Design of Face Recognition Access Entrance Guard System with Mask Based on Embedded Development

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Abstract. This paper investigates all kinds of access entrance guard control systems at home and abroad and analyzes their advantages and disadvantages. COVID-19 epidemic has a serious impact on life, travel must wear a mask, so that the access entrance guard control system can not carry out face recognition under the mask. In view of this kind of situation, an embedded face recognition access entrance guard control system with mask based on EAIDK-310 development board is designed. The system can complete face recognition and body temperature measurement without contact, and drive the motor to open the gate. After testing, the system is suitable for deployment in companies, communities, campuses and other small application scenarios. It is convenient to travel and can reduce the impact of the epidemic.

1. Introduction

As a biometric recognition technology, face recognition technology has been widely used in security industry and other fields. Taking human face as the basis of face data, computer vision and image processing technology are applied to the research and realization of face recognition. In the face of the raging epidemic of COVID-19, wearing a mask has become the standard for the whole people to go out. Face recognition mainly collects many key data points of the human face. Once the key data points of the face mask are blocked, it is easy to appear unable to identify and detect objects. Or the recognition rate is too low, which needs to take off the mask to verify and face the risk of cross-infection. This also makes the face recognition access control system under the mask has become a hot issue in today's society.

2. A summary of scheme argumentation design and occluded face recognition

2.1. Scheme demonstration

With the rapid development of RFID radio frequency technology and biotechnology at home and abroad, access control systems can be roughly categorized into three parts by the difference in principles and methods of input equipment identification. The three access control systems, credit card access control system, QR code access control system and biometric access control system, have their own advantages and disadvantages.
2.1.1. Credit card access control system
According to the type of card, it can be divided into contact card access control system and non-contact card access control system. Contact card access control system makes the card easy to wear and information is easy to copy, easy to invalidate the card due to external magnetic field interference, the use of the scene has become less and less, generally only used in the magnetic stripe card-related occasions. Contactless card does not need to contact with card reading equipment, and has the advantages of convenient use, strong durability, high-cost performance, fast reading speed, difficult to copy card information, high security and so on, so it is the mainstream of the current access control system. However, the biggest disadvantage of the card access control system is that the card is not easy to carry and easy to lose.

2.1.2. QR code access control system
In recent years, a new access control system based on QR code as identification carrier has been developed at home and abroad. The traditional card information is encoded into a QR code graphic, which is sent and saved to the mobile phone or printed directly by SMS and MMS. When in use, the QR code map is read and verified by a special code reading equipment. The entry and exit of personnel are controlled by judging the legitimacy of QR code information and ID card information.

The utility model has the advantages of no need to carry card media, low cost, easy to make, simple structure, flexible and practical, and is often used for temporary rights management, such as temporary visitor registration and reservation. The disadvantage is that the QR code has the characteristics of a large amount of information, but this is a double-edged sword. While we can get more information through the QR code, we may also leak our personal information because of this small QR code. Now there are QR codes on train tickets that can store personal information, and not long ago, there was news that tickets were discarded at will and were used by lawbreakers to obtain passenger information for illegal activities.

2.1.3. Biometric access control system
An access control system that identifies identity by verifying human biometrics. Common biological features are: gesture, fingerprint, palm, facial recognition, iris, finger vein and so on.

The advantage is that there is no need to carry cards and other media, from the point of view of identification, the security is excellent, the probability of repetition is low, and it is not easy to be copied. The disadvantage is that the cost is high, the recognition rate is not high, the requirement to the environment is high, the requirement to the user is high, and it is inconvenient to use. Because the biometric recognition needs to compare many parameter features, the speed is slow, which is not conducive to the situation of too many people. The biological characteristics of the human body will change with the change of environment and time, so it is easy to produce rejection rate, for example, fingerprints vary due to seasons and dry humidity, palms and portraits change with age, iris changes due to eye disease, etc., obviously it is this person, but his biometric characteristics have changed, and the biometric access control system will think that it is not me.

2.2. Scheme design

2.2.1. Hardware equipment
The hardware equipment needed in this paper includes EAIDK-310 embedded artificial intelligence development board, MLX series infrared temperature sensor, camera, motor and driver, 24V mobile power supply.

2.2.2. Research and methods
The paper is on the basis of relevant literature research to the access control system at home and abroad, and in which its classification, working principle and core algorithm were understood; then, after having compared and analyzed all kinds of access control system at home and abroad in literature research,
their advantages and disadvantages were classified out; finally, on the basis of analysis of their advantages, disadvantages and examination as well as combined with the present social actual situation, the design scheme of this paper comes out.

2.3. Overview of occluded face recognition

The most important biometric features of human body include face recognition, and most of the face research focuses on face recognition, and the expression model is divided into 2D face and 3D face respectively. 2D face recognition has been studied for a relatively long time, and the method flow is relatively mature, and it has been used in many fields, but because 2D face information has the limitation of depth data loss, it is unable to express the real face completely. Therefore, there are some shortcomings in practical application, such as low recognition accuracy, low living detection accuracy and so on. 3D face model has stronger description ability and can better express the real face than 2D face model, so the face recognition based on 3D data has a great improvement in both recognition accuracy and living detection accuracy. 3D face data contains the spatial information of the face, which is the inherent information of the face itself, so the 3D face recognition method will not be affected by illumination changes, pose changes, expression changes and partial occlusion, and supports a comprehensive understanding of facial features. In the occlusion face recognition based on 3D, on the one hand, the 3D geometry method is used to extract the important geometric information of the face, and then the shape change of the face is described according to the changes of the geometric information, and then the occlusion is recognized; on the other hand, the depth learning is directly applied to the 3D data, and the strong learning ability of the neural network is used to process the 3D data, extract the 3D features of the face, and better describe the face image.

Compared with 2D data, 3D data has the characteristics of large amount of data, disorder and sparsity, so there are some defects in directly identifying occlusion in 3D data. The commonly used methods are based on facial curve and radial curve [1]. Li et al. [2] proposed an effective 3D face recognition method to deal with facial expression and hair occlusion. In the recognition scheme, the accuracy reached 97.8%. Yu et al. [3] in order to solve the problem of partial occlusion recognition, a new radial string representation and matching method is proposed to recognize 3D facial scanning in the case of local occlusion, which eliminates occlusion effectively. From the point of view of removing occluded human face and repairing occluded region, Yuan et al [4] proposed a new method of unoccluded face image restoration based on 3DMM and generating anti-network GAN, and combined with a global and local anti-convolution neural network to learn face de-occlusion model. This method also reconstructs the correct 3D face model with de-occlusion texture. Similarly, Dagnes et al [5] proposed a new occlusion detection and restoration strategy, which relies on the geometric characteristics of human face, and designs two types of face occlusion recognition for eye and mouth occlusion caused by hands. By considering the influence of the occlusion region on the 3D point cloud, the occlusion is detected, located and classified, and then the occlusion region is gradually removed, and the missing information is recovered by using the symmetrical information of the non-occlusion region. Finally, face recognition depends on the restored face information and local landmarks.

3. Design of embedded development system

3.1. Hardware structure design of the system

The hardware of the system consists of the following parts: (1) main control module: the main chip adopts Arm SoC (RK3228H with high performance). At the same time, it is equipped with OPEN AI LAB embedded AI software development platform AID (including supporting heterogeneous computing library HCL, embedded deep learning framework Tengine, And lightweight embedded computer vision acceleration library BladeCV). (2) face data acquisition module: use USB external camera to collect face data. (3) Infrared temperature acquisition module: non-contact infrared temperature sensor (MLX90614-DCI) infrared energy is focused on the photodetector and converted into corresponding electrical signals. The signal is transformed into the temperature value of the
measured target after passing through the amplifier and signal processing circuit and corrected according to the algorithm in the instrument and the target emissivity. (4) Motor gate drive module: the drive board is Tb6560 stepper motor drive board. The output terminal has 6 inputs and 4 outputs, and the input and output pulse level supports 3.3 V, so it can be used without changing the voltage. The stepper motor uses the 57 stepper motor 57BYG250B whose current 2.8A, torque 1.2N.m, 2-phase 4-wire meet the highest requirements we need, and its price is cheap and suitable for popularization. (5) Terminal information display module: the touch display screen of HDMI interface is used to display the face recognition access control system with mask. The hardware of the system is shown in figure 1.

![Diagram of Hardware Structure Design](image)

**Figure 1. Hardware structure design of the system.**

### 3.2. System software flow design

Embedded development includes two main parts: environment building and program design. The environment is built using Feodora 28, the official system of EAIDK-310.

![Diagram of Software System Flow Chart](image)

**Figure 2. Software system flow chart.**

The main idea of programming is to use the generating countermeasure network (GAN, Generative Adversarial Networks) training data set to generate the TensorFlow model. The data set comes from the National Multimedia Software Engineering and Technology Research Center of Wuhan University. the data set contains 2000 face data, 1000 with and without mask. The model of the trained TensorFlow was tested. The face data acquisition module inputs the face data of the tested person who does not wear a mask to generate feature points. The camera records the face data of the tested person wearing a mask, and loads the trained TensorFlow model into the EAIDK-310 embedded deep learning framework Tengine to generate feature points. The feature points are normalized, and the cosine distance is calculated. The calculation formula of cosine distance is as follows.
Cosine distance, also known as cosine similarity, uses the cosine value of the angle between two vectors in vector space as a measure of the difference between two individuals. When the angle between the two vectors tends to 0, the closer the two vectors are, the smaller the difference is. That is, the closer the value is to 1, the more similar the human face is.

3.3. System operation flow
After the system is started, the information of the people who need to pass through the access control system is recorded through the camera. At the same time, the EAIDK-310 embedded artificial intelligence development board calculates the eigenvalues of the input face images, strengthens the weight of the eye eigenvalues and saves them to the face database; the camera and infrared temperature sensor send the face pictures and human body temperature information collected by the mask to the EAIDK-310 embedded artificial intelligence development board. The EAIDK-310 embedded artificial intelligence development board puts the face information collected by wearing a mask into the trained model, fuses the eye and the trained face model to form a new face information image, calculates the face feature information from the newly generated face information image, and strengthens the weight of the eye feature value, and then searches in the face data to find the face data with the highest similarity. Whether it is a person in the database is judged according to whether the similarity exceeds the threshold; if it exceeds, it is determined to be a person in the database, otherwise it is not a person in the database; whether the gate is opened according to the judgment result of the previous step; after the gate is opened, the gate continues to open when it reaches the limit position and waits for the personnel to pass through; the gate is closed after waiting for the timeout or the personnel to pass, and the gate stops closing after the limit position.

\[
\cos \theta = \frac{\sum_{i=1}^{n} (A_i \cdot B_i)}{\sqrt{\sum_{i=1}^{n} (A_i^2) \cdot \sum_{i=1}^{n} (B_i^2)}}
\]

(1)
4. Conclusions
This system mainly transforms face recognition into human eye recognition. Through the innovation of the algorithm model to improve the accuracy of face recognition, in order to reduce the impact of mask occlusion on face recognition. Specifically, the eye part of the face is divided separately, a "human eye recognition" neural network is trained separately, and the model is fused with the existing "face recognition network". The eye part is strengthened separately, and the stroke features are fused.

The main deficiency is that the tested people wear masks in the wrong way. For example, the mask blocks the human eye, so it is difficult for the algorithm to extract facial eye features, so the face recognition can not be completed normally, thus the authentication can not be completed, and the access control will not be opened. At this time, the tested personnel need to re-adjust the position of the mask to expose the eyes as much as possible, so as to facilitate the verification. The model of TensorFlow must be transformed into a model that can be used in the framework of Tengine, and there will be inevitable errors in the process of transformation.
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