Multimedia Cognitive Wireless Sensor Network Cluster Routing Based on Intelligent Robot Edge Computing and Collection

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This paper proposes a clustering routing algorithm for multimedia cognitive wireless sensor networks based on edge computing and the acquisition of intelligent robots. The routing protocol can realize the efficient aggregation and transmission of perceptual data in cognitive wireless sensor networks (CRSN. Cognitive wireless sensor networks), especially clustering routing protocols, can further reduce the complexity of route selection and improve the scalability of the network, which is very important for the overall performance of the network. Therefore, in this paper, we use intelligent robot edge computing and acquisition technology to study the communication problem of multimedia cognitive wireless sensor networks. Firstly, the edge calculation and acquisition system based on intelligent robots is established. The sensor data is collected and processed in real-time by a robot, and the data is transmitted and calculated in real time. Secondly, a suggested clustered routing technique utilizes multimodal cognition to realize dynamic clustering and routing optimization of wireless sensor networks by comprehensively considering the signal strength and energy residual of network nodes. On this basis, a clustering routing strategy is proposed to divide network nodes into multiple clusters, which improves transmission efficiency and energy utilization. Finally, the effectiveness and superiority of comparative experiments are used to verify the suggested method, and the results show that the algorithm has achieved obvious effects in improving the network transmission efficiency and reducing the network energy consumption. This study provides a new idea and method for real-time transmission and calculation of multimedia cognitive wireless sensor networks.

*Povzetek***:** *Članek predlaga algoritem za usmerjanje in združevanje v multimedijskih kognitivnih brezžičnih senzorskih omrežjih, ki temelji na robnem računanju in inteligentnih robotih.*

1 Introduction

The rapid development of wireless communication technology and the popularity of computers, sensors, and information processing technologies have played a role in driving the rapid development of wireless sensors. Micro-sensors with sensory, computer, and communication capabilities have received widespread attention as a new way to process and develop information. Wireless sensor network (CRSN) is a new type of powerless and sensitive wireless sensor network. It integrates sensors, data processing units, and wireless communication modules for detecting and witnessing physical phenomena such as temperature, humidity, sound, light intensity, soil composition, etc. The combination of the logical information world and the objective physical world has changed the interaction between humans and nature. Broader networking skills and human understanding of the world. Wireless sensor networks can be widely used in military and national security, industry, agriculture, monitoring, biomedicine, environmental monitoring, and other fields. US Weekly reviews as one of the most important technologies that will have an impact on the 21st century [1].

With the development of hardware technology, low-cost CMOS cameras and multimedia sensor networks (MSN) are developed to monitor other video, sound, video, and multimedia data is critical. Wireless sensor networks collect only simple environmental data on multimedia sensor networks, multimedia sensor networks can view the prospect of applications in video surveillance, audio, image, and other multimedia information objects in security and traffic monitoring, smart medical, microphones, and other devices. This has attracted a great deal of attention from scientists both nationally and internationally [2-3]. Leading universities such as the University of California, Georgia Institute of Technology, University of Massachusetts, and Stanford University have initiated successive MSN research;

domestic research institutions, e.g., Beijing University of Posts and Telecommunications, have begun to explore this area. As sensor networks are an emerging technology, there is little difference at the domestic and international levels. It is of great strategic importance to study the best technology that will have a profound impact on human life in the future [4].

Since MSN can detect multimedia messages such as sound, video, and images, it can provide more diverse services. If bandwidth resources, processor capacity, and battery power are limited enough MSNs need to process and send multimedia information in real time. Therefore, compared with traditional wireless sensor networks, wireless sensor networks can transmit data in real-time., reliability, and efficiency put forward higher requirements. Since packet lock protocols in multimedia sensor networks can extend the life of nodes, improve lock performance, and ensure trust and shared control of the network, the design of packet key protocols with good performance is the primary element of multimedia sensor networks. The characteristics of multimedia sensor networks are analyzed, the protocols for sending wireless sensor network packets are discussed, and the protocols for sending real-time energy storage are set according to the structure of the packets.

2 Related works

Table 1: literature survey

Reference	Objective	Findings	Limitations
[5]	The objective of the paper was to describe the most recent routing methods for WSNs, highlighting designed issues and classifying routing protocols according to the way networks were set up and functioned.	The study highlighted the benefits and performance concerns of each routing strategy while evaluating design choices between energy consumption and communication overhead.	It could fail to address all circumstances and issues, even while it offered insights into the choices between conserving energy and communication overhead.
[6]	The objective of the paper was to present an enhanced artificial bee colony (ABC) algorithm-based clustering method for Wireless Sensor Networks (WSNs) that chooses the best cluster leaders.	Based on the refined ABC method, the suggested clustering algorithm efficiently chooses cluster heads by taking into account variables such as cluster head position, density, and network energy.	It could be essential to conduct additional assessments in actual implementations to verify the efficiency and expandability of the suggested methodology.
[7]	The research aimed to propose and test a strategy for deploying edge computer nodes for intelligent production.	The suggested technique performs better in terms of network latency and computing resource deployment cost when compared to the conventional k-means clustering deployment and random deployment methods.	The suggested approach can only be assessed in terms of particular metrics, including network latency and the cost of deploying computer resources, without considering other possible performance metrics or compromises under consideration.
[8]	The study suggested a hybrid approach for effective Cluster Head (CH) selection and data transfer in WSNs called Marine	Comparing the examined cluster-based route systems, the suggested MPO-IPSO-OCR yields improvements in energy	Variations in network structure, size, and other external factors could impact how successful the

	Predators Optimization and Improved Particle Swarm Optimization-based Optimal Cluster Routing (MPO-IPSO-OCR).	stability of 21.28%, network lifespan extension of 18.62%, and maximum throughput of 16.79%.	suggested strategy performed.
[9]	The study's goal was to enhance the current LEACH protocol to address the problem of energy constraint in WSNs.	They provided a new way to improve the current LEACH process and point out its flaws. Comparing the methodology's application to the fundamental LEACH strategy, we observed a notable increase in energy efficiency.	The efficacy of our methodology could vary based on certain network setups and contextual elements.
[10]	The energy consumption of Wireless Sensor Networks (WSNs) could be decreased by using Energy Consumption Optimization-based Clustering Routing (ECOR), based on the article.	According to simulation results, ECOR performs better in CH dispersion and energy consumption reduction than I-LEACH.	The paper could not address every possible scenario and the intricacies of WSNs in the actual world. Additional verification through practical trials could improve the validity of the results.
[11]	The research aimed to provide an intelligent MIMO-based 5G balancing energy-efficient protocol to tackle the issues related to energy efficiency in WSNs.	When compared to current procedures, the suggested approach showed a 30% reduction in energy used.	When implementing the protocol in real-world IoT systems, it was important to take into account its resource needs and the complexity of implementation.

Wireless Multimedia Sensor Introduction: Wireless multimedia sensor networks are a novel kind of self-organizing wireless networks that are energy-sensitive and lack architecture. Its nodes are usually equipped with miniature CMOS cameras, microphones, etc., and batteries to interact with multimedia information sources such as sound and images. The main function of multimedia sensor networks is to detect, process, and disseminate multimedia information wealth.

(1）Multimedia sensor nodes; multimedia sensor nodes are the basis of MSN and are responsible for the transmission of video/audio signals.

The information is detected and stored, in computer and network communication. Structural errors take into account the design of traditional sensor nodes, based on the principles of detail, low cost, low energy consumption, scale, and stability. Most multimedia sensor nodes consist of four parts: sensor module, processing module, wireless communication module, and power module: ① CMOS sensor module mainly includes image and sound selection functions, passive sensors for temperature and noise measurement, reaction measurement, retrieval of information about the monitored area ② Processing module controls the management of the sensor node, such as preprocessor, compression and storage of node collected information or transmitting data from other nodes ③ the wireless communication module responsible for transmitting control information between multimedia sensor nodes and between nodes and node receivers is introduced. Obtaining data collected with other nodes and sending multimedia data collected with this node: the energy supply module is used to provide energy to the multimedia sensor nodes. Currently, most nodes are activated. In passive transient sensors, node energy can be combined with environmental energy technologies such as solar energy [5-6].

Multimedia sensor nodes differ from traditional sensor nodes in their hardware architecture by using diagrams in the CMOS sensors and audio and video processors with higher processing power, for example. Currently, the main nodes of multimedia sensors can be divided into two categories: master nodes such as general-purpose microprocessors, and most nodes such as MICA and GAINZ, which use general-purpose microprocessors. The existing MSN nodes have the following drawbacks: the high energy consumption of functional nodes limits the application scope and overall availability of the network; the size of CMOS sensors is too large, twice as large as ordinary MSNs, which limits their application scope: (1) CMOS is a less destructive precision optical instrument, which is difficult to withstand under harsh and unexpected ejection conditions. Although multimedia sensor node devices have some drawbacks, this problem will soon be solved with the development of electronics, semiconductor materials, and mechanical technology.

(2) Convergence node: In general, as a power transmission device and multimedia detection node, it has a power processing function, storage function, communication function, and sufficient energy supply. It is responsible for issuing and controlling the monitoring tasks of the nodes on the network and sending monitoring decisions to the external network. The media is located between the multimedia sensor nodes and external networks (e.g., satellite and Internet).

(3) Control Center: It is responsible for querying or collecting MSN surveillance information, and can also publish surveillance information or questions on multimedia sensor network nodes, providing a user-friendly interactive interface for users to monitor, analyze, jump, and decide on information surveillance.

Main application areas: In military applications, wireless sensor networks, with their unique advantages, can be used for battlefield target determination, battlefield environment monitoring, and battlefield reconnaissance.

In the civil perimeter, wireless sensor networks can also be widely used in all aspects of our daily life, such as the environment, medical care, and smart home.

Advantages of CRSN Cluster Routing Protocol: Compared with the planned routing protocol, the packet-based routing protocol has the following advantages data integration mechanism: Data integration is the process of deleting redundant data from multiple nodes. This is a very effective way to maintain the energy of nodes in wireless sensor networks. In CRSN cluster routing protocol, cluster nodes obtain cluster member data by using data integration technology to eliminate redundancy and minimize the quantity of data that has to be sent. ②Low energy consumption: In the cluster routing protocol, on the one hand, the data integration mechanism is used to effectively reduce the information flow in the network; On the other hand, the data transmission separation between clusters only allows a limited number of cluster master nodes to carry out remote data transmission. Most conventional nodes just need to send data to the next cluster master nodes, hence lowering the network's overall power usage. ③ High utilization rate of radio communication resources: In multiple planar routing protocols, resources are allocated and managed by a single node, resulting in low channel utilization. Multi-cluster routing protocol divides the whole network into multiple clusters and provides data exchange between nodesThere are two modes: intra-group communication and inter-group communication. Accordingly, the limited channels can be converted into orthogonal channels. The allocated resources are allocated to each group, and the corresponding head node of each group is allocated to its members. Channel resources reduce the probability of signal collision between groups, and improve the utilization of radio communication resources.

3 Multimedia sensor networks cluster routing protocol

In general, WSNs consist of sensor nodes, base stations, and monitoring events. Nodes, as the most important component of the whole network, complete the transmission of information and environmental data. As the software runs on the nodes, the network's overall performance is directly influenced by the clustering protocol's architecture. The initial flat path protocol, because nodes play the same role and do not share tasks, is simple and fast to execute, but poorly scalable and poorly executed. Based on the flight path, the group path protocol divides the nodes into two parts: the group head and the members of the group, and explains their task parts. The group head is responsible for communicating with the members in the cluster, collecting member information and data, and forwarding them; group members can only see information around the node and send it to the group head, then switch to the working state. This grouping strategy divides the network into different logical partitions, thus providing better scalability and efficiency. From a design point of view, the cluster prevention protocol consists of a cluster algorithm and an inhibit protocol. The group algorithm is used to determine the criteria for selecting the group leader and the criteria for the group leader to set members in the group; the path protocol is used to determine the data transmission path and construct the network information transmission channel from the source to the destination.

$$T(n) = \begin{cases} \dfrac{P}{1 - P * \left(r \bmod \dfrac{1}{P} \right)} & n \in G \\ 0 & n \notin G \end{cases} \quad (1)$$

Whether a node n should take the lead in the group is decided by T(n). The node's membership in a candidate group G determines significance. If n is in G,T(n) is computed as($\frac{P}{1-P*\left(r \bmod \frac{1}{P}\right)}$), where r is the round number that is in effect right now and p is the probability of node selection.

The following performance metrics are commonly used when measuring the performance of cluster head algorithms. The number of K network groupings

The amount of group headers directly affects the structure and energy usage of the entire network. If the number of packets on the network is too large, the network will generate more control messages, thus increasing the number of hops to send packets. If the transmission distance is too small, the transmission distance between remote nodes will increase the energy consumption of the network nodes, so an appropriate number of group headers must be selected.

②Stability

Node stability refers to the need to rebuild the node frequency. Changing the number of group nodes can result in a large number of highly aligned nodes in the group header. Therefore, the performance of the grouping algorithm depends heavily on the ability of any node in the group header to build a stable backbone.

③Degree of overlap

In sensor networks, group nodes are responsible for controlling their groups, assigning sources to member nodes in the group, and running paths and sends between groups. Therefore, it is necessary to minimize the group header load and distribute the network load equally to each group to reduce group member node words.

④ Network load balancing

The load to be controlled by the group header nodes can be approximated by the group size, which is used to measure the load balance between groups in the network. The better the network load balancing the greater the value.

3.1 Typical clustering algorithms and protocols

① LEACH clustering protocol

LEACH low-energy transmission protocol is a common transmission protocol for wireless sensor networks and is a low-energy transmission layer [12]. The node is chosen as the group leader if its number is less than the threshold value t (n), then it applies to the current cycle. The equation for calculating the threshold (n)

$$r^2 + \left(2r^2\right) \leq R^2 \qquad (2)$$

Specifically, P is the number of rounds in which the protocol is executed and all nodes in the network send data to the aggregated nodes, called rounds, P is the percentage of expected average participation of all nodes, P is usually 0.005, and G is the set of nodes that are not selected to participate in the next round. rMOD (1/P) shows the number of nodes selected in the round. If the t(n) value is set to 0, a node in the group header is selected so that no node is selected in the group header and a node is selected from the set of nodes not selected in the group header based on the probability of t(n"). Thus, the probability of a cluster head node not being selected as a cluster head in the next 1/p cycle is 0.

In the cluster creation phase, the selected header node delivers the cluster header message to all nodes, and at the MAC layer, the non-cluster header node selects the cluster to join based on the received signal strength using the CSMA protocol. In each cluster, the cluster head node sets the TDMA manager rules based on the number of nodes in the cluster. During the stabilization phase, cluster nodes transmit data between their nodes at time intervals.

The access protocol uses the random group selection method, which can balance the network node load, reduce group power consumption, reduce group head and node traffic, and extend the network lifetime, and the ideas related to cluster head are reflected in many routing protocols that were developed later. However, in this protocol, there is a certain chance of selecting the head nodes of the group, which may be unevenly distributed in the monitoring area. In this protocol, the number of nodes in each ring is 5% of the number of surviving nodes. In experiments, there is no theoretical analysis or specific analysis of the optimal number of blocks, so it is difficult to use in all scenarios.

②GAF algorithm

The algorithm can be applied to wireless sensor networks more efficiently [13]. The first algorithm divides the monitoring area into a virtual cell, and each sensor node selects its cell based on geolocation information. The key of the same cell is the same when sending data packets. The wake-up process and the function of node e group are applied to each cell to achieve load balancing.

The implementation of the GAF algorithm includes the partitioning of virtual cells and the selection of cluster nodes in virtual cells. In virtual cell partitioning, the whole network area is divided into several small virtual cells based on the location of the nodes and the radius of the messages, and any node in a neighboring cell can be directly connected, making the nodes in the same cell equal in terms of routing. Assuming that the communication area of the node is set to R and all the location information of the monitoring area is set to R, the edge length of the cell R can be determined by the following relation.

③UCR protocol

UCR is a heterogeneous clustering protocol in which cluster headers use non-homogeneous competing bands to form cluster heads of varying sizes with relatively few members, and group headers save energy for inter-group data transmission [14]. At the beginning of each data collection cycle, it reconstructs the group headers by selecting high-energy nodes as a group to ensure a uniform load to the network.

First, each node selects a set of eligible objects based on a preset threshold of T. The titles of the eligible objects are calculated based on their distances from the nodes, and the closing range is determined after becoming a group head through wireless competition. the RC competition radius is calculated as follows. $R_i = \left(1 - c\frac{d_{\max} - d\left(s_i, BS\right)}{d_{\max} - d_{\min}}\right)R_0$

(3)

D (Si, BS) denotes the distance between Si nodes and convergence nodes, and Dmax and Dmin denote the maximum and minimum distance based on SI nodes and convergence nodes. The distance between wireless content nodes and convergence nodes decreases linearly.

④VGA protocol

The VGA algorithm is a fixed-size cluster in a linear virtual cell, and different group selection mechanisms are used to move the ad-hoc network according to the needs of the situation [15]. The algorithm builds a simple, stable, and easy-to-propagate virtual master network based on node location information, in which nodes are divided into uniform and heterogeneous bodies, respectively. where Ei (t) is a distance of node i relative to the region's center, Bi (t) is the node's remaining power at time t, and Vi (t) is its moving speed.

⑤ACE algorithm

ACE (Algorithm for Cluster Establishment) is an adaptive distributed algorithm [16]. The algorithm consists of two logical parts: cluster creation control and dynamic migration of clusters. Each node independently implements the ACE algorithm and when new manifolds overlap with existing ones, it is necessary to create new clusters and move them from other clusters to minimize the overlap between clusters. The two logical parts of the algorithm repeat the structural clustering in the nodes.

In the ACE algorithm, nodes are divided into three states. The Unclustered state indicates that the node has not yet been added to any cluster header, the Cluster state indicates that the node has become a member or member of a cluster and that the node cluster header has become a cluster when the protocol is in effect. All nodes are in the Unclustered state. When the iteration loop starts for each node, different iteration algorithms are implemented depending on the state of the node.

$$EF_i(t) = a_1 e^{-vi(t)} + a_2\left(1 - Q_i(t)\right) + a_3 B_i(t) + a_4\left(1 - E_i(t)\right) \quad (4)$$

Each component is given a weight, a_1, a_2, a_3, a_4 to balance its impact. It is associated with the node's availability ($e^{-vi(t)}$), utility ($B_i(t)$), residual energy ($Q_i(t)$), and overall fitness ($EF_i(t)$IT).

ACE algorithm provides faster response, more reliable packet loss and node failure response, and efficient data transmission. Clustering flow form can effectively reduce clustering repetition, reduce coupling interference, and make the adaptive algorithm flexible in large-scale networks.

⑥distributed weight-based energy-efficient hierarchical clustering (DWEHC) protocol

This protocol was proposed by Dean et al. in 2005. Unlike LEACH and HEED protocols, LEACH and HEED protocols use a multi-level group structure to divide the nodes of a group into multiple levels, and the lower-level node data is eventually sent to the group through multiple nodes [17].

Each node calculates the weights of its candidate nodes based on local topology information. For any node, it is based on the formula

$$W_{\text{weight}}(s) = \frac{E_{\text{residual}}(s)}{E_{\text{initial}}(s)} \times \sum_u \frac{R - d}{6R} \quad (5)$$

In the above equation, $_{\text{Residual}}$ (s) is the energy of the rest of the node; E_{initial}(s) initial energy is the node's starting energy; R is the group's radius; while u is the node's adjacent value; D is the distance between node U and node S. If the value of the node is calculated based on a formula stronger than the other nodes in the radius of R, select this node as the group, level 0, and other nodes can be directly linked to level 1 of the cluster head node. Power consumption will be kept to a minimum and the traditional cluster head will be updated constantly. Provides the ability to send data to cluster points directly or with multiple buttons. The classical model can evaluate the topology information of the top node itself, which can change level 1 or level H. If the cluster jumps to the H plane and stores energy, the cluster can change the node information and the node will be loaded at level H. He sends all the information of the cluster nodes down with energy puts the information of each node and his children to the next node and then sends the complete information to the cluster of nodes. This cluster receives the data from the members of the first level and transmits it to the base station.

⑦HEED protocol

Another typical routing protocol proposed by Younis and Fahmi in 2004 is the "HED" routing protocol[18]. Unlike the LEACH protocol, the Heed protocol does not use a random cluster head election method based on the combination of two parameters: node residual energy and internal communication cost. Ultimately, the selected cluster nodes have greater residual energy than normal nodes, lower intra-cluster communication costs, and a small, evenly distributed probability of selecting two neighboring nodes as clusters.

In HEED protocol, the cluster nodes are selected periodically and the residual energy clusters are changed to select the clusters and the communication cost in the clusters is the second parameter. In this cluster head, the message cost is "lowest on average"Available energy (AMRP) is used as a criterion to calculate the formula：

$$AMRP = \frac{\sum_{i=1}^{M} \text{Min}Pwr_i}{M} \quad (6)$$

M it is the total number of nodes in the group; MINPWRI represents the minimum energy required for node I to communicate with the general node of the group leader. The cluster head is selected by iteration. In the first iteration, each node determines the probability of becoming a CHPROB group leader. The formula is as follows

$$CH_{\text{prob}} = \max\left(C_{\text{prob}} \times \frac{E_{\text{res}}}{E_{\max}}, P_{\min}\right) \quad (7)$$

where c_{prob} denotes the initial value of the group heading relationship on the network; E_{res} is the remaining nodes of energy; E_{max} is the initial node energy; and PMIN is the low threshold. The higher the energy of the rest of the node, the higher the CH_{PROB} value, so it is more likely to be the leader of the group. Each node has to go through several iterations to find its head node. If node e cannot find the group leader node in its connection field, select itself as the group leader node and send the selected message to the communication field. At the end of each round, the node copies the CH_{PROB} probability value [19]. Then, if the value is higher than or equivalent to one, the node records and repeats the next cycle until the repetition is complete. Thus, there are two group leaders in the repetition process. If the CH_{PROB} value of group node e is less than 1, it is the temporary node of the group head; otherwise, it is the real node of the group head. If a larger group head node exists in the next loop, the normal node is automatically restored. The group terminal nodes transmit information to the BS through multi-hope mode to adapt to network expansion and achieve inter-network communication under the multi-hope structure. The protocol further discusses the relationship between nodes, intra-group communication radius, and intra-group communication distance.

3.2 Event-triggered data routing based on intelligent robot edge calculation and acquisition design

Intelligent robots are used at the network edge for event-triggered data routing in multimedia cognitive wireless sensor network clusters. These independently calculating and gathering robots maximize resource allocation and energy efficiency. By dynamically routing data based on real-time events and cognitive analysis, this architecture improves network performance and guarantees accurate and timely information distribution. The system facilitates smooth multimedia transmission in a variety of contexts by maximizing throughput and minimizing latency through the utilization of edge computing capabilities. This novel method transforms the way sensor networks function, improving overall responsiveness and dependability in crucial applications. The clustering routing protocol based on energy-saving and high-frequency efficiency consists of two alternative iterations: intra-cluster aggregation and inter-cluster relay. Among them, intra-cluster aggregation refers to the procedure for combining data from nodes in a cluster-to-cluster head nodes according to available channels [20]. Inter-cluster relay most cluster heads lack sufficient hardware resources, and nodes cannot directly communicate with sinks, so another clustered node acts as a relay for forwarding. In-cluster aggregation can be divided into two forms: direct forwarding and intra-cluster relay forwarding. Inter-cluster relay can be divided into two situations: gateway node to gateway node, and packet forwarding node to gateway node.

The head rotation mechanism. To reduce costs, the network usually deploys only one receiver base station for aggregation and data collection, regardless of whether the receiver is installed in any area of the network. The network architecture uses the probability method or weight comparison method to select gateway nodes and cluster heads. Nodes closer to the receiver use higher probability or weight, and they are more likely to be selected as nodes near the gateway or cluster head. This selection mechanism will cause too many gateways or cluster head nodes to appear, and these gateways or cluster head nodes continue to forward data, which leads to excessive energy consumption of these nodes[21]. This will also cause the phenomenon of energy holes in the network, which therefore causes the nodes' energy usage to look out of balance. Figure 1 shows the flow for the event triggered. The cluster head topology shows that the cluster head is crucial to the transfer of data. Therefore, after each round of routing node iteration, the cluster head of each cluster will be updated, and the cluster head rotation mechanism can extend the lifetime of the network.

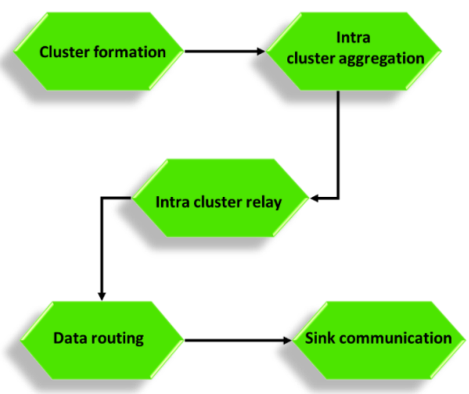

Figure 1: Flow for event-triggered

The weight calculation formula for selecting cluster member nodes to serve as cluster head nodes in the cluster is shown in formula (8).

$$W(n_i) = \alpha \times E_{n_i}^2 \times Num_{chan(n_i)} \times Num(neigrhtbors) \times (\frac{1}{D_{n_i-\mathrm{sink}}^2}) \quad (8)$$

The cluster head node selection formula in WSN is found in equation (8), which balances a variety of criteria including the node energy level ($E_{n_i}^2$), number of communication channels ($Num_{chan(n_i)}$), number of neighbors ($Num(neighbors)$), and proximity to the sink nodes ($D_{n_i}^2$). These variables are used to determine the weight ($W(n_i)$).

Stable intra-cluster aggregation and inter-cluster relay. After the clustering is completed, CRSN will periodically monitor the occurrence of certain events in the event cluster. Before the detectable event generates a trigger current, CRSN is in a low-power sleep state. When a trigger current is detected, the source node will use an access method similar to SCR data routing to forward the data packet to the cluster head or gateway node.

Among them, the source node is the first current node. If this node is one that is a member of a cluster, whether the cluster member node can transmit to the cluster head node in a single hop is divided into two situations: the cluster head node happens to be sent straight to the cluster head since it is within the present node's transmission range [22]. The head node is located outside the communication radius of the current cluster member node, and it selects an upstream node close to the cluster head node from other nodes in the cluster as the gateway node for relay forwarding, then enters the next stage of routing iteration. If this node is a member of a cluster, judge whether the sink is within the one-hop transmission radius. If the condition is established, the current cluster head node directly transmits the data packet to the sink and this event routing ends. Otherwise, the current cluster head node will relay the data packet to the next hop node in a certain way of inter-cluster relay. The next hop node repeats the above judgment process until iteratively transmits to the current node as a sink [23-24].

The advantages of this algorithm are:

It fully considers the fact that the single-hop transmission within the cluster cannot be transmitted to the cluster head node and the inter-cluster communication does not exist in the case of the gateway node outside the cluster. It has improved connection, particularly in the industrial Internet of Things massive amounts monitoring system and lower packet loss rate.

The inter-cluster communication method of intra-cluster aggregation through direct transmission or intra-cluster relay and alternating primary and secondary gateway nodes is more energy-efficient than the one-hop direct sink transmission method of the cluster head node. In-cluster convergence is divided into two situations as shown in Figure 2. In wireless sensor networks, the data that is received from different cluster nodes is processed, aggregated, and ultimately summarized by the cluster-head node into a more accurate result. The process of intra-cluster convergence is to process and aggregate the data from each node to obtain more accurate results, and finally transmit the results to the superior node or the central node to realize data acquisition and processing in the wireless sensor network. Case 1 is that the current trigger node or relay node can be directly transmitted to the cluster head node within one hop range Ru.

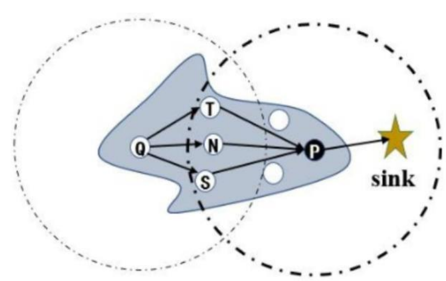

Figure 2: Direct transmission and intra-cluster relay in intra-cluster convergence

As shown in {T, N, S} in Figure 2, it uses direct transmission for intra-cluster aggregation. Otherwise, in case 2. like cluster member Q, it is necessary to select a node from other cluster member nodes in the cluster to relay and forward it to the cluster head node.

Inter-cluster relay and forwarding can be divided into two situations: gateway node and packet forwarding node-gateway node. The difference between these two relay methods is whether there are other clustered candidate gateway nodes within the one-hop communication range R of the current cluster head node [25]. As shown in Figure 3, Case 3 is that the cluster head I can select the best gateway from the set of single-hop neighbor candidate gateway nodes {R, P, M, Q} outside the cluster as the next hop relay; In case 4, the set of single-hop neighbor candidate gateway nodes outside the cluster of cluster head A is empty. Therefore, it must select an optimal packet forwarding node from the set of candidate packet forwarding nodes {B, C} of other cluster member nodes in the cluster, and then use the packet forwarding node as the current node to select the gateway node (consistent with case 3). The calculation formula of the gateway node weight CGNW is shown in formula (9), and the data packet forwarding node weight PFNW is shown in formula (10):

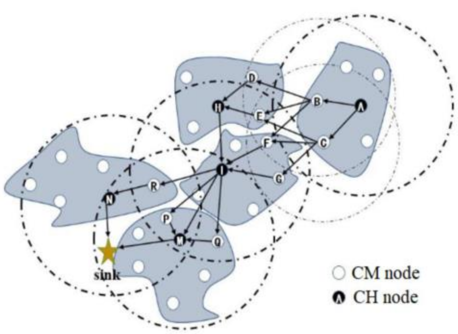

Figure 3: Inter-cluster relay gateway node and packet forwarding node-gateway node

$$CGNM(n_i) = \alpha \times E_{cur} \times \frac{N_{chan(cur-n_i)}}{D_{cur-n_i}} + \beta \times E_{n_i} \times \frac{N_{chan(n_i-ch)}}{D_{n_i-ch}} + \gamma \times E_{ch} \times \frac{N_{chan(ch-\text{sink})}}{D_{ch-\text{sink}}} \tag{9}$$

$$\text{PFNW}(n_i) = E_{n_i} \times (\sum_{q=1}^{Q} E_{next\_chister})Q \times N(neightbors) \times (\sum_{q=1}^{Q} \frac{N_{chan(chister)}}{D_{next\_\text{sink}}}) / Q \tag{10}$$

4 Result analysis

Wireless sensors consist of a network of miniature electrical systems, including systems, wireless communications, and distributed information technology. It is a product of rapid technological development and has great significance in both military and civilian fields. Unlike current computer networks, wireless sensor network systems are designed for everyday use, with the size of the network system, topology, routing protocols, data query methods, etc. As nodes are limited by cost, size, and physical resources, it is unrealistic to develop a network system that meets all requirements. To develop a wireless sensor network system that meets all the requirements, the following requirements need to be met:

(1) Reliability: The system ensures the reliability of data transmission between nodes to prevent data transmission loss or damage.

(2) Stability: The system can maintain network stability and reliability even when the network topology changes or nodes fail.

(3) Energy saving: Nodes should have a long battery life to reduce the number of battery changes and maintenance costs.

(4) Scalability: The system should be extensible so that it can easily scale up when nodes need to be added.

(5) Security: The system should have a high level of security to ensure the confidentiality of data transmission and prevent external attacks.

(**6) Flexibility:** The system should be flexible to adapt to different environments and application scenarios.

(7) Cost-effective: The system should be highly cost-effective to ensure the viability and sustainability of the system.

In the environment monitoring the application of intelligent robots, sensor networks can monitor the environment's temperature, humidity, smoke, and other information. The network has a robot node in addition to many sensor nodes which is responsible for collecting the data of sensor nodes and processing and transmitting it. Multimedia cognition technology and clustering routing algorithms improve the efficiency and quality of data transmission, reduce energy consumption, and extend the life of the network. In addition, in road monitoring applications, wireless sensor networks can monitor road traffic and vehicle status. Apart from a central node, the network consists of several vehicle nodes, the central node is responsible for collecting vehicle node data and processing and transmission. There is still room for miniaturization in current labs and wireless transmitters, but wireless networks require more sensors, as well as diversity and connectivity, which can lead to high power usage. This means that increasing network output to extend its service life requires precise control of the minimum number of wireless sensor networks.

Wireless sensor networks are a hot topic for national and international research. This allows users to connect to different integrated sensors, collect information about the environment, and send information through different specific repetitions. Currently, wireless sensor network systems are widely used in environmental monitoring, disaster management, biomedical health monitoring, smart home, target tracking, security control, etc.

CRSN systems currently face many problems that have to be solved, especially energy limitations have become bottlenecks that hinder their widespread use. Among them, the energy consumption of sensor nodes is distributed as follows: First, modular communication is much more energy intensive than the modules, sensors, and laboratories Second, the function of the communication module is to broadcast and transmit data, as well as idle time, far more than its sleep time. Based on the energy distribution characteristics of the sensor keys. The distribution of energy consumption is very important for the design and optimization of wireless sensor networks and can affect the life cycle and performance of sensor networks to a certain extent. Therefore, when designing and developing sensor nodes, the above energy consumption factors should be considered comprehensively to achieve the optimization of node energy consumption.

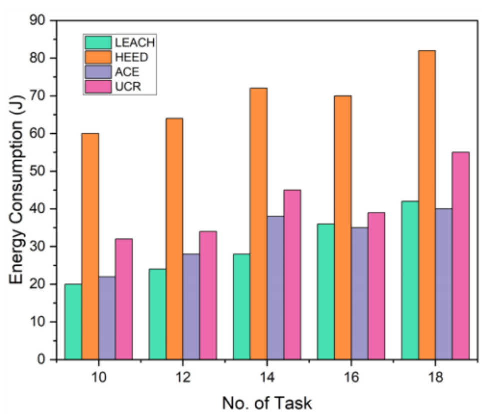

Figure 4: Energy consumption performance

Figure 4 presents the outcomes of four protocols LEACH, HEED, ACE, and UCR that were assessed using 14 tasks to determine their efficacy in the context of energy consumption performance in WSN. With an accomplishment of 82, HEED illuminates above the rest of these treatments, outperforming LEACH (42), ACE (40), and UCR (55). This implies that HEED is a better option for energy-efficient operations in WSN as it more efficiently optimizes energy consumption under the circumstances. HEED performs better than LEACH, ACE, UCR, and HEED protocols when comparing latency performance across 500 nodes in figure 5. Regarding latency, HEED attains 8500, which is better than LEACH (6200), ACE (5500), and UCR (5600). This shows that when network circumstances and node configurations are comparable, HEED outperforms the other protocols in terms of data transmission efficiency and communication overhead management.

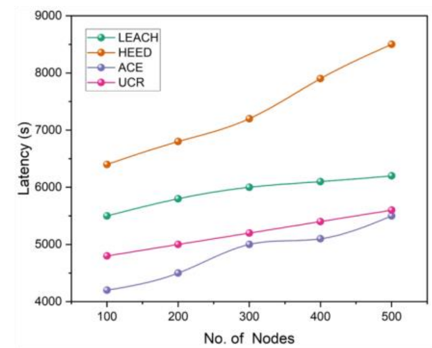

Figure 5: Latency performance

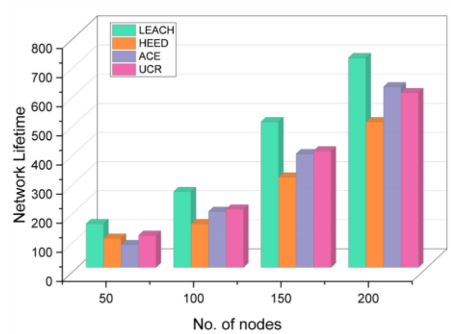

Figure 6: Network lifetime performance

LEACH obtains the best performance among the examined protocols in a comparison of network lifetime performance with 200 nodes in figure 6, achieving 720 for LEACH. Compared to HEED (500), ACE (620), and UCR (600), this statistic shows that LEACH has a greater capacity to prolong the network's operational lifetime. Based on the findings, LEACH's energy management and clustering techniques are more successful at maximizing node energy consumption and extending network availability.

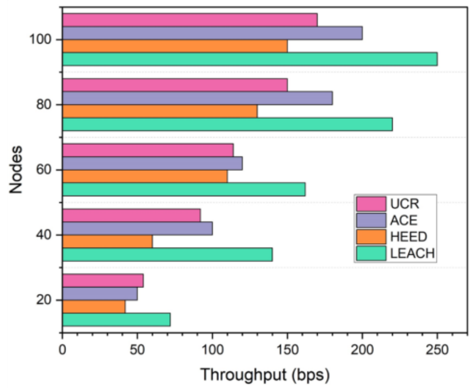

Figure 7: Throughput performance

Throughput performance in figure 7, as it relates to wireless sensor network protocols, is the quantity of data that is successfully sent over the network in a certain length of time. According to the statistics, the LEACH protocol outperforms HEED, ACE, and UCR, which reach throughputs of 150, 200, and 170 correspondingly, at a network size of 100 nodes, LEACH achieving a throughput of 250. This suggests that, when it comes to data transmission efficiency, LEACH outperforms the other protocols at this node count.

5 Discussion

The integration of an intelligent production line and enhanced cognitive manufacturing capabilities allowed the iRobot-Factory to achieve notable improvements in chip assembly and production efficiency. The implementation of edge computing resulted in better overall system performance and decreased system instructions through better resource usage and real-time data processing. The iRobot-Factory model's higher efficiency and scalability were shown through a comparison study with older approaches [26]. The approach maximizes load balancing and energy saving by combining Ant Colony Optimization (ACO) with the Genetic approach (GA). Significant energy savings are achieved throughout the network with experimental validation all while maintaining evenly distributed computational demands among the sensors. This method improves the network's durability and dependability, which makes it ideal for real-world implementation in a range of edge computing applications [27].In Wireless Sensor Networks (WSNs), the Butterfly Optimization Algorithm (BOA) was used to choose the best cluster heads based on variables such as residual energy, node centrality, and distances to neighbors and the base station. Route selection was done using Ant Colony Optimization (ACO), which considered node degree, residual energy, and distance into account. Metrics were evaluated using data nodes, energy use, active and dead nodes, and the information packets gathered by the base station. [28].

6 Conclusion

In this paper, the intelligent robot edge calculation and acquisition method is adopted in the research of multimedia cognitive wireless sensor network clustering routing. Firstly, the concept and advantages of CRSN clustering are briefly introduced, the main factors considered in the design of CRSN clustering algorithm based on intelligent robot edge calculation and acquisition are expounded, and the research status of CRSN clustering routing protocol is systematically analyzed and summarized. Research on radio sensor networks is not yet complete. In this study, intelligent robots are introduced into wireless sensor networks and used for data acquisition and calculation, which avoids the problems of large data transmission and high energy consumption in traditional WSN. At the same time, this paper innovates the clustering routing algorithm, divides the sensor nodes into multiple clusters according to the energy condition, and realizes the effective management and scheduling of the whole sensor network through the data acquisition and transmission of the cluster head nodes by robots. In future research work, routing determination protocols in radio sensor networks will be further investigated in the following areas. The most important function of sensor nodes is preemptive radio communication. In subsequent research, reducing the number of messages between nodes without affecting network performance is an important research direction, perhaps by improving data encoding to reduce data redundancy, pre-processing redundant nodes, and assigning algorithms more explicitly.

Real-world applications

Effective environmental monitoring is achieved in real-world applications with the proposed method. This technique collects multimedia data, including images and films, by placing sensors in various areas. Local data processing by intelligent robots or edge devices creates clusters that maximize energy efficiency and data transfer. It increases real-time data gathering and processing capabilities and reduces the need for centralized servers to improve the scalability, reliability, and responsiveness of monitoring systems.

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

ConflictsofInterest

The authors declare no conflicts of interest.

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