, 0.072587]
CS	0.0890	[0.0798, 0.0982]	0.0944	[0.090502, 0.098298]
SFL	0.1163	[0.103941, 0.128659]	0.1134	[0.10974, 0.11706]
MSFLA	0.1305	[0.122348, 0.138652]	0.1337	[0.13023, 0.13717]

Table 6: Average (Avg) values of ROUGE-2 scores and confidential interval of methods.

of other summarizers on both the datasets.

Furthermore, the validity of MSFLA based summarizer is verified by obtaining relative improvement of MSFLA based summarizer over other methods in terms of ROUGE score. The relative improvement comparison is calculated using the following formula.

$$\frac{(MSFLA\ based\ result - other\ summarizer\ result)}{other\ summarizer\ result} \times 100 \qquad (14)$$

Where $other\ summarizer\ result$ includes PSO, CS or SFLA based summarizer.

From the analysis of results it is clearly observed that, the performance of proposed method based on MSFLA based summarizer is providing consistent result for the given scenario.

Thereafter a statistical significance test has been conducted at the 5% significance level of the summarization results [25].The average values and 95% confidence interval (CI) of ROUGE-1 and ROUGE-2 scores of each method for DUC 2006 and DUC 2007 data sets are shown in Tables 5 and 6 respectively.

From Table 5 and 6, it is observed that the average values of ROUGE-1 and ROUGE 2 for MSFLA method on all data sets are better than that for the other methods.

7 Conclusion

This paper attempts to present a MSFLA based multi-document summarizer. It highlights the implementation steps of MSFLA algorithm to optimize the sentence weight to generate summary from multiple documents. It is modified variation of standard SFLA. The application of PSO, CS and SFLA to extract sentences from multiple documents is also explored. Proposed summarizers are validated over DUC dataset. From the experimental analysis of ROUGE metrics and confidential interval of statistical significance test, clearly refer that the MSFLA summarizer models discussed in this experimental study.

The future study of this research work will be extended for the abstractive summarization problem. The performance of summarizer will also be compared with other competent nature inspired algorithms.

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Twitter-based Opinion Mining for Flight Service Utilizing Machine Learning

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Twitter is one of the most prominent social networking platforms so far. Millions of users utilize Twitter to share their thoughts and views on various topics of interest every day resulting a huge amount of data. This data could be considered to have a rich source of useful information hidden inside. Using machine learning to this data may give rise to effective recommender frameworks for individuals to manage their lives in a much more convenient way. In this paper, we propose a machine learning approach to classify the passenger's tweets regarding the airplane services to understand the pattern of emotions. We adopt Random Forest (RF) and Logistic Regression (LR) to classify each tweet into positive, negative and neutral sentiment. The evaluation of the collected real data demonstrates that these two methods are able to achieve an accuracy ≈80%.

Povzetek: Z metodami strojnega učenja so analiziranji tviti (čivki) letalskih potnikov o letalskih storitvah.

1 Introduction

At present, large scale companies are investing plenty of time, resources and energy to enhance the consumer's loyalty. It may explore more opportunities for the interaction between companies and consumers to get their feedback and suggestion about the products and services with an aspect of customer satisfaction and product quality improvement. This may increase the both the economic and social development of the company. A crucial but challenging step is to automatically analyze the customer feedback by extracting useful information from the huge data of customer feedbacks [1]. Customer feedback data is very important in addressing several issues and sentiment and opinion analysis is one of the important issue among them. Extracted patterns from the data may be utilized by company experts to understand the polarity of the opinion towards different products and services. In general the polarity of opinion may be positive, negative or neutral. Companies may use these polarity of opinions in order to improve their quality of products and/or services.

Sentiment analysis/opinion mining assists in answering different question about products and services by understanding the emotions in the feedbacks [2]. Present world is utilizing the natural language processing (NLP) and text classification techniques to map the sentiments within the text into positive, negative and neutral classes [3].

The sentiments can be seen as an indirect publicity of a company's products and services in the world that provide a direct impact on other customer's. For travelers, the most popular and convenient platform for sharing their opinion is Twitter [4]. Each travel journey on different carriers may bring different comfort levels i.e. good, average or poor level of comfort. These comfort levels are conveyed to the social media i.e. Twitter etc. by the travelers in terms of tweets. If a traveler enjoyed the trip, the respective tweet would demonstrate the happiness or positive emotions towards the travel carrier otherwise negative emotions may be conveyed. Figure 1 depicts a furious tweet by a passenger on British Airways flight. As a result, the company considered it very urgent and important and settled the issue at the earliest. In another scenario (Figure 2), a sarcasm tweet for Indigo Airways

was fired because the baggage of passenger was transferred to a different location (Hyderabad) other than the traveler (Calcutta). The tweet in figure 2 seem to be negative from a human perspective whereas it is difficult to put this into negative class for the machine because of the complex words used in the tweet. Also, tweets on tweets may not contain more than 140 characters at once. Therefore, it is useless to expect the detailed information inside the tweet. However, a general understanding about polarity of emotions can be developed using machine learning methods. Further, tweets in the categories may be analyzed to get insights or possible reasons for these sentiments [5].

Every day more than a million of people are travelling around the world and tweeting their views with respect to the journey. It results in a huge amount of data available for analysis every day. Hence, machine learning techniques can be considered as a solution for such analysis. Machine learning techniques are efficient to handle huge data with large dimensions [6, 7].

Figure 1: A negative tweet illustrating loss of luggage.

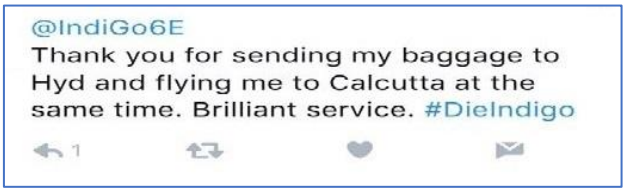

Figure 2: A tweet illustrating wrong transfer of luggage in sarcastic way.

The main motivation behind this work is to provide a better analysis for classification of sentiment from the tweet data in order to assist the airline companies to improve customer satisfaction and improve the quality of service. The organization of the paper is as follows: Section 2 provides the state of art literature review. In section 3, proposed work is discussed. Section 4 presents the experimental results and discussion which is followed by conclusion in section 5.

2 Literature review

Kusen et al. [8] analyzed a twitter data set consisting of 343645 tweets about 2016 Austrian presidential election. This analysis amalgamated approaches from sentiment analysis, network science, and bot detection. It was shown that the immediate relationship between the winners of the 2016 Austrian presidential races was more famous and had a high impact on Twitter than other rivals.

Ahmed et al. [9] have demonstrated how the first time twitter utilized as a campaign tool in the Indian election 2014 by different parties. They demonstrated computer-aided and multi-level manual analysis of 98363 tweet messages by 11 parties during the campaign. It had a high impact on twitter of winning party than other parties.

Stigleitz et al. [10] examined whether opinion persisting in online networking content is related to a client's data sharing coordination. They conducted an examination with regards to political correspondence on Twitter. On the basis of two dataset collections of about 165,000 tweets altogether, they found out that candidly charged Twitter messages had a tendency to be retweeted all the more regularly and more immediately contrasted with biased ones. As a general suggestion, organizations should give careful consideration to the examination of opinion identified with their brands and items in social networking correspondence, in addition to planning promoting content that triggers emotions.

Gunarathne et al. [11] investigated the objection resolution experience of passengers of U.S. aircraft, by utilizing an interesting data collection amalgamating both customers– brand cooperation's on Twitter and how clients felt toward the end of these associations. They located that objection Customer who is more dominant in online networking communities will probably be fulfilled. Customers who have beforehand objection to the brand via social networking media and customers who grumble about process-related instead of result related issues are less inclined to feel better at last. To the best of our insight, this examination is the first to recognize the key factors that shape client sentiments toward their brand– client communications via social networking media. Their outcomes give useful direction to effectively settling clients' objection using social networking field that expects exponential development in the coming decade.

Seunghyun et al. [12] showed social networking examination utilizing Twitter data alluding to cruise travel. This examination likewise incorporated an inside and out an investigation on tweets by three kinds of group users: private, commercial and blogs. The outcomes demonstrated that not exclusively were words identified with industry, travel, emotions, and destination most often utilized as a part of organizing tweets, but also proficient bloggers, cruise lines, celebrities and travel organizations really drove significant subgroups on cruise themes on Twitter. On the basis of such outcomes, this examination gives attainable marketing approach.

3 Proposed work

In this section, our proposed model consists of several steps like preprocessing, feature extraction etc. in order to train the model and use the test dataset to check the evaluation metric on the test dataset. Precision, F1-measure, and Recall are used as an evaluation metric.

3.1 System architecture

Proposed architecture can be seen in the figure no. 3 that how flow started of our model from the dataset, text pre-processing, feature extraction, a division of dataset into training and testing set, the trained model then tested on the test dataset.

3.2 Text preprocessing

As a pre-processing step, we do a basic statistical analysis on the collected data. The statistics include the number of words (denoted as word_counts), the number of hashtags (denoted as hashtag_counts), and counts for other punctuation marks.

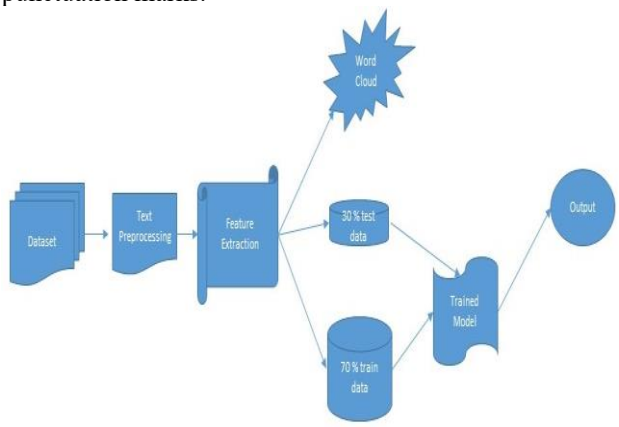

Figure 3: Architecture of Proposed Sentiment Analysis Model.

The distribution of those textual variables over the three sentiment classes is shown in Fig 4.

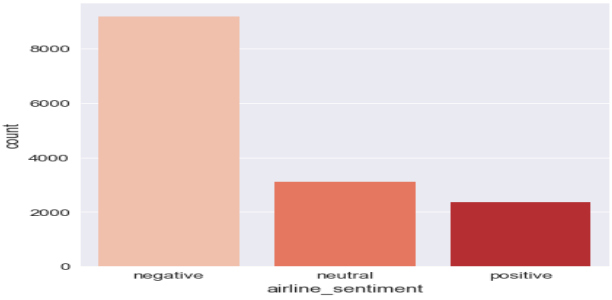

Figure 4: Distribution of Class Labels

We then remove the hashtags, mentions, URLs etc= to make text data more clean for further analysis. We also removed punctuations, stop words and digits. Finally, we stem words and convert them to lowercase. This is the standard procedure for pre-processing textual data. The examples of tweets after pre-processing can be seen in Figure 5.

```
13892    pilot told us would release bags well offer hotel vouchers neither happened
8817     always happy help
6270     wanted southwest know think great used anymore nothing look
420      helping step game tindertips tinderchamp
7170     no come
7529     landing usual great flight wiyh great crew hello sunny west palm beach jetbluerocks
10131    please thank mellie cae tammy baggage claim clt excellent customer service day complaint
609      worstunitedflightsever ua iad las mechanical problems switched aircraft delayed hours
12166    sounds like date
4232     next flights miami another airline
Name: text, dtype: object
```

Figure 5: A sample of preprocessed tweets.

3.3 Random forest

Decision Trees are the most widely used machine learning methods. Random Forest provides an effective way of averaging several decision trees, trained in different segments of the same training dataset with the aim to deteriorate the variance and provide a stable and accurate prediction. Random forest could be an ensemble learning procedure for regression, classification, and elective undertakings, which is achieved by building a large group of decision trees at training phase and provoking the classes which are the model for the mean prediction (regression) or classifications (classes) of the distinctive trees. In a distinct computation, classification is implemented recursively until every leaf is pure. The aim is to dynamically predict the best decision tree until it catches up the adaptability, precision, and balance. There are three measures to split the node are shown in Eq. 1-3.

$$Entropy = \sum_j P_j \log_2 P_j \quad (1)$$

$$Gini = 1 - \sum_j P_j^2 \quad (2)$$

$$Classification\ Error = 1 - max\ P_j \quad (3)$$

Where P_j is the probability of class j.

The algorithms starts as follows: we pick a bootstrap observation from the S in which $S^{(i)}$ represents the i^{th} bootstraps for every tree in the given forest. Then train the decision tree utilizing a revised decision tree algorithm. The revised decision tree algorithms as follows: in contrast of analyzing all feasible feature split, some random features f ⊆ F, at every node of the tree where F is the feature sets. The given node split on the top features in f comparably than selecting F. In this, f is much more compact and smaller than F. The most challenging task is to choosing on which feature to split in the decision tree learning that is why making narrow the feature set makes faster learning. The pseudocode is given as follows:

Algorithm Random Forest

Precondition: A training set $S := (x_1, y_1), \ldots, (x_n, y_n)$, features F, and number of trees in forest B.

```
function RandomForest(S, F)
    H ← ∅
    for i ∈ 1, ..., B do
        S^(i) ← A bootstrap sample from S
        h_i ← RandomizedTreeLearn(S^(i), F)
        H ← H ∪ {h_i}
    end for
    return H
end function
function RandomizedTreeLearn(S, F)
    At each node:
        f ← very small subset of F
        Split on best feature in f
    return The learned tree
end function
```

3.4 Logistic regression

Logistic Regression is a statistical method for investigating a dataset in which there are at least one or more than one independent variables that decide a result. The result is estimated with a dichotomous variable (in which there are just two conceivable results). The objective of logistic regression is to locate the best fitting model to depict the connection between the dichotomous feature and the set of independent factors. Our Hypothesis function can be written like as given below,

$$Y = W^T X \quad (4)$$

A sigmoid function is implemented across the notable hypothesis function to keep into the range of (0, 1). The sigmoid function can be described as,

$$sg(y) = 1/(1+e^{-y}) \quad (5)$$

So our new hypothesis is

$$sg(y) = sg(W^T X) = 1/(1+e^{-WTX}) \quad (6)$$

Boundary Estimation:

Our new hypothesis function provides us the values in between 0 and 1so it can be clarified probability of y would be 1 for given X and this can be written in this form,

$$sg(y) = P(y = 1|x, W) \quad (7)$$

Cost Function:

Taking a square error function does not work from the transformed hypothesis function so we make a new form of cost function which is as follows:

$$E(sg(W, x), y) = -log(1-sg(W, x)) \text{ if } y = 0$$
$$E(sg(W, x), y) = -log(sg(W, x)) \text{ if } y = 1$$

Therefore, the mean of cost function will be as follows,

$$H(W) = \frac{1}{m}\sum_{i=1}^{m} E(sg(W, x\,i), yi) \quad (8)$$

Parameter Estimation:

We utilize an iterative approach known as Gradient Descent to enhance the parameters across every step and reduce the cost function to the most feasible value. Gradient Descent requires a convex cost function to avoid getting stuck in a local minimum at the optimization stage. We begin with irregular parameter values and update their values at every stage to reduce the cost function to some extent until we reach the lowest point or equivalently there are not any changes to the value of the target function. The gradient descent step is as follows,

$$\beta_{(i+1)} = \beta_i - p\,\frac{\delta H(W)}{\delta \beta i} \quad (9)$$

For every i =1, 2, 3…, n and p is the learning rate controlling the speed that it moves across the slope on the curve to reduce the cost function.

Above process can be shown in the pseudocode for logistic regression with L1 regularization. The procedure starts with providing input dataset D with corresponding labels and iteration numbers. In this, w_h is the temporary variable. Our algorithm start working as mentioned in the pseudocode.

Algorithm Logistic Regression with L1 regularization

```
procedure StochasticGradientDescent(D, Labels, Iter)
Input: Dataset D, Labels of Dataset, Iteration num
Output: optimal weight of logistic regression
    w ← [1, 1, ..., 1]
    Initialize q_i with zero for all i
    for k = 1 → Iter do
        chooseData = D
        for i = 1 → m do
            γ ← Learning Rate
            λ ← Regularization Lambda
            u = u + γλ
            Select a index of chooseData idx randomly
            x ← chooseData[idx]
            del chooseData[idx]
            for i ∈ featuresinsamplex do
                w_i = w_i − γ ∂loss(w,x_i)/∂w
                wh ← w
                if w_i > 0 then
                    w_i ← max(0, w_i − (u + q_i))
                else if w_i < 0 then
                    w_i ← min(0, w_i + (u − q_i))
                end if
                q_i ← q_i + (w_i − wh)
            end for
        end for
    end for
```

3.5 Evaluation metric

In order to measure the accuracy of classification [13], we used different parameters such as Recall, Precision, and F-measure [12]. Recall can be regarded as the measure of completeness whereas Precision can be seen as a measure of exactness. Formally, precision can be defined as the ratio of correctly classified instances of one class and a total number of instances classified in the same class, whereas recall is the ratio of correctly classified instances of one class and overall instances of the same class. Both precision and Recall can be calculated using the confusion matrix. Confusion matrix represents the number of correctly classified and incorrectly classified instances of all classes. Using the confusion matrix, all performance evaluation measures can be calculated. For a twitter dataset with a binary classification problem, if the total 600 tweets are classified to one class, among which 500 of them are correctly classified, and the total number of tweets in this class are 700. Then, the precision of the classifier is 500/600= 83.3%, and the recall of the classifier is 500/700=71.4%. The Recall and Precision are integrated to develop a new measure known as F-measure or F-score. The formula to calculate F-measure is given in Equation 12.

$$\text{Precision}=\frac{TP}{TP+FP} \quad (10)$$

$$\text{Recall}=\frac{TP}{TP+FN} \quad (11)$$

$$\text{F-measure}=2\left(\frac{Precision*Recall}{Precision+Recall}\right) \quad (12)$$

Where TP is True Positive, TN is True Negative, FN is False Negative and FP is False Positive.

4 Experiments

4.1 Data preparation

In this study, we experiment on the US Airlines 2016, which contains 14500 passenger tweets. Since the number of original features is too large, we manually select the textual based features, because are easily accessed by passengers. As can be seen from Figure 6, the class labels are highly unbalanced. The dataset is available for public use [14]. After the preprocessing step, we identified the top 30 frequent words in the dataset, which is shown in Figure 6.

4.2 Experimental analysis

For further evaluation, it is necessary to have test data that could be helpful to evaluate several measures of our model. Data was divided into 70 percent train and 30 percent test set Text count variable has been combined with cleaned data to create a data frame.

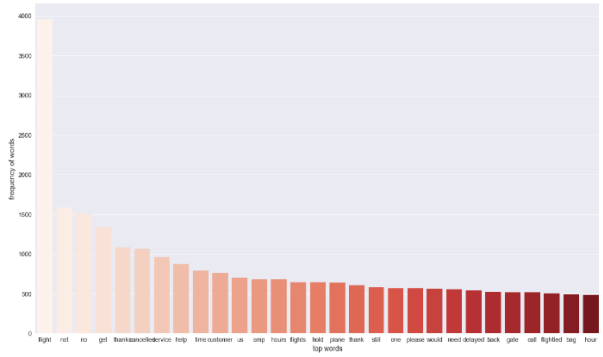

Figure 6: Top 30 most frequent words.

Figure 7: Distribution of Text Variables.

For opting better parameters, it is needed to assess on a different validation from training. By utilizing just a single validation set one might not deliver reliable validation result. To get a more precise estimation, cross-validation is performed.

In this study, we conduct k-fold validation on the data at hand and utilize GridSearchCV to search for the best-performed parameter combination. We select precision as the metric for optimization for both logistic regression and Random Forest classifiers. In order for bag-of-word features to be properly fed into classifiers, we use CountVectorizer to transform words into vectors. The word cloud in Figure 10 gives a decent visual depiction of the word recurrence for each kind of opinion, in which the left one corresponds to the positive opinion and the right one the negative. The span of the word relates to its recurrence across all tweets.

This figure gives us a rough idea of what passengers are discussing. For instance, for negative opinion, passengers appear to gripe about delayed of flight, cancellation of flights, the low-quality of the flight service, the hours holding up and etc. Be that as it may, for positive opinion, passengers are thankful and they discuss extraordinary administration/flight. A cloud of the word has been mentioned in Figure 10 to visualize those positive and negative tweets more properly.

Several other approaches have been used but Logistic Regression and Random Forest gave better result on train and test dataset. The main advantage of using Random Forest for text classification is that it ensemble multiple and different kinds of decision trees and utilize an assortment of the different trees to improve the result of the model.

4.3 Results and discussion

Our proposed model provided this result on the test dataset. As it can be seen that in the case of positive, negative or neutral categories, our proposed model can classify with high precision, recall and f-measures. After applying logistic regression and random forest on the dataset, the performance values are recorded in table 1 and table 2.

As from above tables, it can be seen that both classifiers performed very well, but Random Forest works better as compared to logistic regression, with a consistent higher value in Precision, Recall, and F-score than logistic regression. The 82 % accuracy value on the test data is superior to our predefined target, which is to the maximum value we can achieve by setting the prediction labels for all samples to be the dominant class. The precision is also high for all the three classes and the recall rate is relatively low for the neutral classes.

For better illustrating the effectiveness of our proposed models, we also present examples of some negative and positive tweets classified by our proposed approaches.

Model-predicted accurately like Negative, Negative in the first column and Positive, Positive for the second column based on the test set.

Sentiment Class	Precision	Recall	F1-Score
Positive	0.80	0.74	0.77
Negative	0.73	0.53	0.62
Neutral	0.83	0.93	0.88

Table 1: Evaluation Metric of Logistic Regression.

Sentiment Class	Precision	Recall	F1-Score
Positive	0.82	0.74	0.78
Negative	0.75	0.60	0.65
Neutral	0.84	0.95	0.90

Table 2: Evaluation Metric of Random Forest.

Negative Tweets	Positive Tweets
" @united It's a shame choosing #United may be the difference between reuniting with aging friends and never seeing them again #PoorService",	"@united Big thanks to Ms. Winston for assisting me over the phone with a baggage claim issue today. She really went the extra mile!"
"@united flight attendant doesn,Äôt understand not understanding English doesn,Äôt mean they are deaf. Stop yelling English slowly at them"	"@United THANK U! Secured room for the night Thx to VERY helpful customer service rep N. Dorns. I thanked her. Can u 2? #goodenoughmother"

Table 3: Sample of the classified data into positive and negative tweets.

5 Conclusion and future scope

This study tackles the sentiment classification problem by utilizing two machine learning models. On the collected data, we achieve an accuracy of 82%. This study has impacts on the aviation industry in that it provides an effective and efficient way to monitor the passengers' sentiments for aviation companies to improve their service. For future work, we would like to conduct a deeper analysis of the data and extract more useful information for providing recommendations for several airplane organization and passengers. It would be also used to use a bigger dataset than the used dataset because a larger dataset may provide some better result than used one. The author would like to use also deep learning models and especially focus on how to identify the sarcasm because there are several sentences seems positive but their meaning is negative so this is a really big issue to sort out and at present, existing models are not efficient to sort it out effectively.

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Mining Multi-Dimensional Intra and Inter-Association Patterns of Call Records for Targeted Advertising using Multi-Granulation Rough Sets

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Customer contacts to various businesses identified in telecom call records convey their interest in availing those services. Multi-dimensional attribute dependence with day and time of such communications generate useful insights for targeted advertising. Also, frequent and significant inter patterns of service associations give the probability that takers of one service may also be the prospects of the other. This work presents a multi granulation rough sets model to address the issue of prospect discovery from interest traits depicted in call records. The proposed method solves problems like higher computational complexity and large statistically insignificant patterns space inherent in traditional intra and inter-pattern mining methods. The algorithm is tested to generate target audience for food and restaurant business using one-month data of anonymous call records of a Thailand based telecom service provider. Some interesting mathematical properties of underlying knowledge structures are also validated.

Povzetek: Klici v tajsko restavracijo so analizirani z namenom iskanja učinkovitih tržnih vzorcev.

1 Introduction

Marketers face the challenge of reaching the right audience for product promotion. Similarly, telecom service providers have heaps of knowledge nuggets in the form of call records but face challenges in transforming data into revenue. The subscribers also want schemes and discounts on products or services. Thus, there is a need for transformation of raw data into knowledge to achieve three-way win-win situation. An enormous proliferation of databases in almost every area of human endeavor has created a high demand for new, powerful tools for turning data into useful, task-oriented knowledge. Data mining deals with the science of converting data into knowledge.[1] Under this discipline, multi-dimensional association patterns generate extra information about associated attribute values in the same transaction. Similarly, inter patterns find attribute dependence over a temporal span. In the context of call records, multi-dimensional association patterns with day and time of service called give knowledge of best day and hour for targeted marketing. Since in call records, each transaction corresponds to interest in one business, information about associated services over a temporal span can be found using inter patterns of such associations.

Various algorithms are proposed in the literature for Intra(association) pattern mining and Inter (sequential) pattern mining [2]–[5]. Feng, et al.[3] studied Multi-dimensional intra pattern mining with application to meteorological data and then further gave a rough set framework for mining generalized inter patterns and highlighted challenges with the setting of minimum support to measure pattern interestingness. Various variants like closed patterns, maximal patterns address the issues of efficiency and large result space of these methods.[2], [8]–[12] In all the above literature, pattern interestingness is measured using two metrics "Support (probability of the presence of an attribute in a database)" and "Confidence (conditional probability of attribute co-occurrence)" representing commonness and strength of attribute association. Only those patterns are interesting that cross minimum support and confidence pre-defined by the user.

However, recent research [13][14] highlights various flaws in the current framework for mining patterns by these metrics. Pattern pruning by using minimum support and confidence criteria generates both statistical Type I error (accepting spurious rules) and Type II errors (rejecting right association rules). The author illustrated that pruning using significance of dependence measure (t) with threshold >2 leads to all non-redundant patterns. Also, degree of dependence can be right criteria besides

support for measuring attribute dependence. The above metrics for pattern interestingness is especially applicable in the context of voluminous data of Call records to businesses since some attribute values are overrepresented, and some are underrepresented in call records and traditional support confidence based pruning will either filter prospects or generate enormous pattern space.

Most of the research in multi-dimensional intra and inter pattern mining is based on the *apriori* pruning systems. As per new research on interestingness measures generate both false positive and true negative implication relations. Parallel research in granular computing emphasize on data mining on granular structures which are abstract linguistic, natural language formulations on information spaces [15]. The theory gives a computing paradigm where information granule is a clump of objects drawn by indistinguishability, similarity and proximity of functionality[16]–[18]. Qian, Liang, Yao, & Dang extended Pawlak's Rough set model to multi-granulation rough sets. They presented several pivotal algorithms and provided a mechanism for problem-solving and rule extraction using multi-granulations. Yang et al.[15] illustrated theories related to hierarchical structures on partition based multi-granulation spaces. They presented optimistic and pessimistic rough set approximations of granular knowledge spaces which utilize a family of equivalence relations. The authors gave definitions of hierarchical structures on partition based multi-granulation spaces which create finer and coarser knowledge structures.

This work combines the research in pattern interestingness measures and rough sets based granulation and partitioning based knowledge structures to address issues in present multi-dimensional intra and inter pattern mining methods like higher algorithm time complexity and huge error prone pattern space of implication relations.

The idea originated from applications of conventional apriori- like methods for mining targeted audience for product promotion from previous calls to similar businesses. The proposed method solves the problem of call records based prospecting for services using the ideas of Multi-granulation partitioning and algorithms for generating lower approximation in MGRS (Multi-granulation Rough Sets). The proposed information retrieval system derives Intra patterns of most common and significant attribute dependence of day and Hour with the services under study. This knowledge is useful for identification of best Day an Hour for service-specific promotions. We further derive inter patterns of service associations. Knowledge on common and significant attribute dependence of services enables a potentially wider audience for service promotions. The method is tested to extract prospective customers for food and restaurant business (café, food ordering services, restaurant and bakery) by granular information of call records of anonymous subscribers of a telecom company of Thailand. Along with best day and Hour of promotion for all the food and restaurant business derived using multi-dimensional association rules; inter pattern mining is used to generate prospects for other related entertainment concepts like travel agencies, beauty salon and nightclub. Besides derivation of statistically valid implication rules that are directly usable for decision making the proposed rough set based intra and inter pattern mining method has lower time complexity and smaller result space than traditional methods. The paper also presents validation of mathematical properties of Multi-granulation knowledge structures so formed.

2 Preliminaries

This section explains some preliminary definitions and concepts underlying the problem addressed and underlying knowledge structures.

2.1 Call data records [19]

Given an information system of call records characterized by

$$U = \{X, B, A_1, A_2 \ldots\ldots A_k\} \quad \ldots(1)$$

X is the set of subscribers under study, B is the set of businesses for which prospects are desired; Ai's are other multi-dimensional attributes under study like day of call, hour of contact, subscriber location etc.

Each Ai is a set of attributes $A = \{a_1, a_2, \ldots\ldots a_m\}$; $V = \cup Va$, Va is the set of values of attributes $a \in A$; $f: X \times A \rightarrow Va$ is an information function

$$f(x, ai) \in Va \; \forall x \in X \text{ and } ai \in A \quad (2)$$

2.2 Concept hierarchy [20]

Let $Va' = \{a'_1, a'_2 \ldots\ldots a'_m\}$ be the domain of attribute set A' such that $ai \in A \subseteq a'i$ meaning A' is a set of linguistic of elements of A. Further, A'' can be further higher order attributes that define Va' as well creating hierarchical knowledge structures about Va. We create Knowledge base K with linguistic representations of attributes in U.

2.3 Rough set [16], [18]

Let $U \neq \emptyset$ be a universe of discourse. A is a family of equivalence relations on U, then the pair $K = (U, A')$ is referred as a knowledge base. If $P \subseteq A$' and $P \neq \emptyset$ then $\cap P$ (intersection of all equivalence relations in P) is also an equivalence relation, and will be denoted by IND(P). It is referred as an indiscernibility relation over P in Pawlak's rough set theory. $\forall R \in A$', we use U/R to represent the family of equivalence classes, which are generated from the equivalence relation R. Therefore, $\forall x \in U$, $x[R]$ denotes the equivalence class on R which contains x. Given $K = (U, A')$ be a knowledge base suppose $P \subseteq A$ then IND(P) is also an equivalence relation. Here, the attribute set A' is linguistic knowledge about A in U. For example, in case of transactions of call records, X represents the subscriber identification, the attribute A1 for interest that is the "called number" maps into the knowledge based as A1' that is the business Sub category called and other Ai's represent other taxonomical knowledge like business category, day of the calling, Hour of call etc.

2.4 Lower and upper approximation [16]

Let $K = (U, A')$ be a knowledge base $P \subseteq A$', then $\forall X \subseteq U$, the lower approximation and upper approximation of X are denoted by $\underline{P}(X)$ and $\overline{P}(X)$ respectively.

$$\underline{P}(X) = \{x \in U: [x]_P \subseteq X\} \quad (3)$$

$$\overline{P}(X) = \{x \in U: x_P \cap X \neq \phi\} \quad (4)$$

2.5 Multi-granulation rough sets [15], [21]

Multi-granulation rough sets are constructed by the family of equivalence relations leading to a family of granular spaces. Two possible constructs used in work are optimistic and pessimistic multi-granulation rough sets.

2.5.1 Optimistic multi-granulation rough sets

In optimistic multi-granulation lower approximation, in multi-independent granular space, we need only at least one of the granular spaces to satisfy the inclusion condition and the target. The upper approximation is defined as the complement of the optimistic multi granulation lower approximation.[15] [22] Let $K=\{U,A\}$ be a knowledge base, i.e. $R=\{R1,R2,..Rm\}$ in which $R1,R2,..Rm \in$ A, then $\forall X \subseteq U$, the optimistic multigranulation lower and upper approximations of X are denoted by

$$\underline{R}^{OPT}(X) = \{x \in U: \exists R_i \in R, [x]_{Ri} \subseteq X\} \quad (5)$$

$$\overline{R}^{OPT}(X) = \sim \underline{R}^{OPT}(X) \quad (6)$$

2.5.2 Pessimistic multi-granulation rough sets [15] [22]

In pessimistic multi-granulation rough sets, the lower approximation is approximated by a family of equivalence relation with the condition that all granular spaces satisfy the inclusion condition between the equivalence class and the target. The upper approximation of the pessimistic multi-granulation rough set is complement of the lower approximation of the pessimistic multi-granulation rough set.

$$\underline{R}^{PES}(X) = \{x \in U: \forall R_i \in R, [x]_{Ri} \subseteq X\} \quad (7)$$

$$\overline{R}^{PES}(X) = \sim \underline{R}^{PES}(\sim X), \quad (8)$$

2.6 Absolute support

Given $K=(U,A')$ be a knowledge base $P \subseteq A$' the support of each $a_i \in A'$ is the size of equivalence class formed on ai . Alternatively, support of an item is defined as the count of its occurrence in the database.

2.7 Degree of dependence [23]

In the real world data, it is quite common that some value combinations are overrepresented, while others are totally missing. In this situation, we cannot make any judgements concerning dependences between attribute sets, but still we can find significant dependencies. In the association rule literature, the relative difference is often defined via another measure called the *degree of dependence* (*dependence* [31], *degree of independence* [32], or *interest* [7]):

The degree of dependence is computed as Equation nine

$$\gamma(A_1 = a_1, A_2 = a_2) = P(A_1 = a_1, A_2 = a_2)/P(A_1 = a_1) * P(A_2 = a_2) \quad (9)$$

2.8 Significance of dependence [13]

The idea of statistical significance tests is to estimate the probability of the observed or a rarer phenomenon, under some null hypothesis. When the objective is to test the significance of the dependency between $X = x$ and $Y = y$, the null hypothesis is the independence assumption: $P(X = x, Y = y) = P(X = x)P(Y = y)$. If the estimated probability p is very small, we can reject the independence assumption, and assume that the observed dependency is not due to chance, but significant at level p. The metric in case of statistical dependence of association is derived as:

$$t(A_1 = a_1, \ldots\ldots A_l = a_l) = \frac{m(A_1=a_1,\ldots\ldots A_l=a_l) - nA_1=a_1,\ldots\ldots A_l=a_l \prod_{i=1}^{l} P(A_i=a_i)}{\sqrt{n} \prod_{i=1}^{l} P(A_i=a_i)(1-\prod_{i=1}^{l} P(A_i=a_i))} \quad (10)$$

This metric if >2 gives statistically valid dependence between associated attributes under study.

2.9 Multi-dimensional intra (association) patterns and inter (sequential pattern)

Given a knowledge base $K=(U,A')$ a multi-dimensional Intra pattern is the size of the equivalence class formed on equivalence on multiple dimensions of interest. Alternately, multi-dimensional intra(association) pattern is characterized by the frequency of attribute value pairs $(xi,ai',aj',$ $ak')$ which form the equivalence class based partitions in the knowledge base.

Inter patterns

Inter patterns are attribute pairs $(xi,(ai')t,(aj')t+n)$ and is derived by attribute combinations over a temporal span against each xi . These are derived by frequency of attribute value pairs in the pessimistic lower approximation of multi-granulation rough sets.

Hierarchical structures of partition based multi-granulation spaces [15]

Given a knowledge base $K=(U,A')$ in which $R \in A'$, R is an equivalence relation that induces a partition based granular space. Given $\mathcal{R} \subseteq A'$ then integration of all granular spaces forms a multi-granular space. Formally, a partition based multi-granular space (PBMS) denoted by

$$K(\mathcal{R}) = \{\frac{u}{R}: R \in \mathcal{R}\} \quad (11)$$

2.10 Finer and foarser partition based multi-granulation structure [15]

Let $K=(U,A')$ be a knowledge base in which $R1,R2 \subseteq A$, If $\forall [x]Rk$ $(Rk \in R1)$ and $\forall [x]Rj$ $(Rj \in R2)$ if $[x]Rk \subseteq [x]Rj$ then we say that $K(\mathscr{R}1)$ is finer than $K(\mathscr{R}2)$ for $K(\mathscr{R}2)$ is coarser than $K(\mathscr{R}1)$. This is denoted by:

$$K(\mathcal{R}1) \preceq K(\mathcal{R}2) \quad (12)$$

This relation becomes strictly finer if the inequality $[x]Rk \neq [x]Rj$ is satisfied.

3 A multi-granulation rough sets based framework for prospecting based on call records

We propose the following method for prospecting based on call records:

3.1 Transform u to k

Given an information system U of call records, use functional mapping of attributes like Called number (called number) its linguistic representation (business subcategory contacted). Similarly, transforming the date/time of the call into two distinct attributes day of contact and hour of contact.

3.2 Partition the knowledge base

This knowledge base so formed is further partitioned by equivalence classes by business subcategory with additional attributes like business category and information on higher upward taxonomy. Each induced partition give definite prospects for the business subcategory under study.

The size of each partition is the support for the service in that sub-category.

3.3 Multi-dimensional intra pattern mining

We use the equivalence class based partitioning in each partition to derive day, hour wise multi-dimensional Intra patterns. We compute the degree of dependence and t value for attribute value combinations. This gives combinations of Day and Time for specific business sub-categories. Sort pattern with support and degree of dependence and t value. The multi-dimensional attribute dependence so identified for each business with day and hour can be used to find optimal and possible days and times for business promotion.

3.4 Inter pattern mining

The algorithm given by [22] is used for extracting inter patterns of service associations. Similar pruning principles of t value are used to derive attribute dependence. The intersection of various partitions gives those subscribers with multiple service interests. The union of all granular spaces on business subcategory on a coarser attribute Business category gives the optimistic lower approximation encapsulating all possible prospects for business categories (higher order granulation) under study. The pessimistic lower approximations lead to prospects of multiple business sub-categories. Those subscribers who exist in all granular spaces under a business subcategory (finer multi-granulation) are positive prospects for that business category which is the coarser equivalence class. The algorithm pseudo code for the mining algorithm is given in Pseudo code 1.

```
Let K= (U, A')
X⊆U and P=P1,P2,…..Pm (are the
partitions in the knowledge base on
the basis of business sub-category).
The algorithm gives the Pessimistic
lower approximation of X by P
Algorithm: Multi-Dimensional Intra
Patterns
   1. X_{∑_{i=1}^{m} Pi} = {x|P_i(x) ⊆ X, i ≤ m}
   2. i = 1,2,…m
   3. j=1,2,…|Pi| point to Yij∈Pi and
   4. For Set i<-1,j<-1 and L=
      null;
         a. For i=1 to m Do
         b. Compute Support
         c. Compute degree of
            dependence
         d. Compute t-value
Algorithm [22] : Inter patterns
L records the computation of the
lower approximation
   1. Partition the knowledge base
      P_i
   2. Set i<-1,j<-1 and L= null;
   3. For i=1 to m Do
   4. For j= 1 to |Ki|
         a. If Yij ∩X = Yij then
               i. Let L ← L ∪ {Y_i^j}
         b. Endif
   5. Endfor
   6. Set j←1
   7. Endfor
```

Pseudocode 1: Algorithm for prospecting.

4 Illustrative example

Figure 1.0 and 2.0 gives the graphical representation of computing optimistic lower approximation or possible set of prospects. The graphic illustration of inter patterns discovered with pessimistic lower approximation is given in Figure 3.0. The partitioning on the basis of business sub-category day and hour gives Support for multi-Dimensional Intra patterns or associations. The most significant of these are derived using pruning criteria of degree of dependence and significance of dependence. Further, if no patterns cross the t>2 threshold, next best criteria of best support and degree of dependence are considered. This gives best combination of patterns of service promotions.

From the given example, it is clear that the maximal pattern length is two and we can infer from any non-empty intersection that subscribers of one service might take offers from promotions of other related services. While the optimistic lower approximation generates possible set of prospects, pessimistic approximations or inter patterns gives definite service takers of multiple services and best support for inter patterns gives best expanded audience for promotion.

Table 1.0
Instance of Call Records

Caller	Called	Day/Time
X1	a2	10/12/2017 16:37
X2	a1	10/12/2017 23:10
X3	a1	10/12/2017 16:50
X4	a3	10/13/2017 16:08
X5	a1	10/13/2017 16:07
X1	a1	10/13/2017 16:08
X2	a2	10/14/2017 11:02
X3	a3	10/14/2017 21:05
X4	a3	10/14/2017 22:03
X5	a1	10/14/2017 22:07

Table 2.0
Knowledge Base

Caller	Called	Day	Time
X1	Café	Thu	16 Hours
X2	Restaurant	Thu	23 Hours
X3	Restaurant	Thu	16 Hours
X4	bakery	Fri	16 Hours
X5	Restaurant	Fri	16 Hours
X1	Restaurant	Fri	16 Hours
X2	Café	Sat	11 Hours
X3	bakery	Sat	21 Hours
X4	bakery	Sat	22 Hours
X5	Restaurant	Sat	22 Hours

Figure 1: Illustrative Example.

Table 3.0
Sub Category Wise Prospects

Optimistic Lower Approximation= $\bigcup_{i=1}^{m} P_i$

Bakery	Café	Restaurant
X3	X1	x1
X4	X2	x2
		x3
		x5

Table 4.0
Multi-Dimensional Intra Patterns
Best Day and Hour For Promotion

Pattern	Support	Significance	t -value
Bakery:16:Fri	10%	2.22	0.83
Bakery:21:Sat	10%	8.33	0.83
Bakery:22:Sat	10%	4.16	0.83
Café:11:Sat	10%	12.5	0.83
Café:16:Thu	10%	3.33	0.83
Res:16:Thu	10%	1.33	0.83
Res:16:Fri	20%	2.66	2.36
Res:22:Sat	10%	2.5	0.83
Res:23:Thu	10%	6.66	0.83

Figure 2: Multi-Dimensional Intra Patterns.

bakery	café	restaurant
x3	x1	x1
x4	x2	x2
		x3
		x5

Pattern and Prospects	Support
bakery ∩ Cafe = {φ}	0
cafe ∩ Restaurant = {$x1, x2$}	2
Bakery ∩ Restaurant = {$x3$}	1
cafe ∩ Bakery ∩ Restaurant = {∅}	0

Figure 3: Inter Patterns of service Associations.

5 Mathematical properties of granular multi-dimensional intra patterns and granular inter patterns

***Theorem 1*:** The space of Multi-Dimensional Intra patterns is coarser on the equivalence class formed by business category and is antisymmetric and transitive with respect to finer equivalence relations on business sub-category.

Proof: Since the union of all finer equivalence relations $K(\mathcal{R}i)$ are encapsulated in $K(\mathcal{R}2)$ which is coarser equivalence relation, $K(\mathcal{R}i) \preceq K(\mathcal{R}2)$ for all i from 1 to 4 (business sub-categories) from Theorem "Partition based multi-granulation of formed by strictly finer and coarser equivalence relation"[15] $\preceq$ is transitive and antisymmetric. This implies prospects of café are also prospects for all food related business. Support of all prospects as per coarser equivalence relation is not the same sum of support of all prospects in finer equivalence relations. This is true as $K(\mathcal{R}i1) \cap K\mathcal{R}i2) \neq \emptyset$.

Theorem 2: The space of inter patterns derived from finer multi granulation [15] of pessimistic lower approximations are larger sets than sets formed by coarser equivalence relations. Also, upper approximations are smaller than lower approximations.

Proof: This is implied for corollary 1 "Partition-based multi-granulation set formed by strictly finer relation with coarser equivalence class has a bigger pessimistic lower approximation" [15] if $K(\mathcal{R}1) \preceq K(\mathcal{R}2)$ then $\underline{R}1^{PES}(X) \supseteq \underline{R}2^{PES}(X)$ and Theorem 1 as the pessimistic lower approximation formed on R2 will be those subscribers that have presence in all finer equivalence relations. This set will be smaller than set of subscribers that have presence in either one of the finer equivalence relations.

6 Results of intra and inter pattern mining on call records

The proposed method was tested on anonymised call records tracked for one month to 7765 businesses listed in four Sub-categories under "Food category" namely Restaurant, Bakery, Café and Food ordering Services in a local business directory. Neither, demographic nor SMS data was used or captured for our analysis. Also, the details of generated prospects had pseudo-identifiers. This data can only be used by the provider for promotional exercise only on mutual consent for using such information. Also, Call records had only date and time stamp information of the Business sites under Study. Moreover, call logs with the subscriber resolution have been used to mine nuggets of knowledge [24][25] with due considerations of user privacy. Also, only the knowledge spaces as in Table 2.0 (Figure 1.0) was used to addresses business questions under study. The best case Intra

patterns of Day and hour combination against the businesses under investigation are given in Figure 4.0

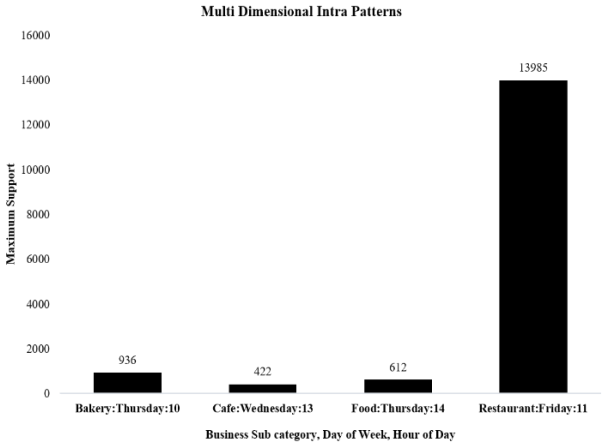

Figure 4: Best Patterns Business Sub Category, Day and Hour Pattern.

The scope of the study was extended to other business subcategories in the entertainment taxonomy like beauty and health, Spa, travel agency, nightclub to study the Inter pattern space etc. The support for maximal patterns is as given in Figure 5.0. It is evident using the proposed method; we can find those subscribers who can be directly targeted for the services they have availed. Further, using the concept of optimistic lower approximation a bigger audience that is those who have availed a related service can also be contacted for promotion.

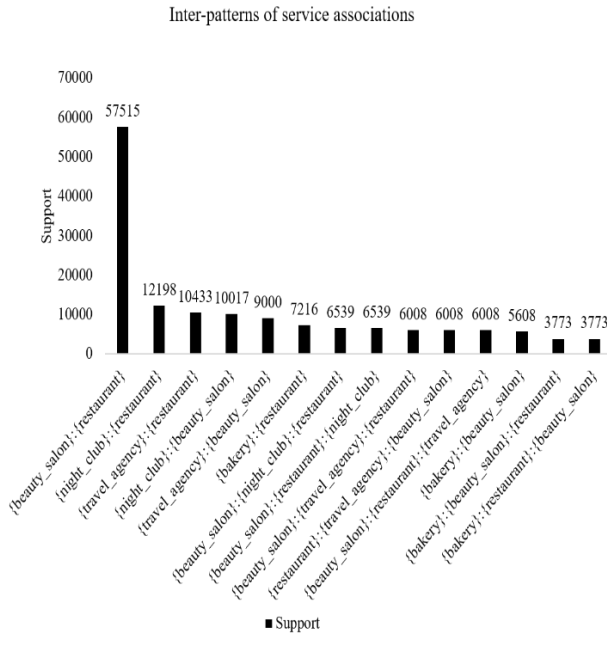

Figure 5: Inter patterns of Service Associations.

7 Discussion

The proposed method has lower time complexity and smaller statistically valid result space which is directly usable for decision making.

7.1 Time complexity comparison

We can derive Intra patterns from call records using tradition multi-Dimensional Intra patterns mining using efficient variants of apriori methods [26] at user defined support and confidence thresholds by embedding day and Hour information in individual transactions. Inter patterns of service associations can be mined with the same by collating sequence of customer contacts in the form of a transaction for a given period under study. Time complexity of hash tree like approach is $O\left(N\sum_k\binom{w}{k}\alpha_k\right)$ [27] where N is the number of transactions w is the maximum transaction width and $\boldsymbol{\alpha_k}$ is the cost of updating support count of a candidate k itemset in a hash tree. Using proposed method of "Multi-Granulation Rough Set based Multi-dimensional Intra and Inter pattern mining" Time complexity is the sum of the cost of database partitioning, computing lower approximations and computing pessimistic lower approximation.

Which is $O(m|N/ki|^2)+ O(m \times ki \times \log ki)$, Here m is the number of partition and N/Ki is the size of the dataset in the partition which is lower than traditional methods.

7.2 Comparison of rule space and directly usable pattern discovery

The proposed method suffices Type I and Type II statistical errors in pattern discovery. We derive non-redundant pattern space with granulation; also all knowledge about pattern dependencies is encapsulated in higher order concepts. Given d unique items in the database under study, a total number of itemsets are 2^d and total number of possible rules are 3^d-2^{d+1}+1.[27] In the presented application, all rules are important since multi-dimensional patterns of the most frequent day of contact and most frequent time of contact are desired for all businesses under study. With optimistic and pessimistic granular spaces, d unique items are encapsulated in m unique higher order concepts where m≤d. In our case 32 business sub-categories are mapped into 5 unique categories. Also, pruning by statistical significance and significance of dependence identifies statistically valid dependencies in case of inter- pattern mining. Just ordering rules derived by support gives desired patterns for designing business promotion strategies.

8 Conclusion

It is evident that all the properties of coarser and finer information granulation hold true for the pattern space of multi-dimensional Intra patterns. The proposed method has lower computation cost and also addresses issues related to Type I and Type II errors common to the support confidence framework. Further, proposed architecture is also scalable due to partitioning and granulation. The future work includes extending the presented idea to incremental mining of intra and inter patterns space. Further, the idea will be tested on problems in environment sciences and spatial data mining. The applicability of the proposed method is limited to domains

where a logical concept hierarchy exist in data attributes under study.

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A Computational Multiagent Model of Bioluminescent Bacteria for the Emergence of Self-Sustainable and Self-Maintaining Artificial Wireless Networks

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Biology is a rich source of inspiration in designing digital artifacts capable of autonomous, cooperative and distributed behaviors. Particularly, conceptual links can be established between (1) communication networks and (2) colonies of bacteria that communicate using chemical molecules. The goal of this paper is to propose a computational multiagent model of an interspecies bacterial communication system, termed quorum sensing, and analyze its self-sustainability and its self-maintaining ability to cooperatively form artificial wireless networks. Specifically, we propose a bottom-up agent-based approach combined with Ordinary Differential Equations, which abstract the intracellular dynamics, such as a proposed metabolism model that serves as a basis underlying self-sustainable networks. Results show that artificial bacterial cells have regeneration abilities in the light of random cell death and selected area for cell death, and a metabolism allowing them to exploit their own produced energy to cooperate at the population level to exhibit near-optimal self-organizing light-producing behaviors. The resulting artificial networks display several beneficial properties and could be used for the emergence of resistant wireless network topologies without the use of overhead messages.

Povzetek: Analizirano je komuniciranje med bakterijami, na osnovi katerih so razvite agentne metode za bolj odporna brezžična omrežja.

1 Introduction

Biology is a rich source of inspiration in designing artifacts capable of adaptive, distributed and autonomous behavior, which is one of the main goals of artificial life. In our works, we are interested in simulating the biological principles of self-regulation, to design artificial systems that display self-organized behaviors. One of the self-organizing principles of living organisms is that their units have the ability to communicate to help fulfill their goals. For instance, there is a growing belief that the robustness of biological systems is often derived from collective behaviors at a population level [1]. In the context of unicellular organisms, bacteria were considered for a long time to be independent unicellular organisms until 1979. Bacterial colonies of Vibrio-fischeri and Vibrio-harveyi were shown to be able to exhibit a cooperative light-emitting behavior, when the population reaches high cell densities [2]. This phenomenon is referred to as Quorum Sensing (QS). In fact, bacterial cells can communicate with each other by synthesizing, emitting, and sensing a signaling molecule known as an "autoinducer". When the autoinducer binds to the corresponding genetic receptor in a receiving cell, it triggers a regulatory response, which in turn results in the generation of more signaling molecules in the colony.

Communication is essential to any kind of coordinated parallel processes. The methods of communication have been investigated by the artificial life community in two contexts: unicellular and multicellular organisms. Multicellular approaches include artificial embryogeny [3] and morphogenetic engineering [4] models, which are developmental models that build an entire organism (a pattern or a morphology) from a single cell. The underlying idea is to model the behavior of how a single cell could reproduce and generate a predefined shape under specific constraints. Many multicellular models have been developed and used to solve different problems such as morphogenesis of French flags [5], [6].

Cell signaling in biological multicellular organisms results from a highly complex network of signaling pathways, including juxtracrine, paracrine and endocrine pathways, which are often abstracted into high-level mechanisms in computational models, and are difficult to thoroughly analyze. On the other hand, unicellular cell signaling mechanisms, such as quorum sensing, are relatively simple. Each bacterium produces and releases a signaling molecule that regulates gene expression over the bacterial colony when the population reaches high cell densities. Moreover, despite their sizes, bacteria have computational and evolutionary autonomous capabilities for self-replication and self-organization [7]. Indeed, compared to a cell of a multicellular organism, a bacterial cell is a mobile and autonomous entity that can grow and act independently at an individual level, and coordinate its behavior with other cells at a population level.

In this paper, we propose the exploration of the unicellular approach, which provides several intrinsic beneficial properties, e.g. all the organisms are autonomous and share a single distributed communication system (QS).

To this end, we use a bottom-up agent-based approach and propose a cell-based model combined with Ordinary Differential Equations (ODEs), which includes a model of growth, a model of bioluminescence and a model of metabolism. We test our model in a set of experiments where we evaluate the sustainability and communication capabilities of bacterial colonies, their self-organized bioluminescence behavior, and their regeneration abilities. Our experiments reveal several insights into the cell behaviors to develop scalable artificial communication networks. In summation, our main contributions are:

i. As communication is essential to any kind of coordinated parallel processes in natural and artificial systems, we propose a computer-based simulation of a bacterial communication system (QS).
ii. Metabolism, as the biological process that allows for energy production, is crucial to any functional behavior. Thus, we propose a model of metabolism that allows bacteria to self-sustain, enabling them to grow, divide, and communicate using their own self-produced energy.
iii. Bacterial cells in our model are able to cooperate at the population level to exhibit near-optimal light-producing behaviors using our proposed model of bioluminescence.
iv. Our unicellular communication model possesses emerging abilities of regeneration in two cases: random distributed cell death, and particular cell death in a specific region of the colony.
v. Bioluminescence is conceived as a basis underlying cooperative artificial network formation. The emergent communication network displays beneficial properties: self-reproduction of the network nodes (cell division), cooperative formation of the network links (QS), and autonomy via self-sustaining network nodes (metabolism). These intrinsic network properties lead to the evolution of cooperation toward common goals, such as increasing the number of networked cells.
vi. A parallel is made between wireless networks and simulations of bacteria colonies that communicate using QS molecules. The resulting artificial network could be potentially used for the emergence of autonomous networks that can address issues such as limiting the use of configuration messages commonly known as overhead messages, which are a key factor for the development of new self-organized networks [8].

Finally, we believe that the abstract representation of complex interactions among QS molecules would contribute to enrich our understanding of biological microbial communities, which may provide further insights for novel design techniques.

The rest of this paper is organized as follows. Section 2 presents the related works and the problem statement. Our cellular model for quorum sensing, growth, metabolism, and bioluminescence is described in Section 3. Our artificial communication network model is presented in Section 4. The simulation results are evaluated and discussed in Section 5 and 6. Section 7 concludes the paper.

2 Related works and problem statement

The related works are grouped in three subsections: quorum sensing, regeneration and bioinspired wireless networking for self-organizing network topologies.

2.1 Quorum sensing

Quorum sensing, as a simple and powerful biological communication system, has attracted the interest of interdisciplinary research groups. In the field of bioinspired systems, QS has been investigated from different perspectives, including artificial ecosystems [9], membrane computing [10], digital evolution [11], swarm robotics [12], logic computing [13], dynamic clustering [14], synthetic systems [15], bioinspired agent-based modeling [16] and control [17], and game theory [18].

On the one hand, in the field of artificial life, only a small number of works have investigated digital simulations of QS considering metabolism and bioluminescence. While in the seminal works of [19] and [20], a QS simulation was proposed, their model did not consider bacterial metabolism for energy production and consumption. Since energy is vital to any physiological process in living organisms, in this paper we include such a model of metabolism in our simulations. Furthermore, we propose a computational model of bioluminescence using the same QS model.

Additionally, few works have investigated the analogy between QS simulations and communication networks: in our work, we establish a conceptual link between QS and artificial communication networks. In [21], a QS-based communication network model was proposed, which used autoinducer molecules for communication. In our work, we address a similar problem using a network-centric approach, but we use a light-based communication protocol instead of autoinducers, because:

- propagation of light is less limited by distance than a signaling molecule,
- the different intensities of light are favorable for hierarchical structures, with several cell types: super-spreaders of light called wild-type

cooperators, simple spreaders called cooperators, and non-bioluminescent cells which do not spread light, called cheaters. Hierarchical structures are known to be beneficial for the optimization of the network resources [22].

2.2 Regeneration abilities

Regeneration is the ability of an organism, unicellular or multicellular, to resist damage by re-growth and renewal of dead cells. Hardware regeneration, often referred to as self-repairing, is a technique that allows electronic systems to reconfigure themselves if a part of a unit breaks down. Bioinspired developmental models are usually used. This part of electronics is commonly called embryogenics. Miller developed a self-repairing system, [23] [24] using cellular automata and Cartesian Genetic Programming. His model can generate a French flag able to reconstruct itself when the environment randomly moves the cells. This work has been reproduced by Liu [25] on a reprogrammable electronic ship, showing fault-tolerance abilities.

As additional models about regeneration of artificial multicellular organisms have been proposed, we can cite the regeneration of dead cells in previous studies: the two-dimensional and three-dimensional shapes of Fleischer [26] , the star fish of Cussat-Blanc et al. [27], and the bat of Djezzar et al. [28]. In [29], an efficient cell-to-cell communication mechanism that allows the maintenance of Planarian worm-like shapes was introduced. The efficiency of the model has been verified in the light of random cell death. However, regeneration after a selected area for cell death was presented as a challenge that was not raised by the proposed mechanism.

On unicellular artificial life simulation models, regeneration is less studied. Fewer works exist on regeneration and resistance of unicellular organisms. In this paper, we present a unicellular model of communication with emerging abilities of regeneration studied in two cases: (1) in the light of random cell death, and also (2) a selected area for cell death due to factors such as the action of an antibiotic or damage on a specific area of the unicellular-based structure. These regeneration abilities are beneficial for the development of self-organizing network topologies with self-maintaining features.

2.3 Bioinspired wireless networking for self-organizing topologies

One of the major challenges is topology when wireless networks are designed. The network topology or physical placement of nodes is the base infrastructure that can intensely affect the entire network performance. Indeed, a careful node placement in a wireless networks can be an effective optimization means for coping with many resources limitation problems such as energy, location data requirements, computation time, and especially overhead communications, such as hello configuration messages. Overhead messages present common issues in designing a network topology, particularly:

- computation time and energy.
- security vulnerability. For example, during the exchange of overhead (hello) messages, a listener node can save important information on the network's structure such as the location of cluster heads.
- self-adaptation when the topology is subjected to failures. A flaw in the topology necessitates the re-launching of overhead controls as well as human intervention.

Nature and bio-inspired mechanisms of self-organization could present an efficient solution to reduce overhead controls in designing a wireless network topology. Indeed, artificial and swarm intelligence have a long history of use as bioinspired alternative approaches able to transform natural patterns of collective behavior into useful models for self-organizing network topologies. In fact, researchers have proposed models inspired from ants [30], honeybees [31], fireflies [32], [33], Boids of Reynolds [34], etc. A survey on bioinspired networking is presented in [8]. Most of the existing approaches, bioinspired or not, require geographic data on nodes, such as position, and overhead messages.

Considering the wireless network as a biological system is very interesting. It is connected to the goal of this paper. To achieve this goal, artificial life and particularly morphogenetic engineering is an original promising idea to emulate self-regulation, cooperation and regeneration capabilities of colonies of bacteria for the emergence of network topologies presenting these features.

Consequently, in this paper we propose an artificial life simulation model of bacteria QS for the emergence of wireless network topologies, and for the purpose of:

- eliminating overhead messages.
- regeneration, resilience, and tolerance abilities, especially when the network is subjected to failures or external attacks.

3 Cellular dynamics model

Our cells are bacterial agents that evolve in a two-dimensional environment and have the ability to sense the environment (taking up substrates and autoinducers), grow, divide and survive. They possess a QS genetic controller circuit allowing them to coordinate their cellular communication with other cells. Moreover, they are able to synthesize light *via* a proposed model of bioluminescence and have a metabolism allowing them to accomplish all of these actions.

3.1 Quorum sensing

To simulate cell-to-cell communication in heterogeneous microbial communities, we use a generic $LuxI/LuxR$ QS language that is employed by over thirty species of Gram-negative bacteria [2]. All $LuxI/R$ systems are mediated by autoinducers, such as acylated homoserine lactone (AHL). Explicitly, the autoinducer molecule is synthesized by the

synthase $luxI$ homologs, $LuxR$ is a receptor that can bind the AHL molecules, and the $LuxR-AHL$ complex activates the transcription of the downstream operon.

The molecular regulation network of a bacterial agent is based on the empirical ODE-models proposed by [19] and [20]. This model uses two positive feedback loops (Figure 1). The autoinducer AHL (A) and the receptor LuxR (R) form a dimerized complex (C) that regulates the expression of both $luxI$ and $luxR$ genes, which produces more AHL molecules and $LuxR$ receptors, respectively. The following equations describe the molecular dynamics of this genetic circuit:

$$\frac{d[A]}{dt} = C_A + \frac{k_A[C]}{K_A+[C]} - k_0[A] - k_1[R][A] + k_2[RA] - p_e[A] + p_a[A_e] \ , \quad (1)$$

$$\frac{d[R]}{dt} = C_R + \frac{k_R[C]}{K_R+[C]} - k_3[R] - k_1[R][A] + k_2[RA] \ , \quad (2)$$

$$\frac{d[RA]}{dt} = k_1[R][A] - k_2[RA] - 2k_4[RA]^2 + 2k_5[C], \quad (3)$$

$$\frac{d[C]}{dt} = k_4[RA]^2 - k_5[C] \ , \quad (4)$$

$$\frac{d[A_e]}{dt} = \sum_{bact} (p_e[A] - p_a[A_e]) + D\,\nabla^2[A_e], \quad (5)$$

where the notation $[X]$ represents the concentration of a particular molecular species X and RA is the $LuxR-AHL$ complex. A_e is the extracellular concentration of A sensed from the environment. $p_e$and p_a are emission rate and absorption rate of A and A_e, respectively. C_A and C_R represent the basal level transcription of A and R, respectively.

3.2 Growth

For simplicity, cells grow through the substrate-dependent growth model of Monod [35]. In the model of Monod, the specific growth rate (μ) of a bacterium biomass (X) depends on the substrate concentration (S). The equation is given by:

$$\mu = \mu_{max} \cdot \frac{S}{S+K_S} \quad (6)$$

where μ_{max} is the maximum growth rate and k_s is the substrate affinity (the value of S when $\mu/\mu max = 0.5$). These two parameters are assumed to be constant but depend on strain and environmental conditions. Using the specific growth rate (μ), $d[X]/dt$ is calculated as follows:

$$\frac{d[X]}{dt} = X \cdot \mu \quad (7)$$

To calculate the specific energy requirement rate (q_{ATP}) for cell growth, Stouthamer and Bettenhausen [36] introduced Eq. 8 and used the energetic growth yield coefficients $(Y_{X/ATP})$. This parameter is assumed to be constant and represents the cell mass synthesized (X) per unit of energy generated (ATP). The equation is given by:

$$q_{ATP} = \frac{\mu}{Y_{X/ATP}} \quad (8)$$

We note that the energy (ATP) consumption due to the cell growth is subtracted from the total energy of the cell.

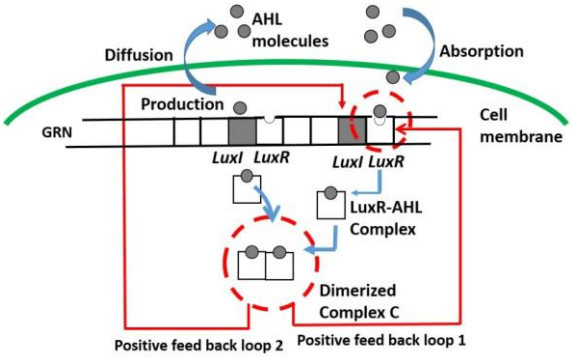

Figure 1: Dynamics of a $LuxI/LuxR$ quorum sensing. The $LuxI$ synthesize the autoinducer molecule (AHL). The receptor $LuxR$ can bind the AHL molecule to form a complex $LuxR-AHL$. The dimerized complex composed of two $LuxR-AHL$ complexes, regulates the expression of both $LuxR$ (positive feedback loop 1), and $LuxI$ (positive feedback loop 2), which produces more $LuxR$ receptors and AHL molecules, respectively.

3.3 Bioluminescence

In general, bioluminescence is a light-producing reaction catalyzed by a luciferase. Luciferase is a photoprotein enzyme that transforms a light-producing substrate called luciferin into light. The process requires the presence of other substances, like oxygen and adenosine triphosphate (ATP). For simplicity, oxygen is assumed to exist in abundance in the environment. Therefore, the enzymatic reaction can be written in the form of a bi-molecular reaction that involves an enzyme (E), binding to a substrate (S) to form a complex (ES), which in turn releases a product (P), regenerating the original enzyme. This may be represented as follows:

$$E + S \underset{K_r}{\overset{K_f}{\longleftrightarrow}} ES \xrightarrow{K_{cat}} E + P, \quad (9)$$

where K_f is the forward rate, K_r is the reverse rate, and K_{cat} is the catalytic rate. By applying conservation constraints of the material and assuming that the concentration of enzymes is very low in comparison with the metabolite concentration, the equation describing this reaction is as follows:

$$\frac{d[P]}{dt} = \frac{K_{cat}[E][S]}{\frac{K_r+K_{cat}}{K_f}+[S]} \ , (10)$$

By setting: $K_L = \frac{K_r+K_{cat}}{K_f}$ and $P_{max} = K_{cat}[E]$, we obtain the following equation:

$$\frac{d[P]}{dt} = \frac{P_{max}[S]}{K_L+[S]}, (11)$$

where P_{max} represents the maximum production rate and $K_L$is the concentration of S at which the reaction rate is at half-maximum.

In the case of bioluminescent bacteria, the bacterial luciferase is encoded and synthesized by the lux operon. The transcription of the lux operon is activated by the $LuxR - AHL$ dimerized complex (C) as shown in Figure

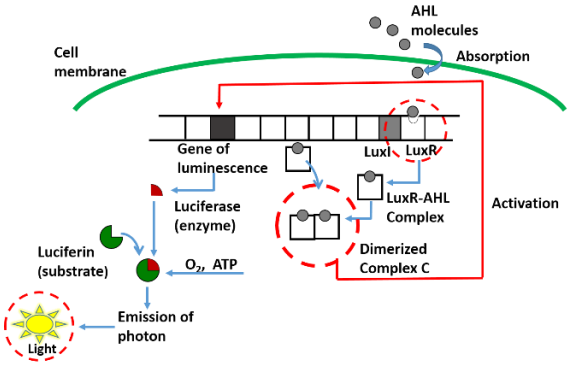

Figure 2: Light production regulated by a $luxI/luxR$ QS.

2. The bacterium produces light only at high cell density (*i.e.* only when a quorum is met). At low cell densities, even with higher concentration of the luciferin substrate, bacterial cells do not produce light. Then, we assume that: (1) the substrate exists abundantly in the cell cytoplasm and (2) the dimerized complex C that controls the synthesis of the luciferase enzyme is assumed to be a determining factor. Therefore, we model the cell light production as a function of the dimerized complex C. Hence equation Eq. 11 is modified to:

$$\frac{d[L]}{dt} = \frac{L_{max}[C]}{K_L + [C]}, (12)$$

where L is the light production rate, L_{max} is the maximum light production rate, and K_L is the concentration of C at which L is at half-maximum. Bioluminescence is expressed as the accumulation of the green fluorescent protein gfp. The gfp is incremented at each time step according to the light production rate L. The more *gfp* a cell accumulates, the greener the cell becomes.

3.4 Metabolism

Metabolism is the process that describes energy production and consumption [37]. In our model, metabolism is calculated by subtracting the energy spent to grow, divide, produce light, or survive (maintenance energy) from the total energy of the organism (sum of basal energy and energy produced from substrate). Figure 3 represents material and energy inputs and outputs of the cell metabolism. ATP is the molecule that stores and transports energy in living organisms. We model the bacterial ATP cycle as follows:

$$\Delta ATP = (ATP_0 + E.ATP_S - ATP_G - ATP_D - ATP_L - ATP_M)(\Delta t), \quad (13)$$

where:

- ΔATP is the total energy change of the organism.
- ATP_0 is the basal energy.
- ATP_S is the substrate energy. It represents the energy produced from metabolized substrates. This term is calculated as follows:

$$\frac{d[ATP_S]}{dt} = Y_{ATP/S} \cdot \frac{d[S]}{dt}, \quad (14)$$

where $Y_{ATP/S}$ is the energetic substrate yield. It represents the amount of ATP produced per unit of substrate.

- E is the substrate metabolism efficiency (equal to 40%). This is because only 40 to 50% of the energy stored in a carbon substrate is converted to biological energy (ATP). The rest is released as heat (Figure 3).
- ATP_G is the growth energy. It represents the energy consumption due to the cell growth. The consumption of ATP due to the cell growth, at each time step, is given by:

$$\frac{d[ATP_G]}{dt} = q_{ATP} \cdot X, \quad (15)$$

Using Eq. 8, Eq. 15 becomes:

$$\frac{d[ATP_G]}{dt} = \frac{\mu}{Y_{X/ATP}} \cdot X, \quad (16)$$

Using Eq. 7, Eq. 16 becomes:

$$\frac{d[ATP_G]}{dt} = \frac{1}{Y_{X/ATP}} \cdot \frac{d[X]}{dt}, \quad (17)$$

- ATP_D is the division energy. It represents the energetic cost of cell division and is equal to 0.5 μM.
- ATP_L is the light energy. It represents the energy used to produce light. We use a similar equation to Eq. 17 to calculate ATP_L. This is given by:

$$\frac{d[ATP_L]}{dt} = \frac{1}{Y_{L/ATP}} \cdot \frac{d[L]}{dt}, \quad (18)$$

where $Y_{L/ATP}$ is the energetic light yield coefficient.

- ATP_M is the maintenance energy (equal to 0.25 µM).

3.5 Parameters

Table 2 lists the parameters used in our model. QS parameter values are adopted from [20].

Parameter	Value	Unit
p_e	*0.025*	-
p_a	*0.025*	-
μ_{max}	*0.034*	*fl/min*
K_S	*1*	μMol
$Y_{X/ATP}$	0.034	$fl/\mu Mol$
L_{max}	2.0e -1	RLU/min
K_L	2.1e-7	μMol
ATP_0	*1000*	μMol
$Y_{ATP/S}$	1000	-
$Y_{L/ATP}$	0.135	$RLU/\mu Mol$
T_L	0.20	-

Table 1: Model parameters.

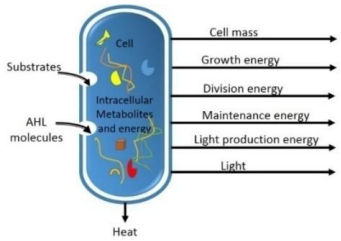

Figure 3: Material and energy inputs and outputs of the cell metabolism.

4 Artificial wireless network

QS is intrinsically a wireless communication system. Practically, traditional wireless networks can connect heterogeneous devices without physical links. Similarly, within microbiomes, different types of bacteria can establish a wireless molecular communication network without previously established paths.

However, the QS-based communication network is different from a classical wireless network in the sense that bacterial cells do not have IP addresses and the signals that they convey (autoinducers) do not have specific destinations encoded in the signals. This means that QS establishes communication without access to the location of cells. We want to take advantage of this property for the emergence of a network topology without using data location (cell position) and overhead messages. To do so, our network is based only on the internal dynamics of nodes, *i.e.* intracellular factors, and we use light as a modeling choice for the following reasons:

1. Light is a self-organizing cooperative behavior that emerges from QS dynamics.
2. The different light productivities, *i.e.* intensities, strong, (hyper-luminescent cells), medium, (luminescent cells), and null (non- luminescent cells), permit a network topology with a certain hierarchy, very suitable for networks, because it optimizes the network resources [22].
3. Light as an internal factor (gfp) allows self-selection of the node types without a centralized control. Indeed, a simple local test of the value of the gfp at a cell allows for the determination of the node's type.
4. Light is an internal factor, but it has a beneficial external half-side effect. It is visible by other nodes and therefore can be sensed, for example, by a photosensitive sensor node. A signaling molecule such as autoinducer does not have this characteristic. The internal concentration of a signaling molecule inside a node is not visible by other nodes.
5. The strength of the emitted signal in a traditional wireless network may be analogous to the light intensity.
6. The sensitivity of the receiver in a traditional wireless network is analogous to the concentration of the signal receptor ($Lux\ R$).

Based on the above observations, we propose a QS network based only on intracellular factors. Figure 4 shows the network node types and explains how the network links are established to from a network topology. The following subsections explains the network links and nodes.

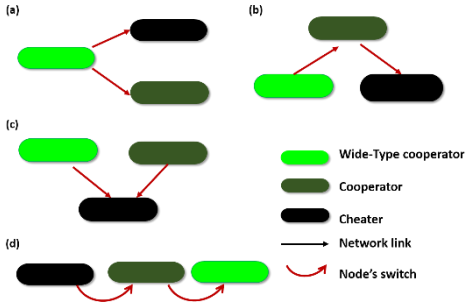

Figure 4: Establishment of the bacteria network topology. (a) WT-cooperator bacteria can connect to cooperators and cheaters. (b) Cooperator bacteria can connect to cheaters and can receive signals from WT-cooperators. (c) Cheaters cannot connect to WT-cooperators and cooperators but can receive signals. The direction of the link shows how the link is established. (d) The more gfp a cell accumulates, the greener the cell becomes, and the cell switches to the other cell type. Cheaters can switch to cooperators, and cooperators can switch to WT-cooperators.

4.1 Network links

A directed link is established from bacterium A to bacterium B under two conditions:

- The light signal concentration ($gfp/volume$) inside bacterium A is larger than that of bacterium B.
- The bacterium B is a sensitive receiver. A bacterium is considered to be a sensitive receiver to light if its concentration of $LuxR$ is above an activation threshold TR.

The first condition specifies the link direction. It represents the fact that there is a descending light gradient from bacterium A to Bacterium B. The second condition ensures that bacterium B is able to receive the signal.

4.2 Network nodes

QS is a cooperative effort of a bacterial population in which certain bacteria do not participate. The non-participating bacteria are usually called cheaters [38].
In our work, a node is an abstraction of a bacterium cell. Since, within microbiomes, different type of cooperators and cheaters tend to coexist in collaboration or in conflict with one another [39], [40], we adopt a similar biological terminology to define the node's types of our artificial wireless network.

To account for different light productivity, we classify the network nodes into three categories based on the intracellular intensity of light (gfp/volume). More precisely:

– nodes with $gfp/volume > 20$ are up-regulated cells with high productivity of light (they are able to produce light at a high intensity). The nodes in this category are super spreaders that can send light to all

the other types of nodes. They are considered to be wild-type cooperators (WT-cooperators).

– Nodes with $0 < gfp/volume < 20$ are considered to be cooperators. These nodes are down regulated cells that can receive light from all WT-cooperators but do not produce light at high intensity. So, they are able to send light at a rate $T_L = 0.20$ to sensitive cheaters.

– Nodes with $gfp/volume = 0$ are non-bioluminescent bacteria called cheaters. They may be non-QS cells or QS cells that do not produce light. They are receivers called cheaters because they do not collaborate toward the common goals (producing light and establishing links) but gain benefit from the other cells that can do so.

This classification of nodes based on the intracellular gfp value at a node allows each node to self-select its type without using a centralized process to attribute to each node a specified type.

5 Experiments and results

Using an open source simulator [41], we set up a two-dimensional environment of size $(80\ \mu m, 80\ \mu m)$. At the beginning of the simulation, 100 generic bacterial agents are randomly dispersed in the environment (Figure 5a). A bacterium cell is assumed to be $1\mu m$ in diameter and, initially *2* μm long. Thus, its initial volume is $V = 1.57fl$ (femtoliters). To support the survival and growth of cells, we assume a constant nutrition concentration $S = 10\ \mu Mole$. In Figure 5a-c, cells that are close to the nutrient source are able to sense and absorb substrates. As a cell takes in substrates, it grows until it doubles its volume to $V = 3.14fL$, at which point it divides. When the cell divides, it gives rise to two cells. One of the cells is chosen arbitrarily to be the mother and the other becomes its daughter. Then, the program running on the mother is copied to the daughter cell.

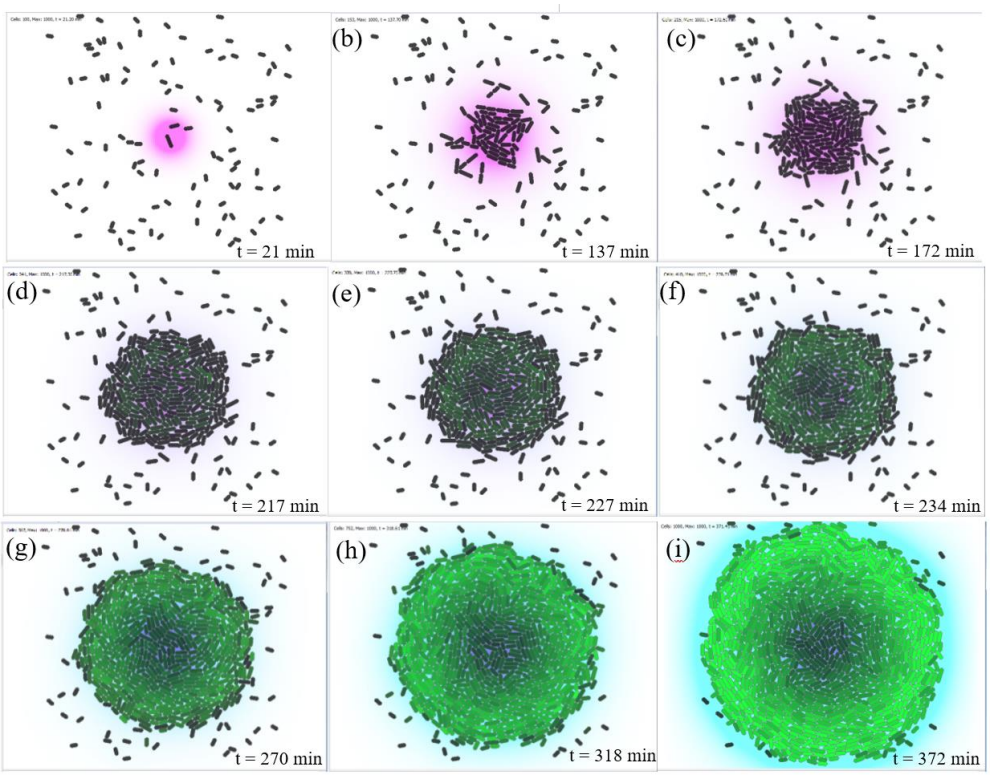

Figure 5: Evolution of bioluminescence, case 1: a single nutrient source placed in the center of the environment. Substrate is shown in purple, AHL in blue, black cells are non-fluorescent. Fluorescence is expressed as a gradient ranging from the dark to light green. (a), (b) and (c) represent the beginning of the simulation: cells grow and divide. In (d), (e) and (f), the quorum is being reached, fluorescent cells begin to appear. Finally, (g), (h) and (i) show homogenous behavior of bioluminescent cells.

5.1 Quorum sensing dynamics

The quorum is met at $t \backsimeq 180$ min, when the population size is 250 cells (Figure 5d). From $t = 270\ min$ towards the end of simulation (Figure 5g- i), we can clearly see the AHL in blue around the colony that does not appear obviously in the early stages, because the diffusion of signaling molecules is spatially limited and significantly slower than the kinetic dynamics of bacteria. Figure 6a shows the evolution of the average amount of autoinducer inside cells over time (median and interquartile range of 20 independent runs of the simulation). From the beginning of the simulation to $t \backsimeq 180$ min, the accumulation of AHL inside the cells was stable, but after this crucial moment at which the quorum is met, the intracellular amount of AHL begins to accelerate up to 0.6. In our model, unlike the seminal work of [20], the environment is not initialized with AHL. AHL is rather

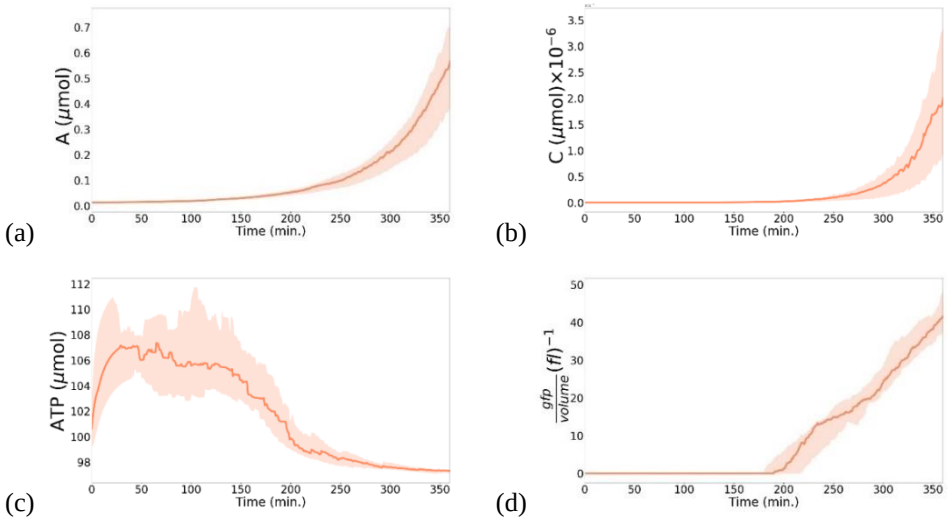

Figure 6: Intracellular molecules dynamics: median and interquartile range of 20 independent simulations. (a) Evolution of the amount of the autoinducer, A. (b) Evolution of the amount of the dimerized complex, C. (c) Evolution of the amount of ATP. (d) Evolution of bioluminescence, gfp/volume.

only produced and diffused by cells. However, in our simulations the average accumulation of AHL by cells exceeds the rate achieved in [20] (0.6 against 0.1). This means that exploiting metabolism, cells grow, reproduce, survive and produce more AHL molecules.

5.2 Bioluminescence regulation

Bioluminescence is shown as a gradient ranging from dark to light green. At high cell densities, the number of cells exceeding 250 contributes to the increase of AHL emitted by all the cells in the environment. The cells accelerate the production rates of AHL, using the positive feedback loop in Eq. 1. Consequently, the intracellular amount of the dimerized complex C increases as well, which can be seen in Figure 6b, where the quantity of the dimerized complex begins to increase from $t \backsimeq 180\ min$. At this moment, the values of the light production rate given by Eq.12 are positives, and thus cells can accumulate $gfps$ and express bioluminescence. Indeed, bioluminescence is observed from time $t = 217$ min in Figure 5d. In Figure 6d, once the quorum is met at $t \backsimeq 180$ min, the cells begin to produce gfp. At this precise moment of the simulation, the ATP rate starts to decelerate (Figure 6c). This is due to the energy cost of bioluminescence. In Figure 6c, from $t = 300\ min$ to the end of the simulation, the ATP level is stabilized, which leads to the sustainable behavior of bacteria.

5.3 Bioluminescence behavior

It is interesting to observe bioluminescence behavior at the individual and the population level. At the individual level, the number of bioluminescent cells represents 73% of the population. This corresponds to the empirical rates found in real populations of bacteria. In fact, analysis of the QS-regulated bioluminescence of a wild type strain revealed that only 69% of the cells of the population produced bioluminescence, 25% remained dark and 6% were dead [42].

At the beginning of the simulation, in Figure 5a–f, the arrangement or spatial organization of bioluminescent cells is not homogeneous, and we cannot observe an organized behavior at the population level. However, from $t = 318\ min$, we can clearly see the degradation of the fluorescence from the center of the colony to its border (Figure 5h). The bioluminescent cells organize themselves around the edge of the colony to make other cells emit light. To investigate this hypothesis, in the second case of the simulation, two nutrient sources were placed in the opposite corners of the environment. This allows the development of two colonies as far as possible from each other. We can observe through this simulation in Figure 7e-f, that the hypothesis is verified. Indeed, in each colony, the bioluminescence occurs toward each other. Also, we can observe that other cells that are not part of both colonies have become fluorescent (green cells surrounded by circles in Figure 7e and 7f).

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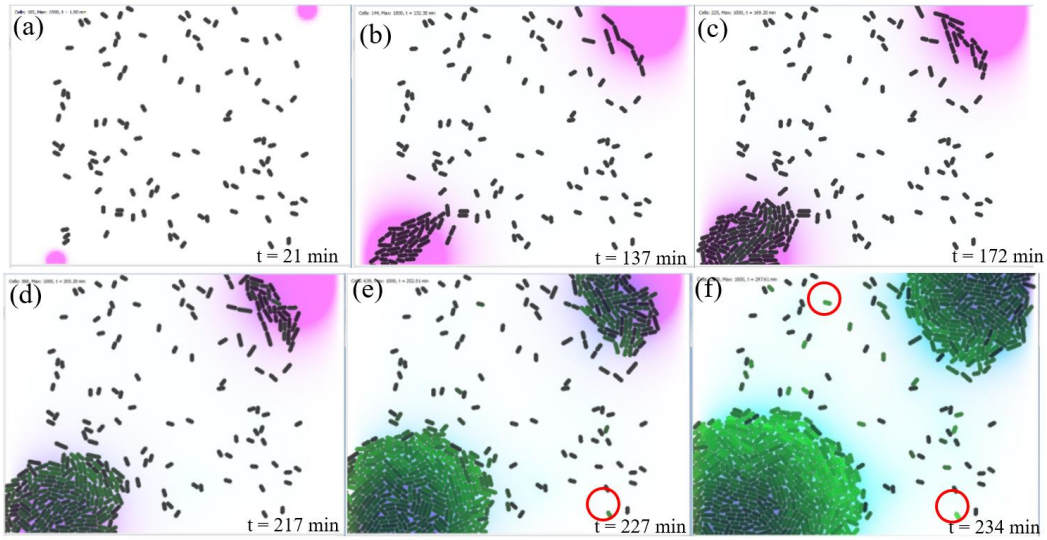

Figure 7**:** Evolution of bioluminescence-case 2: two nutrient sources, the first placed in the top right of the environment, the second placed in bottom left. (a) and (b): Beginning of the simulation. (c) and (d): Bioluminescent cells begin to appear at the left bottom of the environment. (e) and (f): A self-organized bioluminescence behavior of each colony toward each other.

5.4 Regeneration and resistance abilities

The regeneration abilities of our model are tested in two cases: 1) in the light of a random cell death, and 2) a selected area for cell death.

5.4.1 Random cell death

In this experiment, we want to verify how the model behaves with a random distributed cell death. In Figure 8, random cell death of 216 cells is inflicted on the bacteria colony at $t = 255\,min$. The 216 dead cells are regenerated at $t = 311\,min$, for a regeneration total time of $56\,min$. Several simulations of random cells death were carried out over several time stages by varying the number of killed cells.

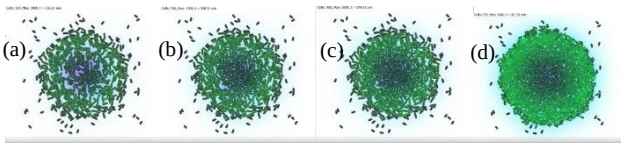

Figure 8: Regeneration after a programed random cell death. (a) a random cell death of 216 cells. (b) and (c) regrowth and regeneration of death cells. (d) Reformation of the colony structure.

Experiments show that the model provides intrinsic abilities of regeneration and maintaining of the structure without reprogramming or adding any further specific technique to the basic model. The average regeneration rate is 4 cells/min for an average regeneration time of $0.25\,min/cell$.

5.4.2 A selected area for cell death

In this experiment, we want to verify how the model behaves with non-equally distributed cell death, *i.e.* where a cluster of adjacent cells dies simultaneously due, for example, to the action of an antibiotic or damage on a specific area of the colony structure. To do so, a selected area for cell death is made. In the experiment reported by Figure 9; 26% of cells of the colony, $124\ cells$, are killed. Dead cells are regenerated in $34\,min$. The experiment shows that the model is capable of regrowth, reformation and maintaining of the structure. Several cuts of selected regions for cell death have been tested. The average regeneration rate is 5 cells/min for an average regeneration time of 0.2 min/cell.

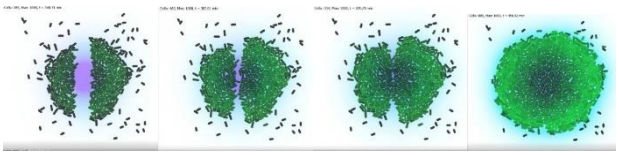

Figure 9: Regeneration after selected area for cell death. (a) A vertical cut (124 killed cells) is made in the middle of the colony. (b)–(c): Regrowth and regeneration of death cells. (d) Reformation of the colony structure.

In [28], after killing 23% of the artificial multicellular creature, the average regeneration rate is $25\ cells/min$ for an average regeneration time of $0.04\,min/cell$. This represents $1/5$ of the regeneration time of our model i.e. $0.2\,min/cell$. Despite this observation, we consider a regeneration time between 0.2 to $0.25\,min/cell$ as advantageous because our model includes physical force and growth kinetic simulations.

5.5 Network evolution

The artificial network evolves as the bacteria colony grows. It evolves *via* (1) self-selection of the cell type (local test of the *gfp* value), and (2) sending of links (based on two simple rules, Section 4.1) without calculation of the cell positions. In this section, we want to observe the evolution of the properties of this network, mainly: the number of networked cells and links of each cell type. Also, we need to test whether a fairly simple network definition allows the entire population of cells to be

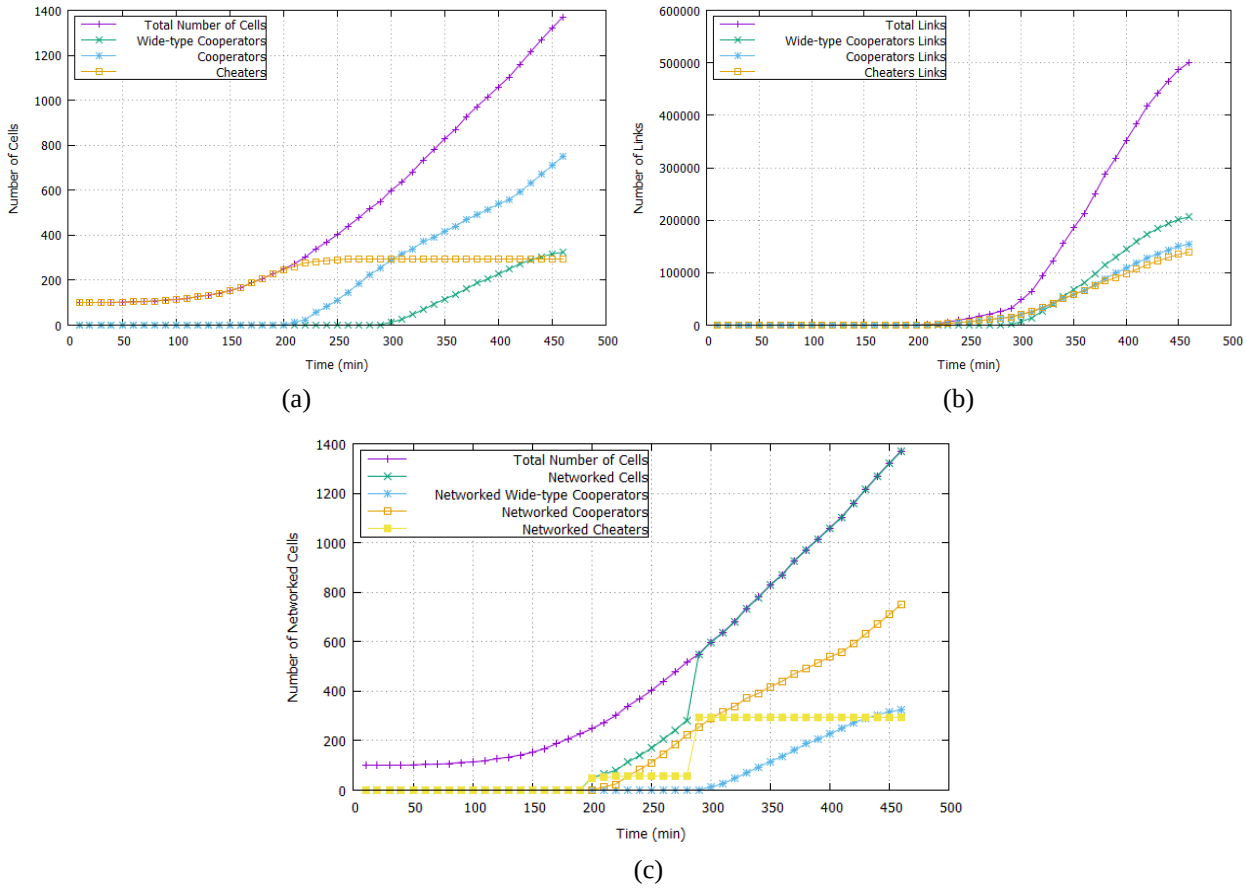

Figure 10**:** Measures of the artificial communication network. (a) Evolution of the number of cells. (b) Evolution of the number of links. (c) Evolution of the number of networked cells.

networked (total number of cells = total number of networked cells). To do so, three measures have been considered: number of cells, number of links, and number of networked cells of each cell type.

A cell is considered to be sensitive to light if its intracellular concentration of $luxR$ is above the threshold $T\_R = 0.0155$. The first measure we calculate is the numbers of different cell types. This is represented in Figure 10a. In Figure 10a, from $t = 0\,min$ to $t = 50\,min$, the number of cheaters is stable and equal to 100 cells. As the colony grows, the number of cheaters begins to increase gradually, where it reaches its maximum *i.e.* 294 cells at $t = 260\,min$. After this time, the number stagnates until the end of the simulation. At the instant $t = 210\,min$, the quorum is being met, the cells begin to emit light and consequently cooperators begin to emerge in the population. At $t = 300\,min$ the number of cooperators exceeds the number of cheaters, while WT-cooperators start to appear. The number of cooperators and WT-cooperators continues to increase as the number of cells increases, while the number of cheaters remains stable. At the end of the simulation, we can notice that cooperator cells are dominant in the population with 752 cells which represents 55% of the population, compared to 294 cheaters and 324 WT-cooperators which account for 21% and 24%, respectively.

Figure 10c represents the third measure we calculate, the number of networked cells. At $t = 290\,min$, networked WT-cooperator cells begin to emerge and the number of networked cells fit the total number of total cells (the number of non-networked cells is equal to 0). Consequently, the network model permits all cells of the population to be networked without calculating the cell position. Indeed, the assumption we have made in the beginning of this section is verified. Although our communication network is defined on the basis of two simple rules, an emission rule and a reception rule, the network allows the totality of the cells of the population (100%) to be networked, whatever their position (near or far from the colony) or their type (QS or non-QS cell, bioluminescent or non-bioluminescent cell).

We note that the results converged as a spontaneous evolution of the network dynamics without the use of any evolutionary algorithm. The artificial network has also the property of self-selection of the node's type without a centralized control. Such artificial communication networks can be used for the emergence of self-organizing wireless network topologies that address issues such as location data and overhead messages.

5.6 Cooperation measurements

As in macroscale communities, within microbiomes, different types of bacteria tend to cooperate towards common goals. Since nodes and links are basic components for any network topology, we consider two common goals. The first common goal is the evolution of

the total number of links. The second common goal is the evolution of the number of networked cells.

Our artificial communication network is based on a cooperative behavior of QS which is light. This cooperative behavior determines the network's node types (*via* the *gfp* value) and how the links are established (a descending gradient of light). So, we need to measure how much cooperator cells contribute towards the common goals for the network: links and nodes. Also, we want to determine which kind of cooperators has the highest degree of cooperation for the common goals. To do so, cooperation is calculated as the benefit/cost ratio. Table 1 shows the results considering two measures of cooperation. The first measure describes the contribution of cooperators (respectively WT-cooperators) for the common goal number 1: total number of links. The second measure describes the contribution of cooperators (respectively WT-cooperator) for the goal number 2: total number of networked cells.

Node type	Common goal 1: total links	Common goal 2: networked cells
Cooperators	500000/752=664.89	1370/752=1.82
WT-cooperators	500000/324=1543.20	1370/324=4.22

Table 2: Cooperation measurements of the network.

The total number of links is 50000, the number of networked cells is 1370, the number of cooperators is 752 and the number WT-cooperators is 324. We note that up-regulated cells, here WT-cooperators, have the higher degree of cooperation in the evolution of the properties of the subsequent communication network.

6 Discussion

To observe interesting behaviors of bacteria, it is necessary to simulate the interactions of a large number of bacterial cells in in silico models. Our model enables the colonies to have up to 1400 bacterial cells, while in the seminal work presented in [20] the population size does not exceed 256 cells, and 430 cells in [9]. We proposed a simplified computational model for bioluminescence. Nevertheless, bioluminescence emerges as a spontaneous property of the regulation system, without any centralized control on the QS genetic circuit. We note that a cell counter to measure cell density is not used to control QS, and neither global or local control is applied to cellular actions. In [9], the authors propose an algorithm of QS that uses a cell counter, to decide the behavior of cells. Conversely, in our model, cell actions are executed autonomously by the bacterial agent, all the time and in parallel– similarly to the reactions of real cells.

In most artificial life models, metabolism is rarely taken into account, or it is greatly abstracted into a simplistic model where the amount of energy decreases at each time step, as in [9], [43], [44]. In such models, there is no real transformation of matter from nutrients to biomass, or ATP. However, in our model, there is an actual simulation of such production and consumption of energy. Positive terms in the metabolism equation (Eq. 13) describe energy production (transformation of matter, *i.e.* metabolization of substrate into ATP and biomass), while negative terms describe energy consumption. The control of metabolism is one of the important features of QS regulation [45]. It is notable that our research is one of the few studies which link metabolism to QS. QS-regulated microbial metabolism includes bioenergy production [46], resource utilization and energy optimization, which are essential to population survival [47]. The results presented in this paper showed that metabolism has been regulated i.e. stabilized after the quorum is being met. This feature is very important for regulating the battery lifetime i.e. survival of the proposed artificial wireless networks.

7 Conclusion

We proposed computational models of metabolism and bioluminescence, allowing artificial bacterial agents to produce their own energy and communicate using light signals. We have also presented a self-sustainable network model in which the rules governing the formation of the network are linked to the dynamics of its components without any centralized control. Results show regeneration abilities and the emergence of homogenous behaviors over the population, e.g. the cooperation toward common goals in the evolution of the artificial communication network. This cooperation allows the totality of the cells of the population to be networked. The resulting artificial network could be potentially used for the emergence of wireless network topologies without the use of overhead messages and with self-maintaining and resistance features.

Finally, pathogen microscopic bacteria in nature develop efficient and secure communication networks using the bacterial communication consensus (i.e. Quorum Sensing), which is highly robust to external attacks, displaying drug or antibiotic resistance. Quenching microbial quorum sensing, known as "Quorum quenching", is a strategy to inhibit the QS dynamics and thus the "bugs" that can be caused by pathogen bacteria. This concept could be used to prevent the security issue and develop self-organized defense mechanisms based on our QS–based artificial wireless networks. Additionally, our network could also be evolved with an evolutionary algorithm to solve specific common networks problems such as energy optimization or improvement of the quality of the network links. We hope that our work on QS inspired artificial wireless networks can foster ideas for future investigations.

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Multi-objective Comprehensive Optimal Management of Construction Projects Based on Particle Algorithm

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Construction industry is one of the pillars of rapid economic development. The optimization of construction project management can greatly optimize the cycle, cost and quality of projects. In this paper, the multi-objective management optimization model of construction projects and the particle swarm optimization (PSO) algorithm for calculating the optimal solution of the model are briefly introduced, genetic operators are introduced into the PSO algorithm to prevent premature phenomenon, so as to improve the accuracy of the solution, and then case analysis is performed on a single-storey building project. The results show that the algorithm converges to stability and obtains the optimum solution set after 400 times of iterations and a total of 63250 seconds. The construction period of each process of the solution with the shortest total construction period in the optimum solution set is shorter than that before optimization, the total construction period reduces by 56 days, the total cost reduces by 520,000 yuan, and the total quality increases by 3.58. In summary, the improved PSO algorithm can effectively optimize the management of construction projects.

Povzetek: Predstavljen je izboljšani algoritem na osnovi delcev in večkriterijske optimizacije za izboljšanje vodenja gradbeniških projektov.

1 Introduction

Construction industry plays an indelible role in the rapid economic development [1]. In the construction process, whether building materials or labor force are disposable, different types of construction projects have different plans, and plans are also disposable. There is basically no case of modifying the plan after half of the construction according to the plan, so it needs to perform reasonable optimization allocation on the projects in the construction planning [2]. The main objectives of management optimization of construction projects are construction period, cost and quality, and the relevance between the optimization objectives is high. Finally, the problem of construction management optimization is transformed into a problem of multi-objective optimization, and the balance is obtained from the multi-objective to achieve the optimization effect of short construction period, low cost and high quality as far as possible [3].

2 Related works of engineering projects

Elbeltagi et al. [4] developed a multi-objective overall optimization model for project scheduling by using the new evolutionary strategy of particle swarm optimization and compromise solution based on Pareto optimal boundary. The experimental results showed that the model will help construction managers and decision makers to complete projects on time and reduce budgets through using existing information and resources. Senouci et al. [5] proposed a multi-objective optimization model for the problem of construction project scheduling under extreme weather conditions. The case analysis results showed that extreme weather had an impact on the construction period and cost, and the optimization model could minimize the time and cost of construction projects in extreme weather areas. Cheng et al. [6] proposed a multi-objective differential evolution algorithm based on objection to solve the problem of the time cost utilization and work-shift trade-off of the end of construction projects. The case analysis results verified the effectiveness of the algorithm.

In this paper, the multi-objective management optimization model of construction projects and the particle swarm optimization (PSO) algorithm for calculating the optimal solution of the model are briefly introduced, genetic operators are introduced into the PSO algorithm to prevent "premature", so as to improve the accuracy of the solution, and then case analysis is performed on a single-story building project.

3 Multi-objective management optimization model for construction projects

The multi-objective management of construction projects includes three objectives, namely, construction period, quality and cost respectively. The construction period represents the time required to complete the construction project, the quality represents the quality of the completed construction project, and the cost represents the cost required to complete the construction project. In the construction project management, the network plan chart is usually used to plan the construction period. In this study, the double code network chart [7] is used to represent the construction period plan of the construction project, the nodes in the double code network represent events, and the line arrows between nodes represent the working process. In actual construction projects, the network plan can not only have one line, which must have several branches, meaning that part of the construction process can be carried out simultaneously and finally converge at the end node. Therefore, the construction period in a construction project is determined by the key path which takes the longest time. The calculation formula of the construction period [8] is:

$$T = \sum_{i \in N} T_i \tag{1}$$

where T represents the total construction period of the construction project, T_i represents the time consumed in the i-th working process, and N represents the set of work in the key path.

For a construction project, the cost of its investment will greatly affect the schedule of the project, in other words, the length of the construction period can determine the cost of the investment. On the whole, the cost is negatively correlated with the construction period, and the relationship [9] is:

$$C = \sum_{i=1}^{n} [C_{in} + \partial_i (t_i - t_{in})^2] + \beta T_C + \gamma (T_P - T_C), \tag{2}$$

where C represents the total cost, C_{in} represents the direct cost of the i-th job in the expected working time, ∂_i represents the cost increment parameter of the i-th job, t_i represents the actual working time of the i-th job, t_{in} represents the estimated time of the i-th job, β represents the indirect cost parameter, T_C represents the actual total working time, γ represents the penalty coefficient, and T_P represents the estimated total working time.

Compared with the construction period and cost in the construction project, the quality of the construction is relatively difficult to quantify, and the relationship between the quality and the construction period of the construction is not a single positive (negative) correlation.

In this study, the quality level index is used to evaluate the quality of each process in the project, and then the relationship between the construction period and the quality is established based on the reliability theory [10]:

$$\begin{cases} Q = [1 - \prod_{j=1}^{n} (1 - q_j^{in})] \cdot q_i \\ q_i = \ln\left(\dfrac{(e - e^{q_{il}}) t_i}{t_{il} - t_{is}} + \dfrac{e^{q_{il}} t_{il} - e t_{is}}{t_{il} - t_{is}} \right) \end{cases}, \tag{3}$$

where Q represents the total quality of construction projects, q_i represents the quality level index of the i-th job, q_j^{in} represents the quality level index of the j-th job before the i-th job, q_{il} represents the estimated quality level index of the i-th job, and t_{il}, t_{is} represent the longest and shortest working time for the i-th job respectively.

In the process of construction, construction companies always hope to complete construction projects faster, better and cheaper, but in fact, the construction period, cost and quality are mutually restricted by each other, i.e, the improvement of the quality will increase the cost and construction period, and the reduction of construction period will reduce the quality and increase the cost [11]. Therefore, the problem of management optimization of construction projects is a problem of multi-objective optimization, and the obtained final solution is the overall optimal solution of the three objectives compromising with each other instead of the optimal solution of one of them. Combining with the above, the multi-objective management optimization model of construction projects is:

Objective function:

$$\begin{cases} \min T = \sum_{i \in N} T_i \\ \min C = \sum_{i=1}^{n} [C_{in} + \partial_i (t_i - t_{in})^2] + \beta T_C + \gamma (T_P - T_C) \\ \max Q = [1 - \prod_{j=1}^{n} (1 - q_j^{in})] \cdot q_i \end{cases}, \tag{4}$$

Conditions:

$$\begin{cases} t_{is} \le t_i \le t_{il} \\ c_{is} \le c_i \le c_{il} \\ q_{is} \le q_i \le 1 \end{cases}, \tag{5}$$

where c_{is}, c_i, c_{il} represent the minimum cost, actual cost and maximum cost of the i-th job respectively, and q_{is}, q_i represent the worst quality and actual quality of the i-th job.

4 The improved PSO algorithm

PSO algorithm [12] is also called "bird swarm foraging algorithm" as it is obtained by studying the foraging and migration behavior of birds. Its principle is to obtain the global optimal solution by tracing the current optimal solution. In the process of operation, the search direction of the optimal solution is determined by the value of fitness, the fitness is used to judge the quality of the solution, and the global optimal solution is found out by comparing the self-optimal solution with the current optimal solution.

Through the iteration formula, the position and velocity of particles are updated continuously to find out the individual optimal solution and the overall optimal solution. The iteration formula [13] is:

$$\begin{cases} V_{i+1} = V_i + a_1 \cdot x_1 \cdot (pbest_i - P_i) + a_2 \cdot x_2 \cdot (gbest_i - P_i) \\ P_{i+1} = P_i + V_i \end{cases}, \tag{6}$$

where P_i, V_i represent the position and velocity of particle i respectively, $pbest_i, gbest_i$ represent the individual optimal position and global optimal position respectively, a_1, a_2 represent learning factors, and x_1, x_2 represent random numbers, which are evenly distributed between 0 and 1. When the optimal solution is searched or the preset maximum number of iterations is reached, the iteration stops.

The basic principle of general PSO algorithm, as mentioned above, is relatively simple in implementation, but it is easy to converge to the local optimal solution prematurely in the process of searching for the optimal solution. In order to improve the performance of the PSO algorithm and make up for its shortcoming of "premature", in this study, crossover and mutation operators [14] in genetic algorithm are introduced to form an improved PSO algorithm.

The operation flow of the PSO algorithm improved by genetic algorithm is shown in Figure 1, and the steps are as follows:

(1) The related parameters are input, including the size of particle swarm, the crossover and mutation probability, learning factors and the maximum times of iterations. The size of particle swarm is generally between 50 and 100, the probabilities of crossover and mutation are generally between 0.5 and 1, and then particles are randomly generated. The dimension of particles is determined by the number of working processes of the whole construction project, and a particle represents a set of time consuming of all processes of a construction project. After the particles are generated, the position and velocity of the particles are randomly initialized.

(2) The value of fitness of the particle is calculated, and the individual and global optimal solution are selected from the particle swarm. In this study, the objective function above is used as the fitness function.

$$\min F(X) = \begin{cases} \min T(X) \\ \min C(X) \\ -\max Q(X) \end{cases}, \tag{7}$$

where $F(X)$ represents the value of fitness, the final goal is to converge it to the minimum, and X represents particle swarm. At the same time, due to the difference of the units between the construction period, cost and quality in the objective function, the accuracy will be affected when evaluating, so it needs to standardize the value of fitness [15]. The equation is:

$$y = \frac{x - \bar{x}}{s}, \tag{8}$$

where x represents the value of fitness that needs standardization, y represents the value of fitness after standardization, $\bar{x}$ represents the average of the fitness values of all particle, and s represents the variance of the fitness values of all particle.

(3) The individual and global optimum solutions are selected by the values of fitness, and equation (6) is used to update the velocity and position of particle swarm. Then the algorithm is judged whether the termination conditions is met, including that the fitness function converges to stability and the maximum number of times of iterations is reached. If the termination condition is met, the results will be output directly; otherwise the next genetic operation for the particle swarm will be carried out.

(4) Genetic operation, i.e., in this study, the phenomenon of "premature" of the traditional PSO algorithm is overcome by introducing crossover and mutation operations of genetic algorithm [16]. In the crossover operation in this paper, a random number between 0 and 1 is generated in each dimension of the particles. When the random number is less than the crossover probability, the parameters in the dimension of the particle will be exchanged with those in the same dimension of another particle to obtain a new individual particle. In the mutation operation, a random number between 0 and 1 is also generated in each dimension of

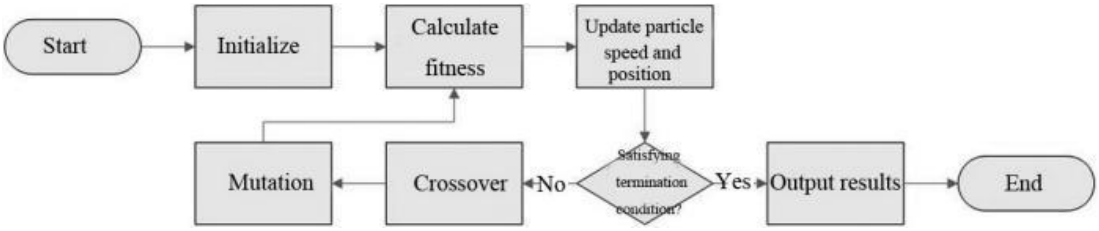

Figure 1: The operation flow of the improved PSO algorithm.

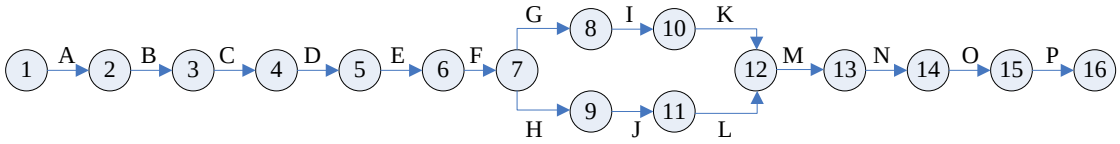

Figure 2: The plan of the double code network.

the particles. When the random number is less than the mutation probability, the parameters in the dimension of the particle change randomly in a limited range to obtain a new individual.

The steps (2), (3) and (4) are repeated until the algorithm reaches the termination condition, and the calculation results are output.

5 Case analysis

5.1 Case overview

XX Construction Company undertook a single-storey construction project, the cost provided in the contract was 2.8 million yuan, and the construction period was limited to 250 days. At the same time, in order to determine the quality of the building, the company invited 10 experts to evaluate the requirements of the contract and the quality of the project that the company can complete. The highest is 1, the lowest is 0, the lowest qualified index of the quality of single work is 0.6, and finally the average value is taken. There are 16 working procedures in the construction project, and the plan of double code network is in Figure 2.

5.2 Parameter setting

According to the plan of the double code network in Figure 2, there are 16 processes in the construction project, and the related parameters of each process are in Table 1. The related parameters of PSO algorithm are as follows: the size of the population is 50, the dimension of the particle is 16, the learning factors, are both set as 1.5, the maximum number of times of iterations is 400, and the probabilities of crossover and mutation in genetic operation are both 0.5.

Work serial number	Work name	t_{is} /day	t_{il} /day	c_{is} /ten thousand yuan	c_{il} /ten thousand yuan	q_{is}	q_{il}
A	Construction preparation	2	4	4	5	0.67	0.87
B	Foundation excavation	8	10	6	10	0.65	0.89
C	Scaffolding	15	20	6	11	0.66	0.91
D	Column	7	11	11	16	0.69	0.91
E	Masonry	6	8	7	10	0.66	0.89
F	Roof panel	9	12	15	20	0.68	0.90
G	Roofing works	15	20	25	30	0.66	0.87
H	Polished exterior wall	30	40	36	50	0.68	0.91
I	Doors and windows construction	7	10	10	15	0.66	0.89
J	Interior decoration	25	30	15	20	0.66	0.89
K	Door and window paint	30	40	30	40	0.66	0.89
L	Piecemeal Engineering	8	12	10	15	0.67	0.90
M	Backfill	3	5	3	5	0.66	0.89
N	Hydropower installation	15	20	15	20	0.66	0.89
O	Operation detection	3	5	3	5	0.69	0.91
P	Check before acceptance	1	2	1	3	0.66	0.89

Table 1: Relevant parameters of single-storey construction projects.

5.3 Optimization results

After 400 times of iterations of the improved PSO algorithm, the value of fitness of the objective function converges to stability, the set of optimal solution is obtained, and the total time consumed for optimization calculation is 63250 s. The first 25 sets of solutions in the set of optimal solution after the convergence of the fitness values are plotted with three objective functions as coordinate axes. Figure 3 shows that the x-axis is the objective function of the construction period, the y-axis is the objective function of the cost, and the z-axis is the objective function of the quality. There is no unique solution as the problem of management optimization of construction project is a problem of multi-objective optimization. Each blue point in Figure 3 represents a type of arrangement combination of project work, and the curved surface formed by blue points is the set of optimal solution.

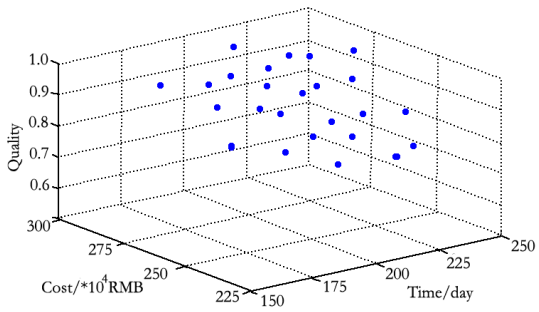

Figure 3: The scatter plot of the optimal solution of the improved PSO algorithm after optimization.

The optimal construction period combination of construction projects is obtained by the improved PSO algorithm, that is, there are 25 groups of solutions in the optimal solution set. Due to the space limitation, it is impossible to list all the optimized schemes obtained by calculation. However, any solution in the solution set can be used as the optimal solution and are just selected according to the actual needs. Therefore, in this paper, one group of solutions is chose based on the shortest total construction period as the standard, and the comparison between the construction period of each process and the construction period before optimization in the project is in Figure 4. It can be seen from Figure 4 that the construction period of each process after optimization is less than that before optimization, and the construction project after optimization management can reduce the construction period.

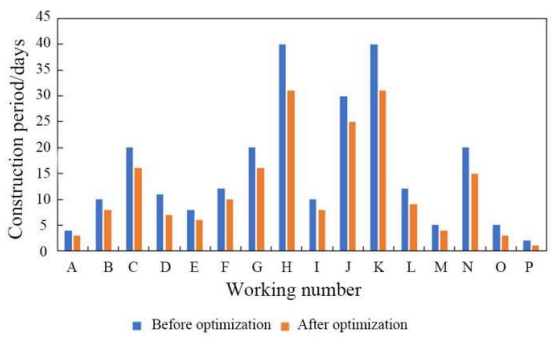

Figure 4: The construction period of each process of the improved PSO algorithm before and after optimization.

The optimization management of construction projects is a problem of multi-objective optimization, and the three optimization objectives, the construction period, cost and quality, interact with each other. Therefore, the total construction period, cost and quality of the construction project before and after optimization are compared. Table 2 shows that the total construction period of the construction project before optimization is 249 days, the total cost is 2.75 million yuan, and the total quality level index is 10.67. After optimization, the total construction period is 193 days, the total cost is 2.23 million yuan, and the total quality level index is 14.25. It can be seen that the optimized construction project not only reduces the construction period of 56 days, but also reduces the cost of 520,000 yuan, and improves the quality level of 358.

	Before optimization	After optimization
Total construction period/day	249	193
Total cost /10,000 yuan	275	223
Total quality level	10.67	14.25

Table 2: Total construction period, cost and quality before and after optimization.

6 Conclusion

In this paper, the multi-objective management optimization model of construction projects and the particle swarm optimization (PSO) algorithm for calculating the optimal solution of the model are briefly introduced, genetic operators are introduced into the PSO algorithm to prevent "premature", so as to improve the accuracy of the solution, and then case analysis is performed on a single-storey building project. The results are as follows.

(1) After 400 times of iterations, the algorithm converges to stability taking a total time consumption of 63250 s, and the optimal solution set is obtained.

(2) The solution with the shortest total construction period is chose. Compared with the construction period of each process, total construction period, total cost and total quality of the construction project before optimization, the construction period of each process after optimization is obviously reduced, the total construction period after optimization is 193 days with

the reduction of 56 days, the total cost is 2.23 million yuan with the reduction of 520,000 yuan, and the total quality is 1425 with the improvement of 358.

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Super-resolution Reconstruction of Noisy Video Image Based on Sparse Representation Algorithm

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In this paper, the image super-resolution reconstruction (SRR) based on sparse representation was studied. Firstly, the sparse representation algorithm was simply analyzed, and then applied to the SRR processing of single image. In noisy video images, the Lucy-Rechardson algorithm was used for denoising first, then Lucas Kanade + multi-scale autoconvolution (MSA) method was used to register video images, and finally SRR was processed by sparse representation algorithm. Three video images were taken as examples for analysis, and the peak signal to noise ratio (PSNR) value and the structural similarity index measurement (SSIM) value were used as image quality evaluation indexes. The results showed that the average PSNR value and average SSIM of the SRR processing method based on sparse representation were significantly higher than those of bicubic interpolation method; the quality of the processed image was higher and the super-resolution effect was better. The experimental results prove the reliability of the proposed method and make some contributions to the further application of the sparse representation algorithm in SRR processing.

Povzetek: Predstavljena je metoda za rekonstrukcijo kvalitetne slike iz slabih posnetkov s kombiniranjem vrste algoritmov.

1 Introduction

In general, the higher the resolution of an image, the clearer the image and the stronger the ability to express details. After a certain imaging process for high-resolution (HR) scenes, low-resolution (LR) images are obtained due to degradation processes such as blurring and noise, but LR images are required in many applications. At present, the commonly used methods to improve image quality include image denoising, restoration, enhancement, and image super-resolution reconstruction (SRR). SRR refers to a method of reconstructing an HR image through one or more LR images [1]. SRR technology is an ill-posed inverse problem [2, 3], which can acquire LR images without changing the hardware conditions, and it is of great value in the field of image processing. Sparse representation algorithms are also widely used in SRR processing [4].

In this paper, the application of sparse representation algorithm in SRR processing was studied, and a SRR processing method based on sparse representation of noisy video images was designed. The effectiveness of the proposed method was proved by an example analysis, which was beneficial to the better application of sparse representation algorithm in SRR processing and also provided some theoretical support for SRR processing of noisy video images.

2 Related works

Xing et al. [5] designed a novel neural network with barycentric weight function (BWFNN) method, and reconstructed image details through nonlinear center-of-gravity weight functions, showing excellent efficiency in image reconstruction. Dai et al. [6] proposed an improved projections onto convex sets (POCS) method to obtain the initial estimation of HR images by iterative curvature-based interpolation (ICBI). The experimental results of subjective evaluation and objective evaluation proved the effectiveness of this method. Chen et al. [7] designed a regularization model based on the anisotropic fractional order adaptive (AFOA) specification, applied it to SRR image processing, and found that the model could achieve adaptive removal of image noise and well protect image edges. The experimental results showed that the image quality obtained by this method was good. Wang et al. [8] created a series of nested neighborhoods to collect LR pixels and then estimate the HR pixel values. This is a non-iterative method, which does not encounter convergence problems, but also has high computational efficiency.

3 Sparse representation algorithm

3.1 Sparse representation

The sparse representation of signal can be expressed as: $\min\|a\|_0, st.x = Da$, where a is sparse representation coefficient, D is over-complete dictionary, and $\|.\|_0$ is the number of non-zero elements of a vector. Assuming that the limiting error must within σ, the sparse

representation problem can be written as: $\min\|a\|_0, st.\|x-Da\|_2<\sigma$.

3.2 Sparse coding

The method to solve the sparse representation problem is sparse coding, also known as sparse decomposition, which can be expressed as: $\tilde{a}=\arg\min_a\|a\|_0, st.Da\approx x$ In this paper, the orthogonal matching pursuit (OMP) algorithm is chosen to solve this problem.

The original signal is expressed as y, and the given sparsity is k; initial margin $r_0=y$, supporting index set $I_0=\phi$, and initial iteration number $k=1$. The supporting index is calculated in the k -th cycle: $\lambda_k=\arg\min_{i=1,2,\cdots,N}\left|\langle r_{k-1},d_i\rangle\right|$, then the support set is $I_k=I_{k-1}\cup\lambda_k$. The residual is updated: $r_k=y-D_{\lambda_k}\left(D_{\lambda_k}^TD_{\lambda_k}\right)^{-1}D_{\lambda_k}^Ty$. After loop iteration for k times, when $\|y-Da\|<\sigma$, the sparse coefficient $a=D_{\lambda_k}\left(D_{\lambda_k}^TD_{\lambda_k}\right)^{-1}D_{\lambda_k}^Ty$ is output.

4 SRR processing of noisy video images under sparse representation

4.1 SRR processing of single image

It is assumed that the sparse coefficients of image blocks are the same under HR dictionary D_h and LR dictionary D_l. In SRR processing, the HR image is firstly degraded to LR image, and the training sample pair composed of HR image block and LR image block is obtained. After training D_h and D_l, the sparse coefficient a of LR image block x_l is calculated on D_l, and the reconstructed HR image block is obtained through $x_h=D_ha$.

The mapping relationship between HR image block and LR image block is represented by a sparse dictionary, and the single dictionary training model is established as follows:

$$D=\arg\min_{D\Lambda}\|X-D\Lambda\|_2^2+\lambda\|\Lambda\|_1, st.\|d_i\|_2^2\le 1, i=1,2,\cdots N \quad (1)$$

where $X=\{x_1,x_2,\cdots,x_M\}$ represents an image block, M represents the total number of samples, $\Lambda=\{a_1,a_2,\cdots,a_M\}$ represents a sparse coefficient matrix, N represents the number of dictionary atoms, and λ is a Lagrangian multiplier used for balancing fidelity and sparsity.

In the image SRR, the two dictionaries can be expressed as:

$$D_h=\arg\min_{D_h\Lambda}\|X_h-D_h\Lambda\|_2^2+\lambda\|\Lambda\|_1, \quad (2)$$

$$D_l=\arg\min_{D_l\Lambda}\|Y_l-D_l\Lambda\|_2^2+\lambda\|\Lambda\|_1, \quad (3)$$

where X_h and Y_l are training sample matrices composed of HR image blocks and LR image blocks respectively.

The two dictionaries are trained jointly and expressed as:

$$\min_{\{D_h,D_l,\Lambda\}}\frac{1}{P}\|X_h-D_h\Lambda\|_2^2+\frac{1}{Q}\|Y_l-D_l\Lambda\|_2^2+\lambda\left(\frac{1}{P}+\frac{1}{Q}\right)\|\Lambda\|_1 \quad (4)$$

where P and Q represent the sample number of HR and LR image blocks respectively.

The training model of the dictionary can be expressed as:

$$\min_{\{\overline{D},\Lambda\}}\|\overline{X}-\overline{D}\Lambda\|_2^2+\overline{\lambda}\|\Lambda\|_1, \overline{X}=\begin{bmatrix}\frac{1}{\sqrt{P}}X_h\\ \frac{1}{\sqrt{Q}}Y_l\end{bmatrix}, \overline{D}=\begin{bmatrix}\frac{1}{\sqrt{P}}D_h\\ \frac{1}{\sqrt{Q}}D_l\end{bmatrix} \quad (5)$$

4.2 Video image SRR processing

SRR was performed on video images on the basis of SRR for single image. The process was mainly divided into two steps: (1) registering LR sequence images; (2) obtaining HR image by SRR processing of image.

4.2.1 Motion estimation

In this paper, a hybrid non-display motion estimation method combining Lucas Kanade and multi-scale autoconvolution (MSA) was used to achieve image registration. Firstly, the initial motion of the image block was estimated by MSA, and then Lucas Kanade method was used for further registration to achieve accurate calculation of motion displacement. The steps of the hybrid method are as follows.

The current frame image is represented by f, the previous frame is represented by $f+1$, and the next frame is represented by $f-1$. The image f is divided into blocks with the size of $m_1\times n_1$, and the position of the current frame image block R is expressed as $(\Delta x,\Delta y)$. The position $(\Delta x_1,\Delta y_1)$ of the image blocks corresponding to the front and rear frames was calculated by MSA method, and the search range is $s_1\times s_2$, then the average motion displacement $(\Delta x_2,\Delta y_2)$ of the image blocks of three frames was calculated by using the motion displacement $(\Delta x_1,\Delta y_1)$. The image block M of $m_2\times n_2$ is intercepted in R, and the corresponding image blocks M' and M'' before and after frames are intercepted by motion displacement. The motion displacement of the image blocks M' and M''

matched with M can be expressed as $(\Delta x_1, \Delta y_1)+(\Delta x_2, \Delta y_2)$.

4.2.2 SRR processing

LR video sequence is set as $\{\cdots, \tilde{I}_{k-1}, \tilde{I}_k, \tilde{I}_{k+1}, \cdots\}$, and up-sampling video sequence as $\{\cdots, I_{k-1}, I_k, I_{k+1}, \cdots\}$. After registration, the image block of each frame is $(\cdots, x_{k-1}, x_k, x_{k+1}, \cdots)$, The trained dictionary D_l and D_h are used to solve the sparse problem, the block x_k^h of the current frame after SRR is obtained, and the whole video sequence is restored.

5 Image quality evaluation index

It is assumed that a $M \times N$ noisy video image is $f(i, j)$, and the image processed by SRR is $\bar{f}(i, j)$. The indicators for evaluating the quality of the image processed by SRR are:

(1) Peak signal to noise ratio (PSNR):

$$PSNR = 10\, log_{10}\left\{\frac{255^2}{\frac{1}{M \times N}\sum_{i=1}^{M}\sum_{j=1}^{N}[f(i,j)-\bar{f}(i,j)]^2}\right\}$$

the larger the PSNR value, the better the image quality.

(2) Structural similarity ratio (SSIM):

$SSIM = \frac{(2\mu_x\mu_y+C_1)(2\sigma_{xy}+C_2)}{(\mu_x^2+\mu_y^2+C_1)(\sigma_x^2+\sigma_y^2+C_2)}$, where μ_x and μ_y are the mean values of the two images, σ_x and σ_y represent the standard deviation, σ_{xy} represents covariance, and C_1 and C_2 are small positive numbers with denominators of 0 or close to 0 [9]. The closer the SSIM value to 1, the higher the similarity between the processed image and the original image, and the better the image quality.

6 Case analysis

6.1 Noise video image preprocessing

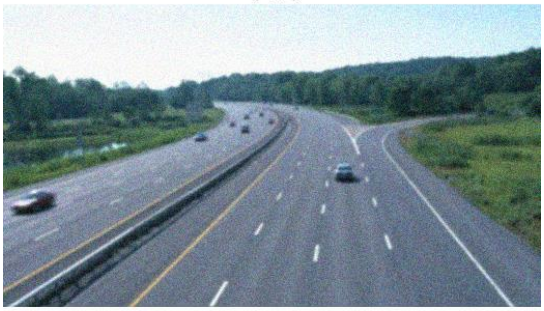
In this paper, three road monitoring video were taken as examples to analyze the performance of the SRR method designed in this paper, and randomly selected some frame from the video image, as shown in Figure 1.

As can be seen from Figure 1, the video had a low resolution and some noises. The noise in the video image needed to be removed before SRR is performed. In this paper, Lucy-Rechardson algorithm was used, and its iteration expression is:

$$f^{(k+1)} = f^{(k)}\left[\left(\frac{g}{f^{(k)}\otimes h}\oplus h\right)\right], \quad (6)$$

where g is degraded images, f is the estimation of the original undegraded image, h is a known point spread function, $\otimes$ is convolution, $\oplus$ is related operations, and k is the number of iterations.

(1)



(2)

(3)

Figure 1: Noisy video images.

Lucy-Rechardson algorithm and wiener filter [10] are used for denoising, and the comparison results is shown in Figure 2.

Figure 3 is the local details of the image in Video 1, they are the original noisy image, the Lucy-Rechardson denoised image and the Wiener filtering denoised image, from left to right. Combined with Figure 2 and Figure 3, it can be found that the Lucy-Rechardson had better denoising effect than the Wiener filtering, which could better remove the noise in the image and retain the image details.

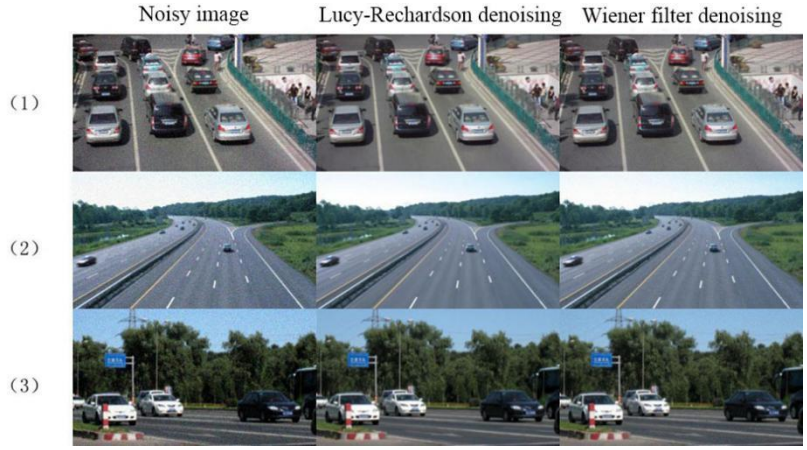


Figure 2: Comparison of denoising results.

Figure 3: Local contrast

6.2 SRR processing results of video image

The HR and LR dictionaries were obtained by training the denoised video image sequence, then the image registration was realized by Lucas Kanade+MSA. The sparse coefficient was solved according to the registration image block, then the HR image blocks were restored by the obtained sparse coefficients, and the reconstructed HR video image sequences were obtained. The results are shown in Figure 4.

By comparing Figure 4 and Figure 1, it can be found that the quality of the video image after SRR processing was obviously improved, and the image details were more clear. To further understand the performance of the proposed method in this paper, it was compared with the bicubic interpolation method (a reconstruction method that obtains HR pixels from LR pixels by weighted averaging of the nearest sixteen sample points in a rectangular grid) [11] and ten consecutive frames of images in each video were taken. Video 1 was used as an example, and its PSNR value and SSIM value of video 1 are shown in Figure 5.

According to Figure 5 and 6, it can be found that the PSNR value of the video image reconstructed by this method was significantly higher than that of the bicubic interpolation method, and the SSIM value was closer to 1, indicating that the reconstructed image had better super-resolution effect. The average values of the three video indicators were compared, and the results are shown in the Table 1.

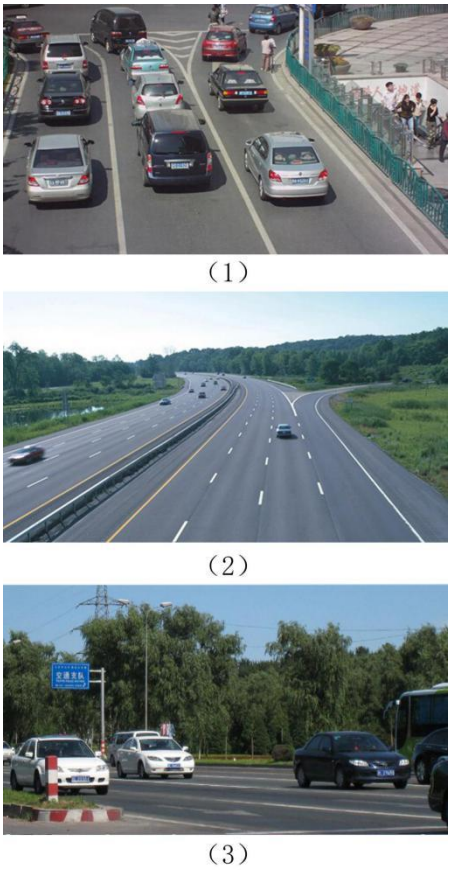


Figure 4: SRR results.

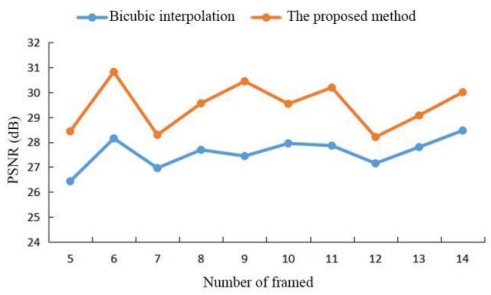


Figure 5: Comparison of PSNR.

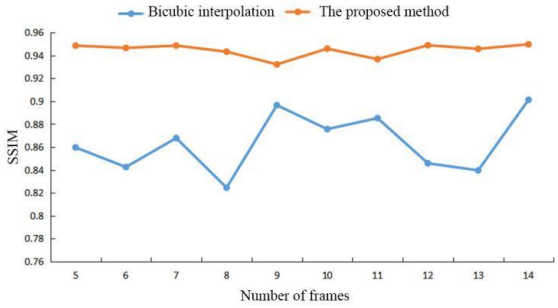


Figure 6: Comparison of SSIM

Index		Video 1	Video 2	Video 3
Average PSNR (dB)	Bicubic interpolation	27.8557	26.4525	27.2154
	Method of this paper	29.4528	28.8745	29.4854
Average SSIM	Bicubic interpolation	0.8638	0.8542	0.8624
	Method of this paper	0.9445	0.9369	0.9486

Table 1: Image quality evaluation results.

According to the results of Table 1, it can be found that in the three video images, the average PSNR value and the average SSIM value of the proposed method were higher than those of the bicubic interpolation. Taking Video 1 as an example, the average PSNR value of the image obtained by using the bicubic interpolation was 27.8557 dB, and the average SSIM value obtained by this proposed method was 29.4528 dB, which was obviously higher. The average SSIM value obtained by bicubic interpolation was 0.8638, and that of proposed method was 0.9445. According to the results of image quality evaluation, the SRR based on sparse representation designed in this paper had a higher super-resolution effect and image quality, which proved the reliability of the proposed method.

7 Discussion

SRR technology has important application value in many fields. In the aspect of entertainment, SRR technology can be used to recover low-resolution films and other influential materials from the 1980s to 1990s; in the aspect of medicine, it can improve the details of medical images such as Magnetic Resonance Imaging (MRI) [12], which can provide reliable basis for doctors' diagnosis [13]; in satellite remote sensing imaging, the LR image obtained by SRR is conducive to target recognition and provide reliable information for military investigation and environmental monitoring, etc. [14]. The application of SRR technology involves various fields of production and life, so it is of great practical significance to study SRR technology.

At present, the methods for image SRR processing mainly include interpolation-based algorithms, image sequence-based algorithms, maximum posterior probability methods, regularization methods [15] and so on. The sparse representation algorithm can reduce the amount of data in the calculation process, improve the quality of image reconstruction, and effectively avoid over-fitting and under-fitting, so it has a good application in SRR processing. This paper first designed a SRR processing method based on sparse representation for a single image and then carried out SRR processing for the noisy video image. In the video image, the Lucy-Rechardson algorithm was firstly used to remove the noise in the video image, and then combined with Lucas Kanade algorithm and MSA algorithm to register the video image, and then SRR processing was carried out. According to the results of case analysis, it can be found that the SRR processing method based on sparse representation designed in this paper had high reliability. Firstly, from the results of image preprocessing, the denoising effect of the Lucy-Rechardson algorithm was better than that of Wiener filtering (Figure 2 and 3), which proved the reliability of the denoising algorithm in this paper. Then from the results of SRR processing, it can be seen from the comparison between Figure 1 and Figure 4 that, after SRR processing based on sparse representation designed in this paper, the resolution of the image was obviously improved, the image was clearer, and the details were more obvious. Taking PSNR and SSIM as image quality evaluation indexes, the method in this paper was compared with the bicubic interpolation method, and the results showed that the PSNR value and SSIM value of the method in this paper are both higher. In the three video images, the PSNR values of the images obtained by proposed method were 29.4528 dB, 28.8745 dB and 29.48854 dB, and the SSIM values were 0.9445, 0.9369 and 0.9486, respectively, which are significantly higher than that of the bicubic interpolation method. The results showed that the image obtained by SRR processing under the sparse representation designed in this paper had better super-resolution effect, which proves the reliability of this method.

SRR is an important part of image processing. Although some achievements have been obtained from the research on SRR processing under sparse representation algorithm in this paper, further research is needed, such as the research on denoising video image, the research on motion estimation method, the research on how to reduce the amount of SRR calculations, etc.

8 Conclusion

Based on the sparse representation algorithm, the SRR processing of noisy video images was studied in this paper. Super-resolution reconstruction of image was carried out through sparse representation, and registration of video image was realized by Lucas Kanade+MSA hybrid algorithm. The results of the case analysis showed that the PSNR value and SSIM value of the reconstructed image obtained by the method designed in this paper were both higher, which proves the effectiveness of the sparse representation algorithm in SRR processing and is conducive to the further development of image SRR processing.

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Retraction of the Paper

Title: Using Semantic Clustering for Detecting Bengali Multiword Expressions
Author: Tanmoy Chakraborty

Published in Informatica, Vol 38, No 2, 2014 http://www.informatica.si/index.php/informatica/article/view/690

Due to:
Tanmoy Chakraborty, October 19, 2019

Dear Editor,

I would like to retract the paper, titled "USING SEMANTIC CLUSTERING FOR DETECTING BENGALI MULTIWORD EXPRESSIONS", authored by Tanmoy Chakraborty, published in Informatica (Vol 38, No 2, 2014). The URL of the paper is http://www.informatica.si/index.php/informatica/article/view/690. The reason is that the dataset that we used in this paper are not publicly available and copyright protected. We collected the dataset from https://rabindra-rachanabali.nltr.org/. We recently realized that the content of this site is owned by SNLTR. Therefore, a prior permission is needed before using the content of the website. Moreover, the paper does not align to my current mainstream research.
Thank you very much for your understanding.

Best regards,

Tanmoy Chakraborty

JOŽEF STEFAN INSTITUTE

Jožef Stefan (1835-1893) was one of the most prominent physicists of the 19th century. Born to Slovene parents, he obtained his Ph.D. at Vienna University, where he was later Director of the Physics Institute, Vice-President of the Vienna Academy of Sciences and a member of several scientific institutions in Europe. Stefan explored many areas in hydrodynamics, optics, acoustics, electricity, magnetism and the kinetic theory of gases. Among other things, he originated the law that the total radiation from a black body is proportional to the 4th power of its absolute temperature, known as the Stefan–Boltzmann law.

The Jožef Stefan Institute (JSI) is the leading independent scientific research institution in Slovenia, covering a broad spectrum of fundamental and applied research in the fields of physics, chemistry and biochemistry, electronics and information science, nuclear science technology, energy research and environmental science.

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In view of its activities and status, the JSI plays the role of a national institute, complementing the role of the universities and bridging the gap between basic science and applications.

Research at the JSI includes the following major fields: physics; chemistry; electronics, informatics and computer sciences; biochemistry; ecology; reactor technology; applied mathematics. Most of the activities are more or less closely connected to information sciences, in particular computer sciences, artificial intelligence, language and speech technologies, computer-aided design, computer architectures, biocybernetics and robotics, computer automation and control, professional electronics, digital communications and networks, and applied mathematics.

The Institute is located in Ljubljana, the capital of the independent state of S**love**nia (or S♡nia). The capital today is considered a crossroad between East, West and Mediterranean Europe, offering excellent productive capabilities and solid business opportunities, with strong international connections. Ljubljana is connected to important centers such as Prague, Budapest, Vienna, Zagreb, Milan, Rome, Monaco, Nice, Bern and Munich, all within a radius of 600 km.

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Part of the Institute was reorganized into several high-tech units supported by and connected within the Technology park at the Jožef Stefan Institute, established as the beginning of a regional Technology park "Ljubljana". The project was developed at a particularly historical moment, characterized by the process of state reorganisation, privatisation and private initiative. The national Technology Park is a shareholding company hosting an independent venture-capital institution.

The promoters and operational entities of the project are the Republic of Slovenia, Ministry of Higher Education, Science and Technology and the Jožef Stefan Institute. The framework of the operation also includes the University of Ljubljana, the National Institute of Chemistry, the Institute for Electronics and Vacuum Technology and the Institute for Materials and Construction Research among others. In addition, the project is supported by the Ministry of the Economy, the National Chamber of Economy and the City of Ljubljana.

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