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Research and Implementation of a Multimodal Biometric-Based Attendance System

Peng Xiaoliang[1,a,*], Yin Hang[1,b], Zhao Shengqi[1,c], Lan Yang[1,d]

[1]*University of Science and Technology Liaoning, Anshan, China*
[a]*1140006010@qq.com,* [b]*18978672@qq.com,* [c]*1404883452@qq.com,* [d]*2723409769@qq.com*
[*]*Corresponding author*

Abstract: *With the increasing requirements of enterprises for employee attendance management, the traditional attendance method can no longer meet the needs of modern enterprises. This paper proposes a multimodal biometric-based attendance method, system, terminal equipment and media, which combines two biometric features, face recognition and gait recognition, and improves the accuracy and real-time attendance recognition. This paper firstly introduces the background and significance of the research, then elaborates the design and realization process of the multimodal biometric-based attendance method and system, and finally verifies the effectiveness and superiority of the method through experiments. The experimental results show that the method is excellent in both accuracy and real-time performance of attendance recognition, and provides a more intelligent and humanized attendance management solution for enterprises.*

Keywords: *Artificial Intelligence, Multimodal, Biometrics, Attendance System*

1. Introduction

With the progress of science and technology and the development of enterprises, attendance management has become an indispensable part of enterprise management. Traditional attendance methods, such as punching cards, signing in, etc., although simple and easy to implement, but there are many drawbacks, such as punching on behalf of the card, missed cards, etc., can not accurately record the attendance of employees. Therefore, the development of an efficient and accurate attendance system is of great significance to improve the efficiency of enterprise management and ensure the working order[1].

In recent years, biometric identification technology has been widely used in the field of time and attendance because of its uniqueness and accuracy. Among them, face recognition and gait recognition are two representative biometric technologies. Face recognition technology captures employees' facial features for identity verification, which is intuitive and easy to operate; while gait recognition technology analyzes employees' walking posture to identify their identities, which has the advantage of being difficult to forge. However, a single biometric identification technology is often affected by the environment, individual differences and other factors, the recognition effect is not ideal. Therefore, this paper proposes a multimodal biometrics-based time and attendance method to improve the accuracy and stability of time and attendance recognition by integrating the two technologies of face recognition and gait recognition[2-3].

In recent years, the attendance technology based on biometric recognition has attracted much attention due to its uniqueness and accuracy. Biometric recognition technologies, such as fingerprint recognition, iris recognition, face recognition, etc., have the advantages of being difficult to forge and stable by extracting the inherent physiological or behavioral characteristics of the human body for identity verification. However, single biometric recognition technology often has limitations, such as being vulnerable to environmental interference, individual differences, etc. Therefore, multimodal biometric recognition technology emerged as the times require. It can significantly improve the accuracy and stability of recognition by fusing multiple biometric information[4].

Based on this, this paper proposes an attendance system based on multimodal biometric features. The system combines two types of biometric features, face recognition and gait recognition, and realizes the accurate recognition of employee attendance by extracting, fusing and classifying these two types of features. Face recognition technology can capture the facial features of the employees, which is intuitive

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and easy to operate; while gait recognition technology can reflect the physical status and identity of the employees to a certain extent by analyzing their walking posture. By combining these two technologies, the system is able to realize stable and efficient attendance recognition in different scenarios.

In this paper, the research background, significance, methodology, realization process and experimental results of the multimodal biometrics-based attendance system will be elaborated in detail, with a view to providing useful references and lessons for the research and practice in related fields.

2. Methods and systems

In this paper, a multimodal biometric-based attendance method is proposed, which includes the acquisition, preprocessing, feature extraction and classifier training of face images and human body images. Through the preprocessing methods of median filtering, histogram equalization and contrast stretching for face images, and the preprocessing steps of extracting human body contour, standard normalized binarization and generation of gait energy maps for human body images, the face features and human body features are fused to obtain the fused feature maps, and then the fused feature maps are finally sent to the classifier for classification to complete the training of the attendance recognition model[5].

Based on the above method, this paper also proposes a multimodal biometric-based attendance system. The system includes a network camera, a server and a terminal device arranged in the attendance place. The server includes a video processing module, an attendance information query module and a user management module, which can process the collected video in real time, train the attendance model and get the recognition results, store the recognition results and count the attendance records according to the recognition results. The terminal device can read the attendance records from the server through the mobile network, which is convenient for users to query and manage[6].

This paper introduces a multimodal biometric-driven time and attendance system, which strives to enhance the accuracy and dependability of attendance recognition by integrating face recognition and gait recognition technologies. The proposed approach encompasses several crucial steps: initially, face and body images are captured using network cameras positioned in the attendance area. These images are subsequently preprocessed to mitigate noise, enhance image quality, and extract salient feature information. Subsequently, face and gait features are seamlessly fused to create a multimodal feature map. A classifier is then employed to classify this fused feature map, and a trainer further refines the classification process. Ultimately, the classifier is trained to accurately classify the multimodal feature map, enabling the training and recognition of the attendance model, thus optimizing the efficiency and precision of attendance monitoring.

3. System design and implementation

With the rapid development of information technology, time and attendance system as an important part of enterprise management, its intelligence, precision level is increasingly concerned. The traditional attendance method can not meet the needs of modern enterprises, so the development of a new type of attendance system has important practical significance and application value.

Multimodal biometric identification technology is a new type of identification technology emerging in recent years, which improves the accuracy and stability of identification by fusing multiple biometric information. In the field of time and attendance, the multimodal biometric-based time and attendance system can overcome the limitations of single biometric identification technology and improve the accuracy and reliability of time and attendance identification. Therefore, the research of this paper has important theoretical significance and practical value[7].

3.1 System architecture

The multimodal biometric time and attendance system is mainly composed of four parts: data acquisition layer, feature extraction layer, feature fusion layer and decision-making layer. The data acquisition layer is responsible for collecting biometric information of employees, such as face images and gait videos; the feature extraction layer processes the collected data with corresponding algorithms to extract the feature vectors of face and gait; the feature fusion layer fuses the extracted face and gait features to form a more comprehensive feature representation; the decision-making layer carries out identification and attendance judgment based on the fused features, Figure 1. Convolutional neural

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network structure diagram.

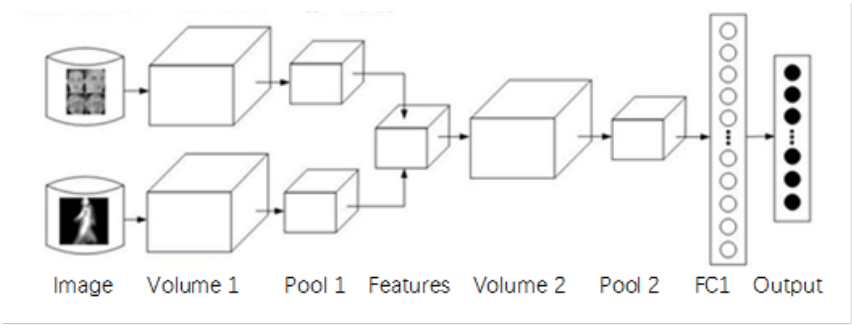

Figure 1: Structure of convolutional neural network

3.2 Key technologies

Face Recognition Technology: Deep learning algorithms are used for feature extraction and classification of face images. By training a large amount of face image data, the model can learn the essential features of the face, so as to realize accurate face recognition[8].

Gait Recognition Technology involves analyzing walking videos of employees to extract key gesture and motion features during their gait. Pattern recognition algorithms are then utilized to learn and classify these features, enabling precise identification of each employee's unique gait pattern[9].

Feature fusion technology: The feature vectors obtained from face recognition and gait recognition are fused to form a more comprehensive and discriminative feature representation. Commonly used feature fusion methods include weighted average, series fusion and machine learning based fusion algorithms.

4. Multimodal biometric based attendance method and system

In this paper, an attendance method based on multimodal biometric features is proposed, which includes the steps of face image and human body image acquisition, preprocessing, feature extraction and classifier training. Through the pre-processing and feature extraction of face and human body images, face features and gait features are obtained; then these two features are fused to form a multimodal feature map; finally, a classifier is used to classify the fused feature map to realize the training and recognition of the attendance recognition model[10].

Based on the above method, this paper also designs and realizes a complete attendance system. The system consists of three parts: the network camera, the server and the terminal device, which are arranged in the attendance place. The network camera is responsible for real-time acquisition of face images and human body images; the server is responsible for pre-processing, feature extraction and classification of the acquired images; and the terminal device is used to display the recognition results and query the attendance records.

The multimodal biometric-based attendance method proposed in this paper is an advanced technology that combines face recognition and gait recognition, aiming to improve the accuracy and efficiency of attendance. The following are the detailed steps of the method and the realization of the corresponding system.

4.1 Attendance methods

4.1.1 Image acquisition

Use HD webcams to capture real-time images of employees' faces and body images as they walk within the time and attendance venue.

Cameras need to be placed in the right place to ensure that the facial features and gait information of the employees are clearly captured.

4.1.2 Pre-processing

The acquired face images are preprocessed, including grayscaling, normalization, denoising, etc., to

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improve the accuracy of subsequent recognition.

The pre-processing of the human image is mainly to extract the key frames in the gait sequence and remove the redundant information.

4.1.3 Feature extraction

The deep learning algorithm (such as convolutional neural network CNN) is used to extract the features of the preprocessed face image and obtain the face feature vector.

Gait recognition algorithms (e.g., contour-based methods or deep learning methods) are used to process human images and extract gait features while walking.

4.1.4 Feature fusion

The extracted face feature vectors and gait feature vectors are fused to form a multimodal feature map. The fusion can be done by series, weighted average or deep learning based fusion strategy.

4.1.5 Classifier training and recognition

The labeled training data sets are used to train classifiers (such as support vector machine SVM, random forest or neural network), so that they can accurately distinguish the characteristics of different employees.

When taking attendance, the real-time collected and processed multimodal features are matched with the trained classifier to realize the fast recognition of employee identity.

4.2 Realization of the attendance system

Based on the above method, this paper designs and realizes a complete attendance system, which is mainly composed of the following three parts.

4.2.1 Webcams

Responsible for real-time capture of face images and body images within the attendance venue.

Cameras need to have high resolution and fast transmission capabilities to ensure that the image quality meets the identification requirements.

4.2.2 Server side

Deployment of high-performance computers or servers for processing image data.

The server side runs the algorithms of preprocessing, feature extraction, feature fusion and classification and recognition to realize the fast processing and analysis of images.

The server is also responsible for managing attendance records, providing data storage and query functions.

4.2.3 Terminal equipment

Includes a monitor and input devices (e.g., keyboard, mouse, etc.) for displaying recognition results and querying attendance records.

The terminal equipment is connected with the server through local area network or Internet to realize real-time data transmission and interaction.

Employees can check their attendance through the terminal equipment, and administrators can set and manage the attendance system through the terminal equipment.

5. Experiment and analysis

In order to verify the effectiveness of the method and system proposed in this paper, we conducted a series of experiments. First, we constructed a dataset containing a large number of face images and human body images for training and testing the attendance recognition model. Then, we used a variety of evaluation indicators to evaluate the performance of attendance recognition, including accuracy, recall, F1 value, etc.

The experimental results show that the method proposed in this paper performs well in the accuracy and real-time performance of attendance recognition. Compared with the traditional attendance method,

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the method proposed in this paper has higher recognition accuracy and lower false recognition rate. At the same time, due to the adoption of parallel processing technology and optimization algorithm, the system proposed in this paper also has obvious advantages in processing speed.

In addition, we also tested the stability and reliability of the system. A variety of abnormal situations, such as network interruption and data loss, are simulated to evaluate the robustness of the system. The experimental results show that the system proposed in this paper can keep stable operation under various abnormal conditions and effectively deal with various challenges.

To realize an attendance system based on multimodal biometrics, it is necessary to write corresponding software programs. This program usually includes image acquisition, preprocessing, feature extraction, feature fusion, classification and recognition, user interface and other modules. Since this is a complex system, I will provide a simplified pseudo-code framework to describe the basic structure of this program.

Please note that the actual implementation will involve specific programming languages and libraries, such as Python, OpenCV, TensorFlow, and detailed algorithm implementation and optimization.

```
python
Import cv2 # OpenCV library for image processing
import numpy as np
From tensorflow.keras.models import load_model # Used to load the trained model
# Assume that there are trained face recognition models and gait recognition models.
face_recognition_model = load_model('face_recognition_model.h5')
gait_recognition_model = load_model('gait_recognition_model.h5')
# Image acquisition function (pseudo code)
def capture_images():
    #Capture images from cameras using OpenCV or other libraries
    face_image = capture_face_image()
    gait_sequence = capture_gait_sequence()
    return face_image, gait_sequence
# Preprocessing function (pseudocode)
def preprocess_images(face_image, gait_sequence):
    # preprocess the face image, such as graying and normalization.
    preprocessed_face_image = preprocess_face(face_image)

    # preprocess gait sequence, such as extracting key frames, normalizing, etc.
    preprocessed_gait_features = preprocess_gait(gait_sequence)

    return preprocessed_face_image, preprocessed_gait_features
# Feature Extraction Function (Pseudocode)
def extract_features(preprocessed_face_image, preprocessed_gait_features):
    # Using face recognition model to extract face features
    face_features = face_recognition_model.predict(preprocessed_face_image)

    # Using gait recognition model to extract gait features
    gait_features = gait_recognition_model.predict(preprocessed_gait_features)
```

ISSN 2616-5767 Vol.7, Issue 3: 103-109, DOI: 10.25236/AJETS.2024.070315

```
    return face_features, gait_features
# Feature Fusion Function (Pseudocode)
def fuse_features(face_features, gait_features):
    # Fusing face and gait features, e.g., strategies such as crosstalk or weighted averaging
    fused_features = np.concatenate((face_features, gait_features), axis=-1)
    return fused_features
# Classification recognition function (pseudo-code)
def classify_employee(fused_features):
    #Use classifiers (such as SVM, neural network, etc.) to classify and recognize fused features
    # Assume here that we have a classifier that's been trained #
    employee_id = classifier.predict(fused_features)
    return employee_id
# Main program (pseudo-code)
def main():
    # Capturing images
    face_image, gait_sequence = capture_images()

    # pre-processed images
    preprocessed_face_image, preprocessed_gait_features = preprocess_images(face_image, gait_sequence)

    # Extracting features
    face_features, gait_features = extract_features(preprocessed_face_image, preprocessed_gait_features)

    # Integration of features
    fused_features = fuse_features(face_features, gait_features)

    # Classify and identify employees
    employee_id = classify_employee(fused_features)

    # Displaying or recording attendance information
    display_or_record_attendance(employee_id)
# Run the main program
if __name__ == '__main__':
    main()
```

Please note that the above code is just a framework pseudo code without specific implementation details. In actual development, you need to select appropriate libraries and algorithms according to specific requirements and environments, and carry out detailed implementation and testing. For example,

ISSN 2616-5767 Vol.7, Issue 3: 103-109, DOI: 10.25236/AJETS.2024.070315

OpenCV or other special camera libraries may be required for image acquisition; Preprocessing, feature extraction and classification may require the use of deep learning frameworks such as TensorFlow or PyTorch, and corresponding models need to be trained; The user interface may require the use of graphical interface libraries such as Tkinter, Qt, or web frameworks.

6. Conclusion

This paper studies the design and implementation of the attendance system based on multimodal biometrics, and verifies its effectiveness and superiority through a series of experiments. Experimental results show that the method performs well in the accuracy and real-time of attendance recognition, and has significant advantages over traditional attendance methods. The attendance system proposed in this paper provides a more intelligent and humanized attendance management solution for enterprises, which has high practical application value and market potential.

However, there are still some shortcomings in this study, such as the recognition effect in extreme environments needs to be further improved, and the processing capability of large-scale data sets needs to be optimized. In the future, we will continue to study multimodal biometrics to further optimize the performance and functionality of the time and attendance system to meet the needs of more enterprises and users. At the same time, we will also pay attention to the application prospects of emerging technologies such as deep learning and artificial intelligence in the field of time and attendance, so as to make more contributions to the promotion of intelligent and accurate time and attendance management.

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References

[1] Zhang Chao, Wang Zhichao, Lin Yan. Design of embedded network control system based on LwIP protocol stack [J]. Application of MCU and Embedded System, 2019 (02).
[2] Zhu Xiangqing, Deng Haoxin, Li Jiabao, Zhu Wanhong, He Changyi, Zhong Chuangping. Smart home system design based on STM32 and Android [J]. Electronic Design Engineering, 2018 (18).
[3] Luo Jiawei, Sun Xuefeng, Li Lin. Design of web face registration and login system based on Baidu AI platform [J]. China New Communications, 2018 (11).
[4] Wu Hailong, Bai Zhengyao, Wu Wenqiang. Design of student attendance system based on STM32 and C# [J]. Foreign Electronic Measurement Technology, 2017 (12).
[5] Xu Shuliang. Design and implementation of enterprise attendance system based on Internet of Things technology [J]. Modern Computer (Professional Edition), 2017 (27).
[6] Gu Chenlei, Liu Yuhang, Nie Zedong, Li Jingzhen, Wang Lei. Development Status of Fingerprint Identification Technology [J]. Chinese Journal of Biomedical Engineering, 2017 (04).
[7] Yang Siyuan. Design and Implementation of Network Attendance System Based on Biometric Technology [J]. Measurement and Testing Technology, 2017 (06).
[8] Cao Hui. RFID technology in the Internet of Things and the construction of the Internet of Things [J]. Information and Computer (Theoretical Edition), 2017 (12).
[9] Xiao Pei; Hu Tianli; Cao Yuan; Zhu Bei; Li Xuan, Smart mirror design based on STM32F407ZGT6 [J]. Scientific and Technological Innovation and Application, 2017 (13)
[10] Zhong Tao; Zhu Ling, Design of emWin system based on STM32 MCU [J]. China New Communications, 2017 (07)