

Smart Mirror Activated by User's Face Recognition with Simulation of Artificial Intelligence Classifier

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Abstract— This paper presented a simple and easy-to-use intelligent mirror with the activated function by face recognition. Firstly, the function of face recognition was realized by the OpenMV platform, and the recognition information was transmitted to the main controller, i.e., Loongson 1C Zhilong development board. The main controller connected to the Django server through the distant communication function of ESP8266 module. The user's schedules were acquisitioned by such a communication pathway and analyzed by the main controller. Finally, the recognized user's business or traveling schedule was shown on a screen located in the rear of a semitransparent mirror. For strangers of this smart mirror, the successful rate of strangers was 100%. For the user, the successful rate of strangers was 90% and accuracy of user's recognition was 100% in 120 times of tests. Furthermore, Adaptive Neuro Fuzzy Inference System supports a nice performance for Automatic classification in computer simulation. The COVID-19 pandemic is still threatening human beings. A smart mirror with the function of face recognition activation is a non-touching solution for avoiding the infections to support an idea for elevating human health.

Keywords—Loongson, RT thread, real-time operating system, OpenMV, wireless transmission, AI, ANFIS.

I. INTRODUCTION

With the rapid development of Internet, smart devices, and artificial intelligence technology has been valued and favoured by governments and enterprises around the world, and has even become a key indicator for evaluating whether new industries have sustainable development and technological innovation capabilities. As a popular identity authentication technology in recent years, face recognition captures the typical features of the face and compares it with the typical feature data in the database, calculates the similarity of feature points, and finally draws a judgment. Compared with the other biometric technologies, face

recognition has the advantages of simple operation and no touch to avoid infections.

The demand for home intelligence has been greatly enthused because people enjoy modern AI services such as the functions of voice recognition, map navigation, and barcode application in the smart phones. The trends will disuse some home appliances without AI aided functions. Therefore, the technology regarded to smart home keeps developing rapidly. When the types of smart home products continue to be refined, more and more products have intelligent functions, such as sockets, desk lamps, speakers, and so on. Smart home technology will be a required application in every family.

Yu et al. [1] presented a smart mirror, LUX, which employed deep learning model for Korean text sentiment analysis to detect user's mental comfort and response interactively. Ghazal et al. [2] proposed that a smart mirror which displayed a variety of information services and regular updates social media and news outlets was controlled by smart phone in ambient Internet of Things (IoT) environments. Yusri et al. [3] indicated that Smart Mirror which allows users to access information such as time and date, weather, warning, traffic, and location map and also control the lights in the house is a concept of smart home-based IoT.

Furthermore, Colantonio et al. [4] reported the results of Project SEMEOTICONS in Union Europe. They pointed out the challenges of building the Smart Mirror i.e. technological, scientific, and clinical challenges. There are many papers to concur the challenges. For technological challenge, many researchers developed the smart mirrors using Raspberry Pi for the central control [5-9]. Because the performances of Raspberry Pi is approaching to those of PC but its volume is much less than that of PC, and many advantages in memory, networking, and video, the Raspberry Pi family is the most popular module for the central control of the smart mirrors. For scientific challenges, Patro, et al. [10] presented a smart mirror with the function of face recognition with a security feature that needs to be integrated if the smart mirror is capable of displaying notifications from Facebook, mails,

Instagram, etc. Camera is attached on top of the mirror. Maheshwari et al. [11] developed the Local Binary Patterns (LBP) Histograms algorithm using OpenCV computer vision library to enhance the accuracy of the face recognitions. Bibri [12] discussed the social shape of the imaginary of data-driven smart city in the near future. He indicated that the smart mirror can be a part of future building to push the modern style of life. For the clinical challenge, recent applications of smart mirrors are purposed to enhance human health. Valencia-Jimenez et al. [13] developed a smart mirror to train the patients with some syndromes for regulations. Miotto et al. [14] implemented a smart mirror to elevate the personalized medicine.

In this study, the central controller is Loongson 1C which is a new microcontroller designed and fabricated in China. The developing platform is Loongson 1C Zhilong development board. The information of daily life such as weather, temperature, business schedule or touring information can show on the smart mirror. Furthermore, some of the imaging processing computation were implemented in this study.

II. METHODS

The technical requirements of this smart mirror were as follows:

- Response messages depending on individual users.
- Face only without any other operations.
- Avoid mistaking the users' faces.
- Convenient APP control.

For achieving the technical requirements, the system was designed by the following parts.

A. System structure

The system block diagram is presented in Fig. 1 which displayed 5 parts included APP of smart phone, microcontrollers, cloud, camera for face recognition, and display and mirror. The APP serving as a manager of the user was connected with the central controller by Bluetooth communication. The central controller was connected with ESP8266 for WIFI link to communicate the data with the cloud. The camera was a part of the OpenMV module which functioned as the face recognition processor to acquisition the features of the user faces for identification and connected with central controller for data processing of features. After all, the data and images projected onto the screen and mirror.

B. Microcontroller

This smart mirror system employed the Loongson 1C as the central controller which contains a floating-point processing unit to enhance the system's floating-point data processing capability. 1C's memory interface supports multiple types of memory, allowing flexible system design. Support 8-bit SLC NAND or MLC NAND FLASH, provide high-capacity storage expansion interface.

C. ESP8266

The ESP8266 WIFI module can be used independently or as a slave to run on other host MCUs. ESP8266WIFI module

integrates antenna switch, RF circuit, power amplifier, low noise amplifier, filter and power management module for minimal external circuitry and minimizes the size of the PCB. At the same time, the ESP can quickly switch between sleep/wake modes to achieve energy saving, and with the adaptive radio frequency adjustment with low power operation, it can achieve low power consumption while the device communicates with the Internet.

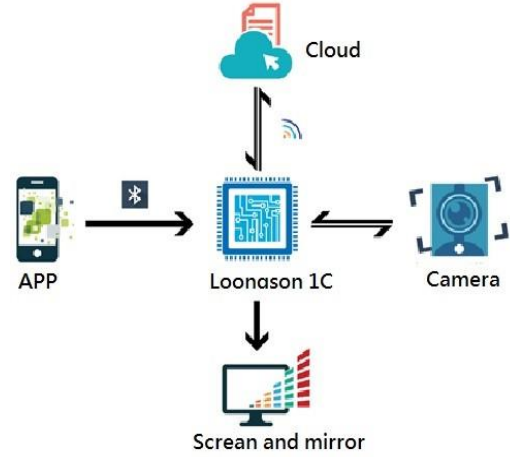


Figure 1. The functional block diagram of the smart mirror

D. Face recognition

The data processes of the face recognition were shown in Fig. 2. After start and initialization of the system, the smart mirror detects the human face. If the mirror acquisitions the human face, it takes a picture of the face. If it is not a human face, the system keeps in this loop. If the mirror take the face of user who has finished the registration, the features of the user's face sends to central controller to display the personal messages onto the mirror else the process goes to step 6 for saving the features of the new user's face. Next, the features of the user's face sends to central controller to display the personal messages onto the mirror then the process goes to step 3.

The face recognition algorithm of OpenMV is to calculate the eigenvalues of photos, and compare the eigenvalues of the photos in the database to obtain the differences of the eigenvalues. The photo of user's face in the database with the minimal compared error is the result of the recognition.

E. ESP 32

ESP32 integrates complete transmit/receive RF functions such as antenna switch, RF balun, power amplifier, filter, power management module and advanced self-calibration circuit. The self-calibration circuit realizes dynamic automatic adjustment to eliminate the defects of the external circuit. The ESP32 comes with two 32-bit, LX6 CPUs clocked at up to 240MHz. ESP32 supports the Bluetooth 4.2 standard and integrates Bluetooth/BLE radio frequency and low power technology. It can meet the communication requirements between APP and Loongson and reduce the overall power consumption.

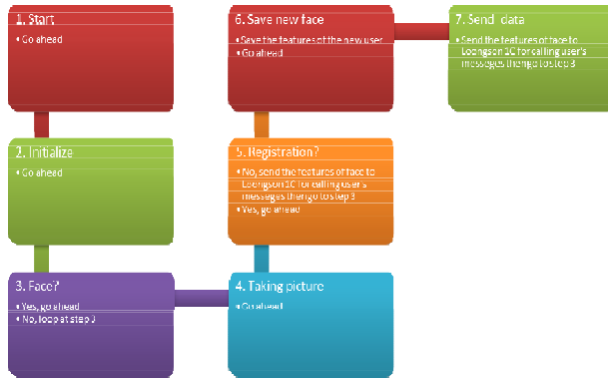


Figure 2. The data processing flow of face recognition

F. Adaptive Neuro Fuzzy Inference System (ANFIS)

ANFIS's architecture proposed by Kosko et al [17,18] is computed using the methods of both artificial neural network and fuzzy logic. This architecture combines the machine learning of artificial neural network and the if-then rules of Fuzzy logic. The peak values of histogram of the errors of eigenvalues were simulated as the input of ANFIS system and the true (0) or false (100) values were the given training results. The simulation was computed in MatLab users' development environment.

III. RESULTS

A. APP

The demonstration of the operations of APP was presented in Fig. 3. The functions of the APP included the managements of devices and users. The device management supported the searching of devices with Bluetooth communication and identified the functioned devices. The connections between APP and devices showed on the screen of the smart phone. The user management can add, delete and update the information of users. It can assign the user ID to the users.

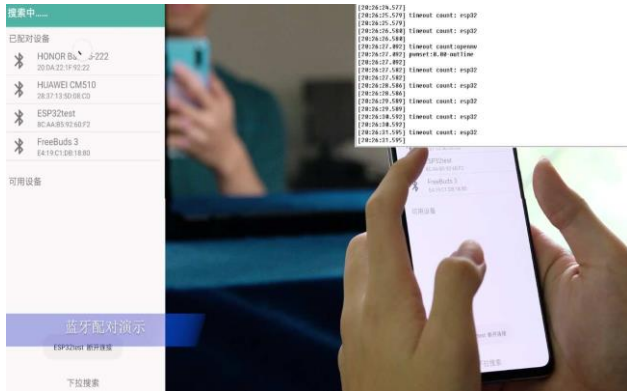


Figure 3. The demonstration of the operations of APP

B. Face recognition

The error distributions of eigenvalues in 120 times of tests of face recognition (a) in the data base, and (b) not in the data base were shown in Fig. 4 where X-axis denoted as the error of eigenvalue and Y-axis denoted as the ratio of the deviation.

In (a), the mean of the error of eigenvalue (μ) was 5422.52 and the standard deviation (σ) was 2019.6. However, in (b), μ was 9439.85 and σ was 1750.4. The better threshold was 7200. For strangers of this smart mirror, the successful rate of strangers (SRS) was 100%. For the user, SRS = 90% and accuracy of user's recognition (SRU) was 100%.

For the auto classification, the simulated performance of ANFIS classifier was presented in Fig. 5. The better threshold was 7000 to 7500 of errors. The classification was established by the scores (S). If $S > 30$, the recognition is fault.

C. The smart mirror

At all, the smart mirror was demonstrated in Fig. 6. This system develops a face recognition information reminder system. This system uses the Loongson 1C Zhilong development board as the main control chip and runs the RT-Thread real-time operating system. With the operating system, it possesses the characteristics of high development efficiency and strong system expansibility. The server built with Django provides a stable response service for the system's information transmission. This system mainly uses the Loongson 1C Zhilong development board, ESP8266, SSD1306 display screen, and the server side is implemented by Django.

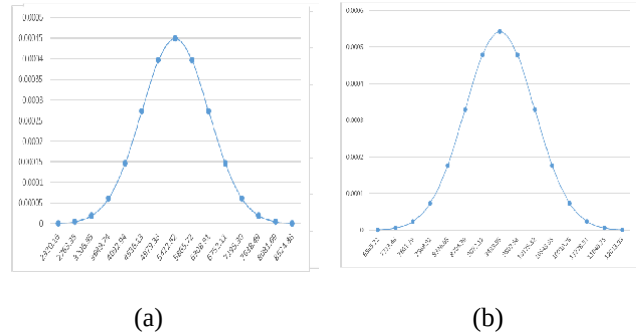


Figure 4. The error distributions of eigenvalues in 120 times of tests of face recognition (a) in the data base, and (b) not in the data

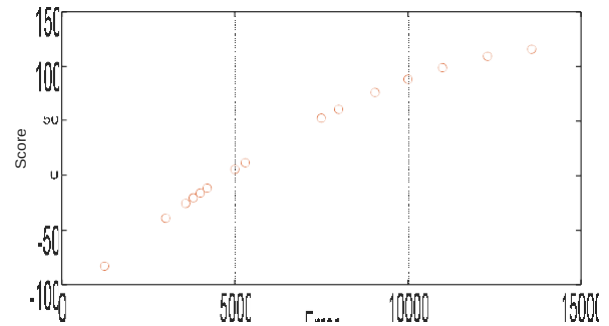


Figure 5. The simulated performance of ANFIS classifier

IV. DISCUSSION

The main difficulties were the scheduling logic and scheduling method of the processing threads, and the analysis of data in the server. Thereafter, the scheduling logic and method between threads were clarified by drawing the thread scheduling time diagram, and the parsing and screening of

server information was solved by inserting identifiers into the information.



Figure 6. The illustration of smart mirror

This design meets the requirements of the design scheme to a certain extent, and the design purpose is to realize a personal information reminder system with simple operation and strong scalability. After testing, the system has achieved the expected effect, is convenient in operation, and has strong expansibility.

The possible improvements of the smart mirror were as follows: (1) Using the algorithm of convolutional neural network to realize face recognition in the embedded system can achieve higher speed and accuracy [15, 16]; (2) Improve the circuit system of the system, and design the power supply circuit to supply power for OpenMV and Zhilong development boards.

The ANFIS classifier was with 2 rules and 80 epoch number in this study. We have tried a test of 4 rules and 40 epoch number. However, the results of the 2 rules and 80 epoch number presented a better performance in classifications. For the two-state results of recognition, the 2 rules Fuzzy logic match the reality.

V. CONCLUSION

The study completes the following tasks: (1) Complete the construction of the Loongson 1C Zhilong development board hardware platform, RT-Thread development platform, and Django development platform, complete the clarification of the serial port between the Zhilong development board and other hardware devices, and determine the device-related communication technology; (2) Carry out the architecture design of the system, modular decomposition for each function, the server function realization, and making a detailed design and implementation plan for the system hardware part; (3) Using Visual Studio Code to program thread communication and synchronization code, server information analysis code, IIC control display code, as well as OpenMV IDE to program face recognition code, face detection code, UART communication code. In addition, the Pycharm IDE has been employed for server code to implement server request response.

The COVID-19 pandemic is still threatening human beings. A smart mirror with the function of face recognition activation

is a non-touching solution for avoiding the infections to support an idea for elevating human health.

ACKNOWLEDGMENTS

The authors thank for the support from Guangdong University of Petrochemical Technology, Guangdong, China (Project number: 702/519244).

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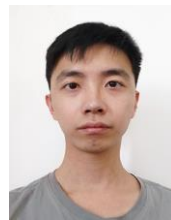
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