Journal of Image Processing Theory and Applications (2025)
Clausius Scientific Press, Canada
DOI: 10.23977/jipta.2025.080112
ISSN 2560-6239 Vol. 8 Num. 1

Face Recognition Attendance System Using OpenCV

Ziyi Luo[a,*], Longsu Wang[b], Weirui Ma[c], Qian Sun[d], Luhao Zhao[e]

Nanjing Tech University Pujiang Institute, Nanjing city, Jiangsu Province, China
[a] 13771885380@163.com, [b] 1415016807@qq.com, [c] 255514320@qq.com, [d] 3403368831@qq.com,
[e] 2454890772@qq.com
**corresponding author*

Keywords: Face recognition, OpenCV, time and attendance system, LBP algorithm.

Abstract: The purpose of this paper is to explore the face recognition technology based on OpenCV and apply it to the attendance system of colleges and universities. The local binary mode L BP algorithm is used to process and extract features from the image, and the core idea is to compare the gray value of each pixel in the image with the surrounding pixels to generate a local binary mode. This method shortens the recognition time and improves the recognition accuracy, while the amount of training data required is relatively small, so as to enhance the generalization ability of the model. After the introduction of dynamic video face detection, the efficiency and quality of the overall teaching have been improved, and the teaching management has been made more automated and intelligent. The results show that the OpenCV face recognition attendance system based on LBP algorithm has practical application value and can bring convenience to the teaching management of colleges and universities.

1. Introduction

As an efficient and convenient biometric method, face recognition technology has been widely used in various fields. With the rapid development of science and technology, conventional attendance management methods—such as manual roll-calling or paper-based sign-ins—have begun to expose their limitations. These methods are not only time-consuming but also prone to manipulation and human error. Students can easily exploit manual systems by having someone else sign in on their behalf or simply falsifying attendance records. However, it is essential for colleges and universities to keep accurate records of student attendance in order to manage their work. The use of face recognition technology for attendance can not only quickly and accurately identify individuals, but also effectively reduce the error caused by human factors. Therefore, this paper aims to design and implement an intelligent attendance system based on OpenCV face recognition algorithm by using the classroom attendance system based on OpenCV face recognition algorithm. Through face recognition technology, it is hoped that the accuracy of attendance records can be ensured and the efficiency of attendance can be improved.

2. Results and Discussion

2.1. Face recognition principle

Face recognition is a technology that uses facial features for identity verification or recognition. The basic principle is to capture an image of a face through a camera, and then use an algorithm to process the image to detect whether a face exists in the image. The detected face is processed by size, style, etc., and its key features are extracted and compared with the pre-stored face. The face detection method used in this article is based on: LBPH, which is a feature descriptor of the LBP algorithm. The LBP algorithm generates a feature representation that is robust to lighting changes by capturing the local texture features of the image. In particular, the LBP algorithm has a high resistance to changes in external factors such as lighting and posture when extracting texture features, which makes it able to effectively recognize faces under different lighting conditions. Another advantage of the LBP algorithm is its computational efficiency. Unlike some other complex face recognition methods that require extensive training data or parameter tuning, LBP does not demand excessive processing time or resources. LBPH divides the detected faces into small cells, each of which produces a histogram, these histograms capture the texture information of local areas and do not require excessive time and complex parameter settings during the calculation process. Through this method, LBPH is able to flexibly handle the difference in shape and size between the model sample face and the detected face, so as to achieve face recognition. This simplicity allows it to be integrated into real-time systems where quick responses are essential, such as in classroom attendance systems (See Figure 1).

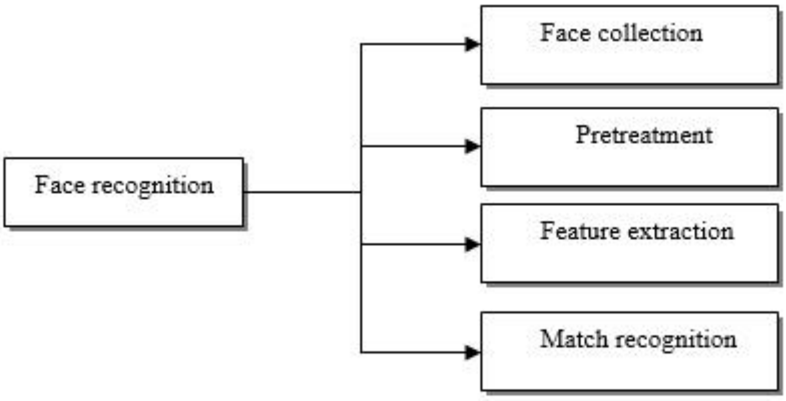

Figure 1: Face recognition flowchart diagram

2.2. LBP algorithm

2.2.1. LBP operator

LBP algorithm, or local binary mode, is a binary encoding method used to capture local texture features of images, which has the advantages of simple and efficient calculation. The original LBP operator generates a binary pattern by comparing the grayscale value of each pixel in the image with the pixel in its neighborhood. In the basic definition of LBP operators, taking a 3X3 window as an example, the central pixel is used as the reference and compared with the pixel values in the surrounding area, and 8 points in such a field will produce 8-bit binary LBP value, which is used to reflect the texture information of the area. It is important to note that these LBP values form a binary string of numbers in a clockwise direction, called an LBP code. The basic LBP operator only covers pixels within a fixed radius, which is suitable for texture analysis in small areas, but the requirements for texture features at different scales, grayscale, and rotation invariance are still limited. Therefore, the LBP algorithm is extended to a larger domain to accommodate feature extraction at different scales. The extended LBP operator allows multiple pixels to be included in a circular neighborhood with radius R. This extension method increases the sensitivity of the algorithm to different scale features and improves the robustness to rotation.

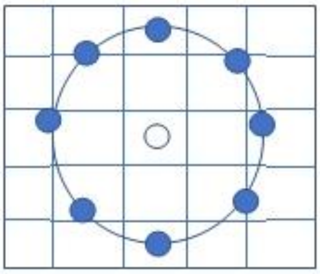

Figure 2: 5×5 LBP operator

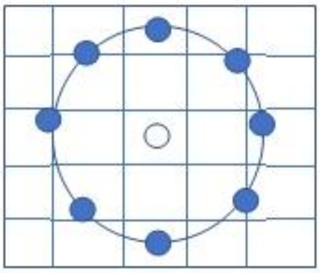

Figure 2: In a 5X5 field, the following eight sampling points are calculated as follows:

$$Xp=Xc+R\cos\frac{2\pi P}{P} \quad (1)$$

$$Yp=Yc-R\sin\frac{2\pi P}{P} \quad (2)$$

where (X_c,Y_c) is any sampling point of the field center point (X_p,Y_p), because the calculated sampling point may not be an integer, the bilinear interpolation method can be used to determine the pixel value of the sampling point, and the gray value between these four pixels can be estimated by weighting the gray value of the surrounding four pixels. The result is a more accurate pixel value. This process improves the accuracy and stability of image processing.

$$f(x,\ y) =\approx [1-x \ \ x]\begin{bmatrix} f(0,0) & f(0,1) \\ f(1,0) & f(1,1) \end{bmatrix}\begin{bmatrix} 1-y \\ y \end{bmatrix} \quad (3)$$

2.2.2. LBP rotation invariant mode

Although the LBP operator is excellent at capturing local texture features and has grayscale invariance, its original definition does not have rotational invariance. When the image is rotated, since the LBP operator generates binary encoding based on the relative position relationship between pixels, different rotation angles will lead to different neighbourhoods pixel positions, resulting in different LBP values (See Figure 3). Therefore, in order to solve this problem, the LBP operator is extended, and an LBP operator with rotational invariance is proposed. Select a number of sampling points in a circular field with a radius of R based on the central pixel and calculate them in a certain order to obtain a series of initially defined LBP values,For these initial LBP codes, all possible rotation states of the LBP codes are generated by cyclic shifting. For example, for an LBP code represented by an 8-bit binary number, a maximum of 7 cyclic shifts can be performed to generate 7 new binary numbers, and then take the minimum of these as the LBP value for the field.

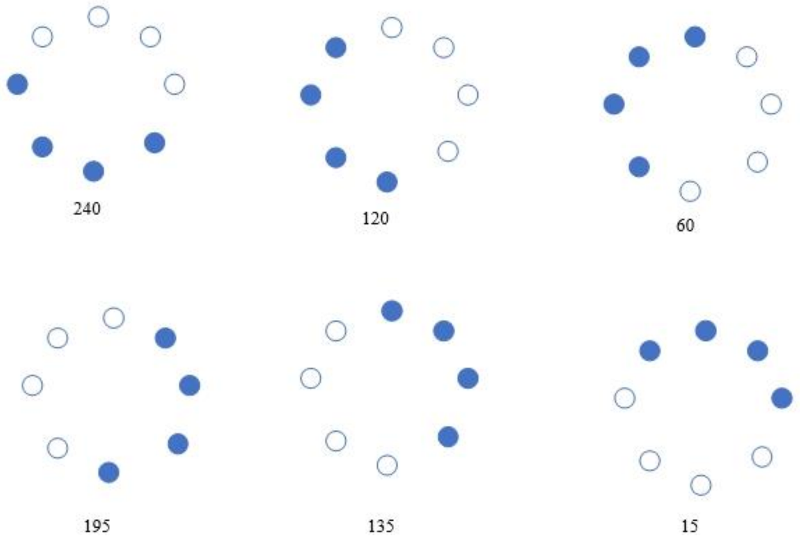

Figure 3: Rotate LBP values at different angles

2.2.3. LBP equivalence mode

As we have seen earlier, local binary patterns (LBP) can generate a number of different binary patterns, and for a circular region with m sampling points and a radius of R, it is possible to produce 2^p patterns. To improve the statistical, it can be treated as conditionality reduction. The equivalence pattern refers to the mode in which the binary sequence corresponding to the L BP is converted from 0 to 1 or 1 to 0, with a maximum of two changes. Modes other than the equivalence model are classified as mixed modes. With this improvement, 2p is reduced to P(P-1)+2, where P is the number of sampling points. In the above 3X3 neighborhoods, the number of species is reduced from 256 to 58, of which 57 are equivalent modes, and the remaining one is a mixed mode, that is, the gray value of the LBP image is 1 to 58, while the other more complex modes are regarded as mixed modes. It can be seen that the Equivalent Mode LBP feature image tends to be darker as a whole. This improvement not only greatly reduces the dimension of the feature vector, but also effectively reduces the influence of high-frequency noise on pattern recognition.

2.2.4. LBP feature vector of the image

In image processing, if you directly compare the histograms of two complete pictures, the recognition effect will be poor. Therefore, this paper uses LBPH, that is, a statistical histogram based on LBP features, which combines LBP features with the spatial information of the image. By segmenting the LBP feature image into m modules,For each module, calculate the histogram of LBP values inside it, that is, count the frequency of occurrence of each LBP pattern in the module. In this way, by analyzing the local texture distribution of the image block by block, LBPH not only retains the local texture features of LBP, but also incorporates spatial location information.Generally speaking, the higher the number of tiles, the better the recognition effect, but increasing the number of tiles will increase the final computational complexity. as follows Figure 4 and Figure 5.It is the 5X5 block scheme adopted in this paper.[1]

Figure 4: Gray transform image

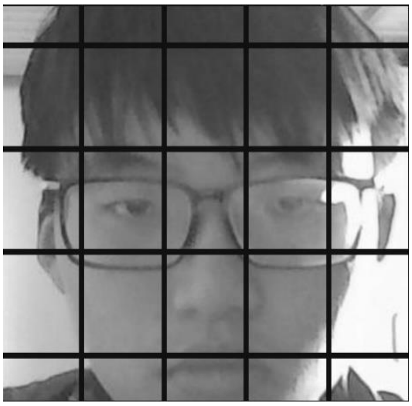

Figure 5: The segmented image

Next, we convert several regions into a series of column vectors, classify and summarize them to form a histogram for statistics, and assemble each region one by one to form a final histogram. The histogram represents the formula definition[5]For:

$$\mathrm{Hi} = \sum_{x,y} I\{f_i(x,y) = i\} \quad i=0,1,2\text{-}n\text{-}1 \tag{4}$$

where $f_i(x,y)$ represents the LBP value of a pixel in the image, n represents the total number of LBP modes, and each piece is counted after being divided into m blocks R_n:

$$\mathrm{Hi} = \sum_{x,y} I\{f_i(x,y) = i\} I\{(x,y) \in R_n\} \tag{5}$$

The resulting histogram is as follows Figure 6 and Figure 7

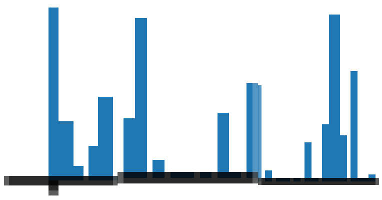

Figure 6: Chunked histogram

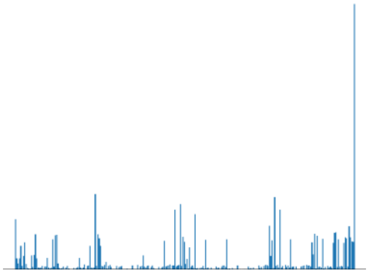

Figure 7: Overall histogram

We use machine learning methods to train LBP feature vectors and save them in the corresponding folders. In a subsequent application, we compare these feature vectors with the detected faces.

3. System implementation

The face detection system is divided into the following steps(See Figure 8)

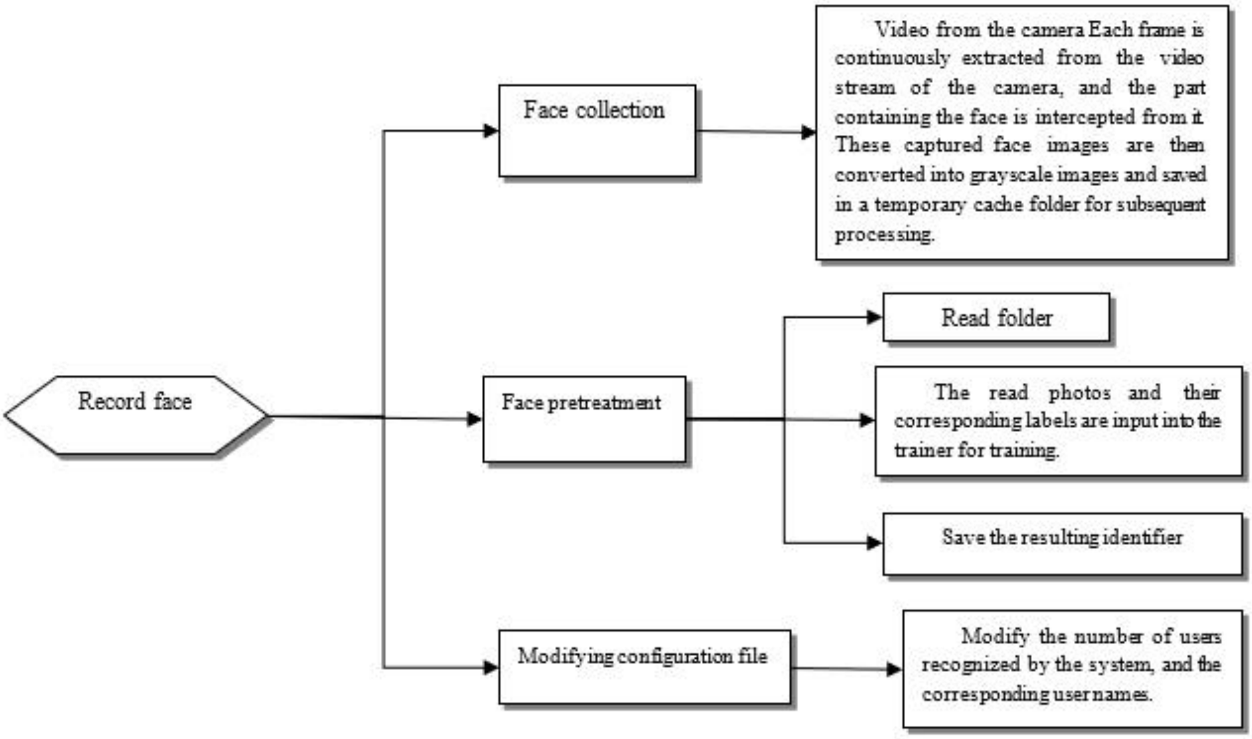

Figure 8: System implementation procedure

3.1.1. Face collection

In the face collection process, the system captures and recognizes faces in real time from dynamic video streams using a camera, which allows for efficient and continuous face acquisition. The more face images that are captured under different conditions, the better the system's ability to recognize individuals accurately and consistently. To enhance the accuracy and reliability of identification, we ensure that at least 100 face images are captured per individual and stored in a designated folder for further processing. To ensure the system has strong generalization capabilities across various conditions, the captured images are first standardized to maintain uniformity in size and resolution. At the same time, in order to cover different lighting conditions, expressions, and angles, we deliberately chose a variety of acquisition environments. Additionally, we encrypt all stored images to address privacy concerns and to safeguard personal data, ensuring compliance with privacy regulations. In order to improve the accuracy of the data, we collected images of different styles, shapes, and expressions to improve the accuracy of recognition.[3]as Figure 9 show.

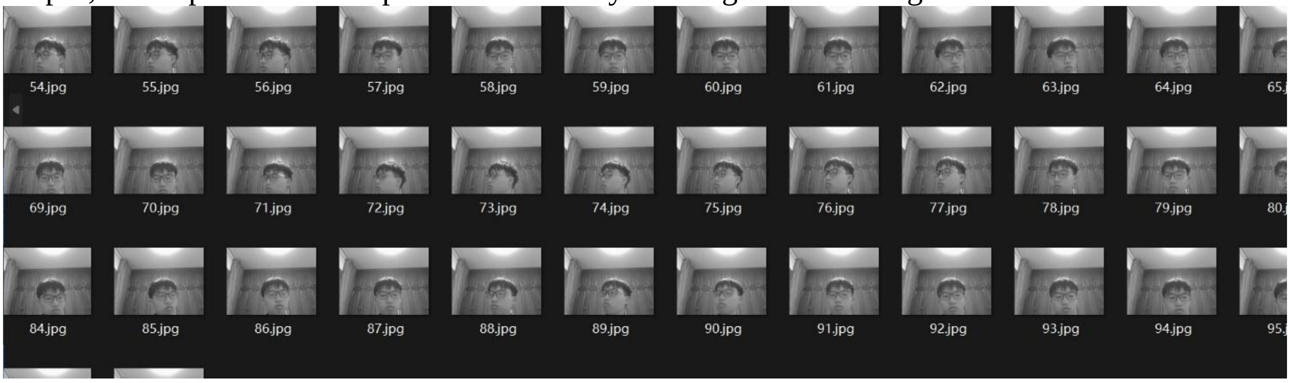

Figure 9: 100 pictures of different shapes

3.1.2. Face pretreatment

Since the raw images are often affected by environmental conditions and may contain noise or inconsistencies, they cannot be used directly for feature extraction. We apply a series of pre-processing steps, including grayscale conversion and size normalization. These steps ensure that the images are more uniform in quality, reducing the impact of lighting variations and making them more suitable for the feature extraction stage. Grayscale conversion simplifies the image by focusing only on texture patterns, and size normalization ensures that all images fit a consistent format, which is essential for accurate comparisons. Next, we use the LBP algorithm to extract features from the preprocessed face images. LBP features can effectively capture local texture information to form a histogram that represents each image. After feature extraction is complete, this histogram data is used for model training and ultimately stored in a database. In the database, we associate each feature vector with the corresponding face tag, and classify and organize the information for subsequent query and matching. [2]

3.1.3. face recognition

Once the system captures a new face via the camera during operation, it extracts the relevant features and searches for a match within the database. The recognition process is based on comparing the feature vectors of the newly captured face with those stored in the database. If the similarity between the new face and the stored template exceeds 60%, the system classifies the match as successful. Otherwise, the system registers the recognition as a failure. To further improve the robustness of the recognition process, we have implemented a ten-attempt judgment strategy. Under this system, a match is only considered valid if the similarity score exceeds 60% in more than five out of ten attempts. This approach helps to reduce false positives and ensure more reliable results, especially when the captured images are of varying quality.as follows Figure 10 and Figure 11. [4]

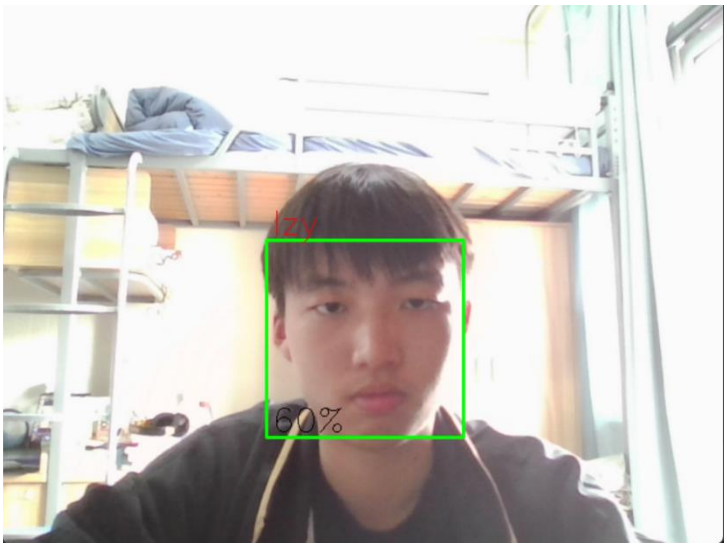

Figure 10: Specific identification picture

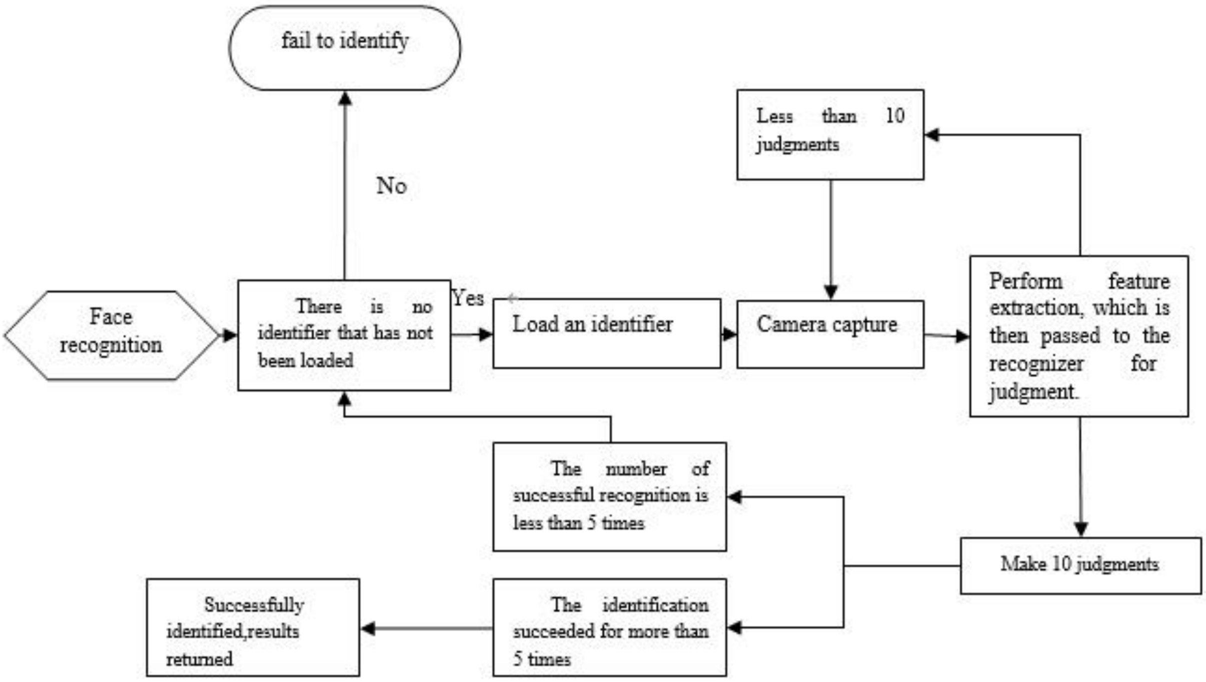

Figure 11: Face recognition decision principle

4. Conclusions

In this paper, the face recognition attendance system based on OpenCV is successfully implemented through python, which plays an important role in daily attendance. By using the system for face sign-in, we have successfully solved the problems in daily attendance, which not only reduces labor costs and time costs, but also effectively prevents fraud and errors, provides more accurate and credible data support, and makes management more scientific and standardized. One of the main challenges observed during the system's implementation is its sensitivity to uneven lighting conditions. Variations in lighting can affect the brightness and contrast of the facial images captured by the system, which, in turn, impacts the extraction and matching of LBP features. Since the LBP algorithm is designed to focus on local texture details, drastic changes in lighting can obscure these features, leading to reduced recognition accuracy. This is particularly evident when faces are captured under strong shadows or direct sunlight, where the system may struggle to maintain consistent results. In the following consideration, iteration can be integrated with other image preprocessing technologies to reduce the impact of uneven lighting, reduce the impact of uneven lighting and other methods.Face recognition attendance based on OpenCV has broad application prospects and development space, and with the continuous progress and improvement of technology, it will be widely used and promoted.

References

[1] XIAO Rui,WANG Jipeng. Attendance Management System for Mine Personnel Based on Face Recognition [J]. Modern Information Technology, 2023, 7 (07): 35-37+41. DOI:10.19850/j.cnki.2096-4706.2023.07.009.

[2] LIU Si, MA Jingyu, YUAN Qian, et al. Face Recognition System Based on Edge Computing [J]. Software Engineering, 2020, 23 (12): 40-42. DOI:10.19644/j.cnki.issn2096-1472.2020.12.012.

[3] Jin Weixiang,Xing Chen. Face Recognition Classroom Attendance System Based on OpenCV [J]. Journal of Zhejiang Institute of Water Resources and Hydropower, 2019, 31 (06): 58-62+87.

[4] ZHANG Yifu,CHEN Tianfei,ZHANG Jiansong. Online Face Recognition Time Attendance System Based on Raspberry Pi [J]. Electronic Design Engineering, 2019, 27 (22): 152-156. DOI:10.14022/j.cnki.dzsjgc.2019.22.033.

[5] SUN Zhi. Research and implementation of face recognition algorithm experimental platform based on OpenCV[D]. Jilin University, 2014.