Design and Study of Urban Rail Transit Security System Based on Face Recognition Technology

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Keywords: Face recognition technology; Urban rail; Traffic security system; Face recognition algorithm

Received: December 11, 2021

In the modern world, it is difficult to prevent terrorism due to the relatively closed environment, dense personnel, large passenger flow, long line and wide coverage of urban rail transit. Identity recognition is a core element of security. The design and study of an urban rail transit security system based on face recognition technology are proposed in this paper. Through the study on the face recognition algorithm of intelligent security systems in urban rail transit, the related introduction of face recognition technology is done. The analysis of the main mode of face recognition is carried out utilizing the practical application design ideas. The results by experimental analysis show that if FAR is set to a very low range (such as 0.1% or even 0.01%) meanwhile FRR can reach a very low level (such as less than 1%). Such a system has practical value and otherwise, it may face a large number of passenger affairs and complaints to be handled. When FAR is set to 0.1% and N is 1.6 million, FRR can reach 2.1%. However, according to the test, when the picture quality deteriorates (during image captured by a webcam), the FRR will increase by 2 to 3 times. If a Webcam is used for recognition in Mugshot, the lowest FRR of the three top algorithms is only 5.21%.

Povzetek: Tehnologija prepoznavanja obrazov je uporabljena za nadzor osumljencev - teroristov na vlakih.

1 Introduction

At present, each urban rail transit is equipped with a video surveillance system. A large number of surveillance cameras are installed within the station area for subway operation and public security monitoring. Such a video monitoring system has almost become a tool to provide post-evidence recording and has lost the ability to prevent or stop criminal activities from occurring [1]. Urban rail transit has small space and large passenger flow, so safe operation is always the most concerning thing for government departments, operating units, and public security organs. How to identify the dangerous elements hidden in the crowd timely and accurately when entering the scope of rail transit is an urgent problem to be solved by the operation unit and the Ministry of public security. With the progress of society, some high technologies have been continuously used in industrial or civilian production and life. As the most advanced biometric technology and image processing technology in the world, face recognition technology is developing and improving day by day and is constantly applied to various fields in society. The technical development of the urban rail transit integrated monitoring system is shown in Figure 1 [2]. As a highly intelligent security monitoring means, face recognition technology is gradually applied in various fields of society. The introduction of a face recognition system in urban rail transit will certainly help to reduce the work pressure of public security personnel, provide good technical support for the safe operation of urban rail transit and criminal investigation and investigation, contribute to the personal and property safety of passengers, and maintain social stability. But due to the particularity of urban rail transit, the application of the technology in urban rail transit also needs to constantly improved. Many problems hinder face recognition technology in the further application of urban rail transit, so need continuous research to improve the technology.

Based on the current research, this paper proposes the design and research of an urban rail transit security system based on face recognition technology, through the study of face recognition algorithm and face recognition technology and the analysis of the main mode of face recognition. Conduct the practical application of the design ideas. The results show that by setting False

Acceptance Rate (FAR) to a very low range, such as 0.1% or even 0.01%, while False Rejection Rate (FRR) can reach a very low level, such as below 1%, the system has utility, otherwise, the application may face a large number of passenger affairs and complaints to be handled. When the FAR is set at 0.1%, and N = 1.6 million, the FRR can reach 2.1%. However, according to the test, when the picture quality deteriorates, such as Webcam (images collected by web camera), the FRR will increase by 2 to 3 times. If Webcam is identified in Mugshot, the lowest FRR of the three top algorithms is only 5.21%. The application of face recognition in the rail transit Automated Fare collection (AFC) system puts forward higher requirements for the integration, processing, and analysis ability of data.

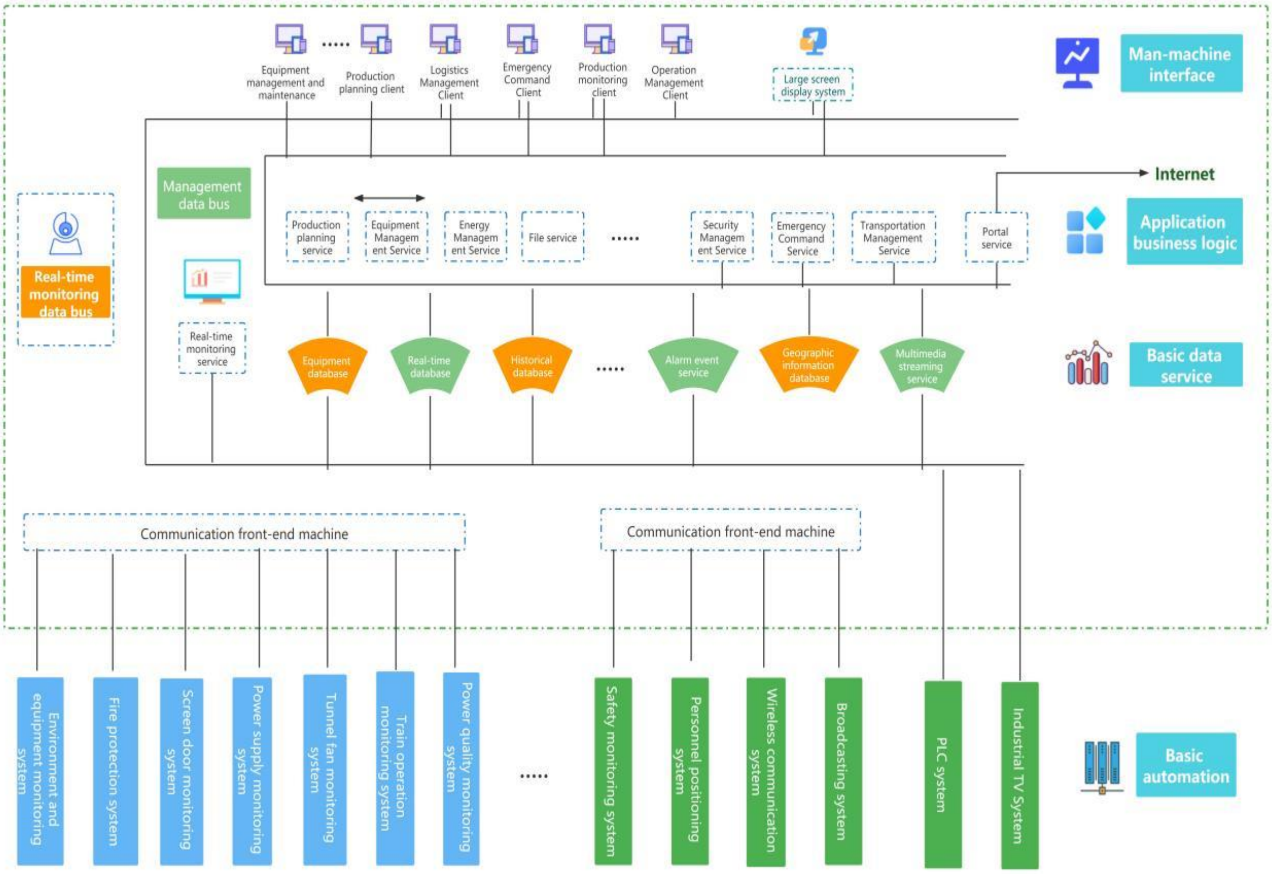

Figure 1: Technical development process of urban rail transit integrated monitoring system

It also provides a good platform for the development and application of big data, cloud computing, Internet of Things, artificial intelligence and other technologies.

To precisely acquire the concentration level of the travelers, it is necessary to precisely get the traveler stream of each key area. This paper plans identification gear for assessing traveler stream, which has incorporated the data acquisition equipment and algorithm process. From the assortment of image recognition, the most recent examination aftereffects of profound learning are utilized to recognize the traveler stream, and the blunder of the video traveler stream is rectified with the WIFI test hardware. To screen the early and late peak time of the megacities and the traveler stream in the vital place of the tram station, the abrupt occasions in the station and the activity span are decreased, while diminishing the unexpected occasions.

The rest of this article is organized as: Section 2 presents the related works in various domains. Section 3 consists of methods comprising the concept. Results and analysis are discussed in Section 4 followed by concluding remarks in section 5.

2 Literature review

In the literature, Yanpeng *et al.* analyzed the main technical indicators for the application of face recognition in urban rail transit AFC system. They investigated the technical level of the current top face recognition algorithms in the world, and proposed a design idea for the large-scale application of 1: N face recognition system in urban rail transit AFC system [3]. Feng *et al.* believe that the recognition server outputs the comparison results and alarms to the station's local monitoring terminal and remote monitoring center according to the comparison results [4]. Chen *et al.* for rail transit industry in recent years rapid development needs of public security and intelligence operations proposes a face recognition system based on intelligent subway design. The face recognition function design, front-end acquisition unit selection and deployment location, overall system architecture design is analyzed and discussed, and for other domestic embarks on a facial recognition system of the construction of the rail transit to provide reference [5]. Li *et al.* believe that the extraction of facial features is a key step in face recognition, which directly affects the accuracy of recognition. It is completed by the video analysis server set up in the station. The face recognition process is shown in Figure 2 [6]. Gao *et al.* present an article that puts forward the design and implementation method of the technology so that the school can complete the technical design and management of the student attendance system through the application of the equipment, and give full play to the supervision effect of the equipment [7]. Liu *et al.* present their view of the inability to obtain real-time learning status of learners in online learning. Their paper uses face recognition technology to monitor and analyze learners' learning status in front of the camera.

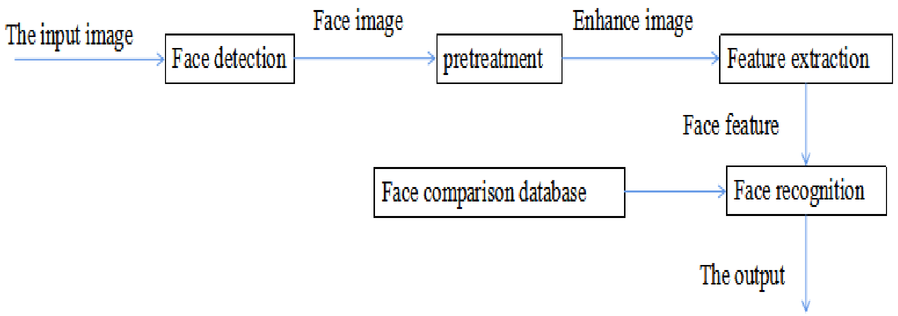

Figure 2: Face recognition process

The authors have designed and developed an intelligent supervising assistant system based on face recognition. The system collects students' images in real-time through the camera, establishes a mathematical model according to the main features of the face, extracts the relevant characteristic values, obtains the data such as face plane, three-dimensional rotation Angle, and eye closure state, and judges the learning state of learners. The experiment proves that the system can better assist managers to monitor the learning state of learners and improve learners' concentration during online learning [8]. Zhu *et al.* display information, such as the similarity ratio of face recognition, the location of the face, etc., through a graphical user interface, and switch the relevant video image to the monitoring terminal for easy tracking and monitoring [9]. Lu *et al.* study and analyze large-angle deflection face mainly by three-dimensional facial feature extraction. Three-dimensional facial feature extraction is a method of extracting facial feature points and head posture information from a given area [10]. Shen *et al.* believe that the location of facial features needs to adapt to the changes in various aspects of the face in different positions to the greatest extent, which can further improve the accuracy of the algorithm [11]. Shi and Lei believe that image preprocessing techniques include geometric ruler normalization, glasses extraction, and image gray-scale attribute correction. When normalizing the geometric size, the eyes and jaw points are automatically positioned, the two eyes are aligned by scaling and rotation, and the distance between the two centers of jaw points is a predefined constant, and then the image is cropped to a fixed size [12].

Although face recognition technology is in continuous development and improvement [13-20], the recognition rate, anti-counterfeiting, fingerprint, retina, and other has a large gap [21-25]. The large passenger flow and complex environmental characteristics of urban

rail transit also affect the application of face recognition technology in urban rail transit. In this regard, the application of a face recognition system in urban rail transit should also pay attention to the following aspects: the uncertainty in the process of video image acquisition [26-29]. Due to the complex environment of urban rail

transit, such as lighting, installation location, occlusion, and human posture, the acquired video and image quality are different, and the face acquisition is unclear or lacking [30-32], which affects the recognition rate. Therefore, in the installation and selection of the camera should pay attention to the installation position, light, lens exposure angle, and the selection of wide dynamic function, to improve the quality of video images [33-37].

Diversity of face patterns and uncertainty about-face plastic deformation. Because the same face has a diversity of faces such as beard, glasses, hairstyles, and the shape and deformation of different expressions, it affects the precise extraction of facial characteristics. The use of more advanced image processing technology and stable and accurate face expression method is the basis of the wide application of face recognition technology in urban rail transit. Urban rail transit has the characteristics of large passenger flow [38]. There are often many faces in a video image, and the task of video analysis and comparison is large. To realize real-time investigation, it is necessary to configure the number of video analysis servers and comparison servers reasonably [39], and the face detection and comparison technology are constantly optimized and improved. The face recognition system based on the original video monitoring system must establish a linkage with the original video monitoring system, make full use of the advantages of large-scale monitoring coverage, and realize the tracking of personnel through linkage control, to improve the case handling efficiency of police officers [40].

3 Research method

3.1 Study on the Face Recognition Algorithm of Intelligent Security System in Urban Rail Transit

The Adaboost face detection algorithm mainly uses the gray distribution characteristics of the face area to construct the classifier. The first step is to extract the Haar feature of the face gray distribution and use the integral diagram to quickly calculate the feature value. The second step is to use the weighted voting method to achieve the construction of the Adaboost strong classifier. The third step is to obtain a stronger joint classifier. The Haar feature represents a simple rectangular feature. Haar features can reflect a variety of image features, including horizontal, vertical, edge, center, linear and diagonal features [41].

Each Haar feature corresponds to a weak classifier, and the definition formula is:

$$h_i(x) = \begin{cases} 1, if, P_i f_i(x) \le P_i \theta_i \\ 0, other \end{cases} \quad (1)$$

From equation 1: $f_i(x)$ represents the rectangular feature value of the i[th] rectangle, $i(x)$ represents the classification result of the rectangular feature i on x. When the value is 0, it means that it is a non-human sample. If its value is 1, it means that it is a human face sample. P_i is used to determine the direction of the inequality, and θ_i represents the optimal threshold of the rectangular feature i [42].

3.2 Overview of face recognition technology

Face recognition technology is a technology that combines digital image processing, computer graphics, pattern recognition, visualization technology, human physiology, cognitive science, psychology, and other research fields to analyze the collected face graphics, determine the position, size, and posture of the face, and extract effective recognition information for face feature comparison, to realize identity recognition [43].

3.3 Advantages of face recognition over other biometric technologies

Biometrics is a technology that uses the inherent physiological or behavioral characteristics of the human body to perform identification. The physiological or behavioral characteristics require universality (covering a wide range of people) and differences (there should be identifiable differences between different individuals), stability (will not change within a certain period), and vitality (cannot be simulated by simulation) [44]. The comparison of their technical characteristics is shown in Tables 1 and 2 below.

Project	Face recognition	Palm vein recognition
Deployment cost	Non-contact type	High
Data acquisition	No feeling, no need to cooperate	Non-contact type
Accessibility	Fast	Palm extension fit
Recognition speed	High	Common
Safety	Light and dress blocking; Age change	Very high
Possible interference	Face recognition	Age, physiological changes

Table 1: Technical features of face recognition and palm vein recognition

Project	Fingerprint recognition	Iris recognition
Deployment cost	Contact type	medium
Data acquisition	Finger extension fit	Non-contact type
Accessibility	Fast	High fit required
Recognition speed	Common	Slow
Safety	Dirt and skin wear	Very high
Possible interference	Fingerprint recognition	Contact lenses

Table 2: Technical characteristics of fingerprint recognition and iris recognition

It can be seen from Tables 1 and 2 that although palm vein recognition has advantages in terms of safety and stability, it is not easy to promote due to the cost of equipment and recognition speed. Fingerprint recognition is a contact check, which has problems of insanity and susceptibility to interference. Iris recognition is difficult to operate and slow to recognize [45-49].

3.4 Face recognition training process

Face tracking function was tested for different face conditions, including single face, multiple faces, and face in and out or interleaved [50]. The system automatically initializes a tracking window before the face tracking starts, and assigns a Camshift tracker to each face in the video surveillance to realize multiple face recognition. Through many system function tests, it is found that the Camshift algorithm can have a good tracking effect and robustness in practical application, even for large Angle deflection or position change of face [51-54]. Even if there is a complex situation of people in and out of the area or face interleave, the system can normally start the face detection program and constantly correct the face tracking window, the system can quickly obtain all the face areas in each frame of the image, and is more rapid and stable than the face detection frame by frame.

4 Results and Analysis

The following key indicators are used to replace traditional physical tickets with facial features to realize face-to-pay rides in urban rail transit. First, the face feature database N: the number of registered person images in the system's face database [55]. Second, the false acceptance rate (FAR): refers to the probability of identifying an unregistered user as a registered user. Suppose that in a face recognition test, the threshold is set to T. If the comparison value of a test object is greater than T, it is considered that the object should be recognized as true, as presented in Equation 2.

One 1: N face recognition can be regarded as one face recognition performed N times, as presented in Equation 3. When FAR(1, T) is very small, FAR(N, T)=N(FAR(1, I), it can be seen that FAR will increase linearly as N increases [56-60]. Third, the false rejection rate (FRR): refers to the probability that registered users are rejected and is presented in Equation 4.

$$FAR(N,T)=\frac{\text{Comparison value of non-registered personnel} > \text{The number of T}}{\text{Total number of comparisons in the library by non-registered personnel}} \quad (2)$$

$$FAR(N,T)=1-(1-FAR(1,t))^{N} \quad (3)$$

$$FAR(N,T)=\frac{\text{Comparison value of non-registered personnel} > \text{The number of T}}{\text{Total number of comparisons in the library by non-registered personnel}} \quad (4)$$

Since a registrant is recognized as truly independent of other comparison data, it is generally considered that FRR (N, T) = FRR (1, T). But in actual tests, since the registration database is not a linear data structure, it may be an index or tree structure, causing FRR (N, T) to slowly increase as N increases. Fourth, the recognition time t: the time from the extraction of features from the face image to the completion of the feature comparison.

In the AFC system, FAR determines the safety of the system, FRR determines the accessibility of the system, and t determines the passing speed of the gate. For most face recognition algorithms, the threshold T used by the computer for face recognition is different, and FAR and FRR are also different. FAR increases with the decrease of T (relaxation conditions), and FRR decreases with the decrease of T. Therefore, FAR and FRR are almost contradictory indicators. Different applications have different requirements for FAR and FRR indexes, as shown in Figure 3. High-security applications have a low tolerance for FAR. For public security agencies to find personnel, it is suitable to use a lower FN.

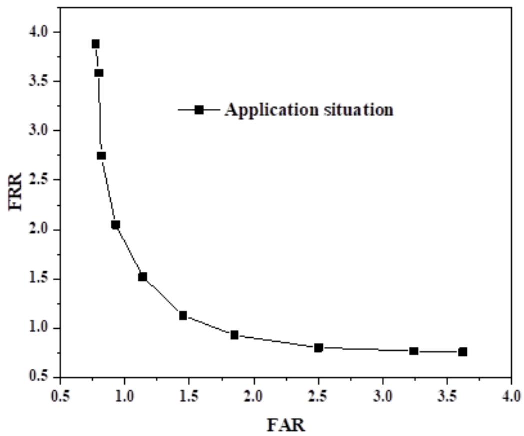

Figure 3: Applications for different indicators

For urban rail transit, due to the huge passenger flow and the money transaction involved, it should be classified as a high-security application. Therefore, the FAR needs to be set to a very low range, such as 0.1% or even 0.01%, and the FRR can reach a very low level, such as less than 1%. Such a system has practical value. Otherwise, once applied, it may face a large number of passenger affairs and complaints to be handled.

Figures 4, 5, and 6 show the performance curves of the three top international algorithms in the latest Face Recognition Vendor Test (FRVT) evaluation. The processed images are all Mugshot (face photos). When FAR is set to 0.1% and N is 1.6 million, FRR can reach 2.1%. However, according to the test, when the picture quality deteriorates, such as when using a Webcam (image captured by a web camera), the FRR will increase by 2 to 3 times. If a Webcam is used for recognition in Mugshot, the lowest FRR of the three top algorithms is only 5.21%.

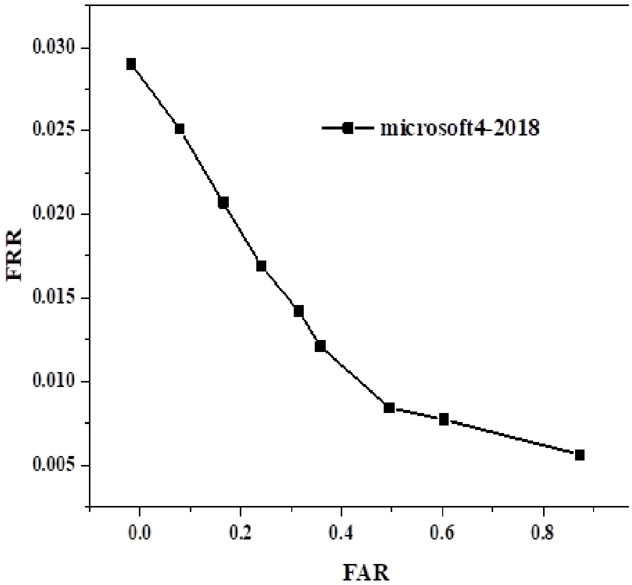

Figure 4: Performance curve of microsoft4-2018 top algorithms

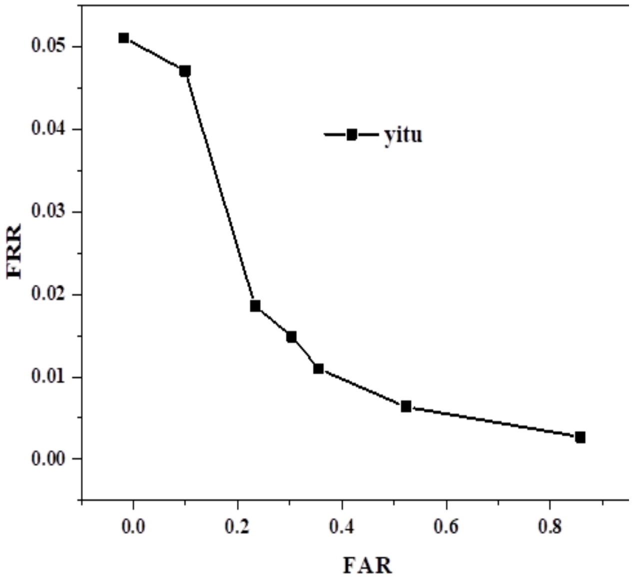

Figure 5: Performance curve of yitu top algorithm

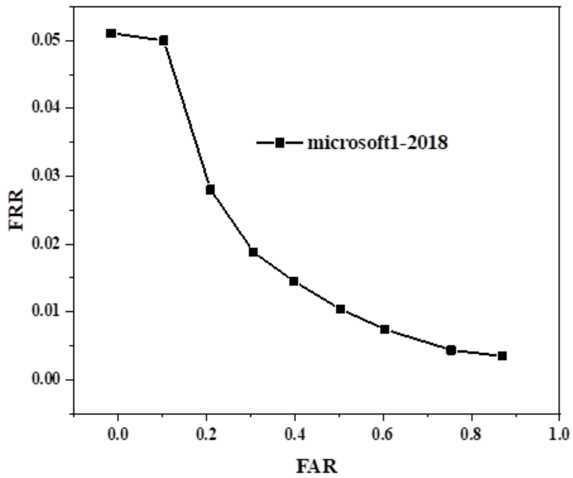

Figure 6: Performance curve of microsoft1-2018 top algorithms

Therefore, the actual application effect of face recognition is often different from the evaluation results. At present, domestic manufacturers focusing on intelligent face recognition, such as Yitu, Me gvii, Sense time, and other companies, have launched 1: N face recognition products, but at present, they can only meet the above requirements of FAR and FRR and achieve the face feature library N to the order of tens of thousands of yuan, and the recognition time t is controlled within 1s. It can be seen that with the current computer processing ability and face recognition algorithm performance, it cannot be directly applied on a large scale, and only small-scale pilot ideas can be carried out using specific personnel schemes, single-line commuter passenger schemes, and post-payment based on the third-party payment platform.

5 Conclusion

The urban rail transit should be classified as high-security application due to the huge passenger flow and the money transaction involved. This article presents the design idea of large application 1: N face recognition system in urban rail transit AFC system. The designed system can realize various functions, and has higher detection efficiency, lower error rate, and better application value. Therefore, the FAR needs to be set to a very low range, such as 0.1% or even 0.01%, and the FRR can reach a very low level, such as less than 1%. However, according to the test, when the picture quality deterior, such as Webcam (images collected by web camera), the FRR will increase by 2 to 3 times. If Webcam is identified in Mugshot, the lowest FRR of the three top algorithms is only 5.21%. The application of face recognition in the rail transit AFC system puts forward higher requirements for the integration, processing, and analysis ability of data. However, it also provides a good platform for the development and application of big data, cloud computing, Internet of Things, artificial intelligence and other technologies. It is believed that the future implications of this research work lie in further exploration of face recognition technology which will certainly shine in the rail transit industry.

Acknowledgments:

The study was supported by "Science and technoloy research project of Jiangxi education department, China (No. GJJ191175)"

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