Emotional Feedback Lighting Control System Based on Face Recognition

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Abstract. In order to solve the vicious circle of negative emotions caused by stress spreading in the family. This paper designs a lighting control system that reflects the user's emotions in real time to assist users in managing emotions. The system establishes an emotion-color conversion model based on color psychology. Based on the Face++ face recognition cloud platform, the Raspberry Pi and Arduino form the hardware core for the overall design, hardware selection and software programming of the lighting control system. The system collects the user's facial image and uploads the image to the cloud platform, and then the cloud platform performs face recognition on the image. The recognized face parameters are returned to the system. Then according to the emotion-color conversion model, the face parameters are converted into light parameters. Finally, the system transforms the light according to the light parameters, so that it realizes the effect of transforming the light color according to the facial expression of the user, and plays a role in supporting the management of emotions.

Keywords: Face recognition · Emotions · Lighting system

1 Introduction

Nowadays, people generally need to face the pressure problems brought by modern fast-paced life. Negative emotions caused by stress are infectious and diffuse [1]. This negative emotion is bring to the family easily, and causes family disharmony. Eventually it will lead to a vicious circle of stress accumulation. This vicious circle will keep people in a sub-health state for a long time [2]. To solve such this vicious circle, we need to pay attention to managing emotions and avoid putting work pressure on the family.

This paper designed a lighting control system. The system uses the expression recognition technology in face recognition to develop a lighting control system that reflects the user's real-time emotions. The system captures the user's expression through the built-in camera, and uploads the captured expression to the server for analysis and processing. The expression is converted into a light color parameter,

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which controls the user's the current expression state through the change of the color of the light, so as to achieve the effect of supporting the management of emotions.

2 Face Recognition Technology

After more than 60 years of development, artificial intelligence has made breakthroughs in algorithm and data accumulation. In recent years, artificial intelligence has triggered new scenes in many industries, inspiring unprecedented value and triggering investment from the world [3]. As an important field of artificial intelligence, face recognition constantly breaks through the research bottleneck, and it has greatly improved in various aspects such as recognition speed and accuracy. Therefore, its application value is gradually reflected [4–7].

The main process of the traditional face recognition system is shown in Fig. 1.

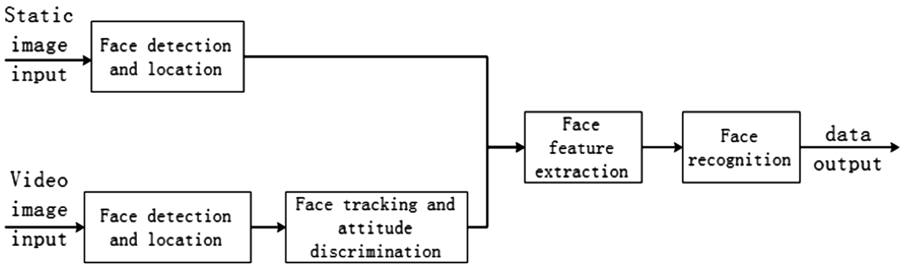

Fig. 1. Flow diagram of face recognition system

First, check if there is a human face in the image, determine its position in the image and separate it from the image. Secondly, extracting the facial features. Finally, identifying the processed image. The purpose is to match the recognized image with the pre-stored face image in the database and output the matching result [8–10].

3 Description of the System

3.1 Description of System Flow

The system uses a combination of Raspberry Pi and Arduino as the control system. The face image is captured by the camera. The face image is processed by the Raspberry Pi and uploaded to the Face++ artificial intelligence cloud platform. After the face image is processed by the Raspberry Pi, it will be uploaded to the Face++ artificial intelligence cloud platform.

Cloud platform analyzes face images, and then obtain feature data. After receiving the feature data, the Raspberry Pi processes it and outputs the corresponding control parameters. Arduino implements the corresponding light changes based on the received control parameters. The system flow is shown in Fig. 2.

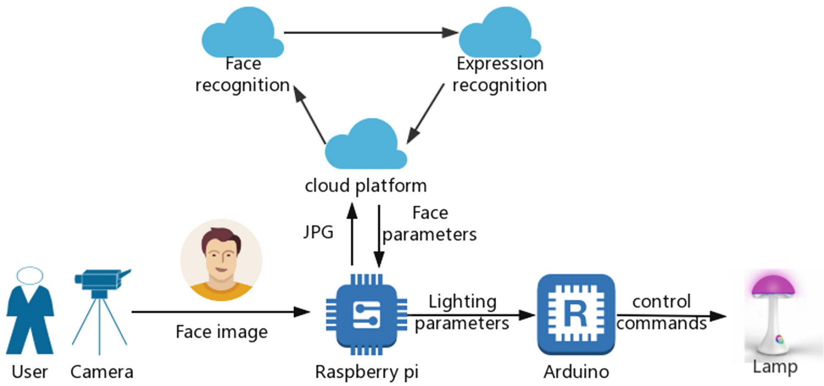

Fig. 2. Flow diagram of system

3.2 Description of the System Structure

The system uses Face++ artificial intelligence open platform as the face recognition platform, and the Raspberry Pi and Arduino as the hardware core for the lighting control system software and hardware design. The system is divided into three parts: the first part is the image acquisition module, which includes the functions of collecting and uploading face images; the second part is the face recognition module, which includes collecting and recognizing face features and returning face parameters; the third part is the light control module, which includes the functions of receiving face parameters and controlling light changes.

Functional architecture is shown in Fig. 3:

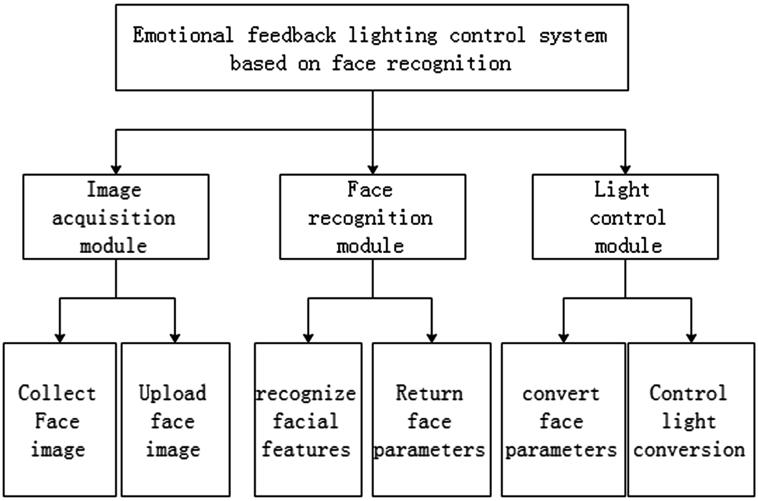

Fig. 3. System function diagram

(1) Collect face image: collect face image from the camera on the Raspberry Pi.
(2) Upload face image: the captured image is preprocessed and uploaded to the Face++ face recognition cloud platform.
(3) Recognize facial features: cloud platform uses face recognition technology to identify current images.
(4) Return face parameters: the cloud platform sends the recognized face parameters to the Raspberry Pi.
(5) Convert face parameters: the Raspberry Pi converts the face parameters into light parameters according to the preset formula and sends them to the Arduino through serial communication.
(6) Control light conversion: Arduino further processes the received light parameters to achieve the light transformation.

3.3 Description of System Functions

The system establishes an emotion-color mapping relationship, as shown in Fig. 4. According to color psychology, based on red, green and blue light colors, dividing the color circle into three areas of equal area, each representing an emotion. Its mathematical model is established as follows: extract the light colors corresponding to the three emotions of happiness, surprise, and sadness. They are orange, purple, and cyan. Then take the complementary colors of these three colors, which are blue, green, and red. This gives an inverse relationship between light and color: When the proportion of "happiness" is increased, the blue component of the light color will decrease and the light will be more yellow; When the proportion of "surprise" is increased, the green component of the light color will decrease and the light will be more purple; When the proportion of "sadness" is increased, the red component of the light color will decrease and the light will be more cyan. Through this emotional color mapping, the user can know the current expression state from the light color.

Fig. 4. Emotion-color mapping diagram (Color figure online)

4 System Software and Hardware Design

4.1 System Hardware Design

The system hardware structure is shown in Fig. 5. This system consists of host computer and slave computer two levels system: Raspberry Pi as the host computer, Arduino as the slave computer. They are connected to the camera and the controlled light sources. Power supply to the Raspberry Pi, Arduino, and controlled light sources.

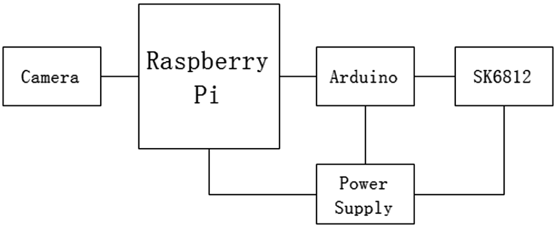

Fig. 5. Hardware structure diagram

As the host computer, the Raspberry Pi mainly undertakes the functions of data uploading, data receiving and data conversion of the system. As a slave computer, Arduino has a powerful expansion capability to make up for the shortcomings of the expansion of the Raspberry Pi. This makes the system more perfect.

Raspberry Pi and Arduino use the serial communication between them to exchange parameters. The connection method is shown in Fig. 6.

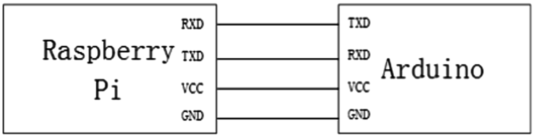

Fig. 6. Connection diagram of Raspberry Pi and Arduino

In the latest hardware upgrade of Raspberry Pi 0 W, the camera interface has been added, which enables the system to directly use the Raspberry Pi to achieve image acquisition. The camera interface category is CMOS Sensor Interface (CSI), so the system uses the matching CSI camera to achieve image acquisition. In terms of light source, the system uses RGB full color lamp bead SK6812. Its driving circuit and RGB chip are integrated in a 5050 package component to form a complete external control pixel point, which enables the system to achieve precise dimming effect.

The SK6812's data protocol uses a single-pole return to MA communication mode. The connection method is shown in Fig. 7.

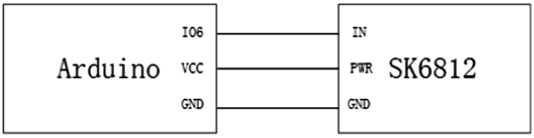

Fig. 7. Connection diagram of Arduino and SK6812

4.2 System Software Design

The system software part mainly includes the Raspberry Pi program and the Arduino program. Designed mainly according to the system flow chart of Fig. 8.

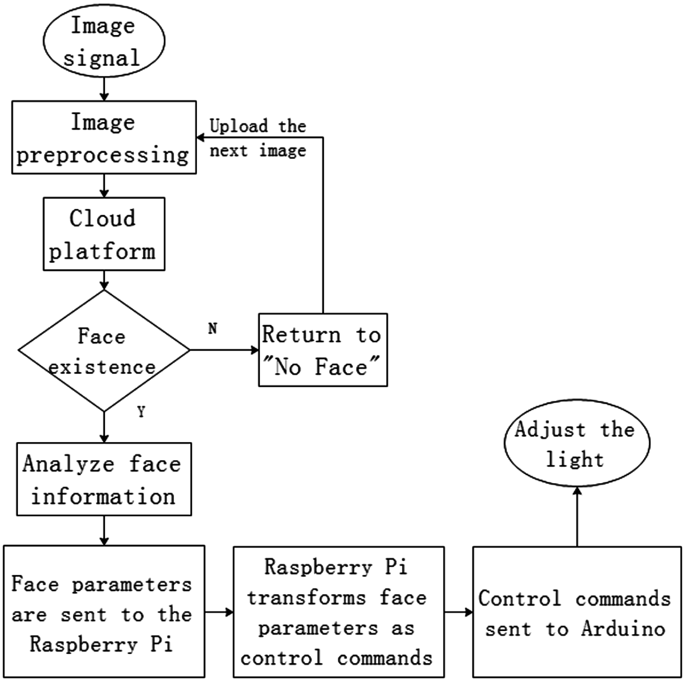

Fig. 8. System flow chart

(1) Raspberry Pi programming

As the host computer, the Raspberry Pi needs to complete the five functions of acquiring images, uploading images, receiving face parameters, transforming face parameters, and sending control commands.

First, call PiCamera to capture the image and save the image data captured by the camera. Then call the image upload function to upload the image to the face recognition cloud platform via the API provided by face++. Analytic data from the cloud platform will return to the Raspberry Pi. If there is a face in the image, it will get 4 emotional parameters: happiness, neutral, sadness, surprise. If there is no face in the image, it will prompt “ERROR: face_capture”.

After obtaining 4 kinds of emotional parameters, the Raspberry Pi needs to convert the emotional parameters into light parameters. The system selects RGB lamp beads as the light source, so, selecting “sadness, surprise, happiness” three kinds of emotion parameter corresponding conversion in the program.

b = int(255 − 255*data[‘happiness’]/100), When the proportion of “happiness” is increased, the blue component of the light color will decrease and the light will be more yellow; g = int(255 − 255*data[‘surprise’]/100), When the proportion of “surprise” is increased, the green component of the light color will decrease and the light will be more purple; r = int(255 − 255*data[‘sadness’]/100), When the proportion of “sadness” is increased, the red component of the light color will decrease and the light will be more cyan.

After the conversion is completed, the data needs to be sent to the Arduino through the serial communication. It is necessary to install and configure the pyserial module before using the Raspberry Pi serial communication. Configure the serial port to automatically recognize the serial port number mode. The baud rate is set to 9600 and the time of connection timeout is 0.1 s. Because the Raspberry Pi’s own serial communication command interferes with the data transmission of this system. For example, its end command is “0”, etc. Therefore, you need to use the program to rewrite the system commands. So, it is necessary to rewrite the system commands. Set 251–255 as the system verification command, 255 to verify the status of the serial port ready, 254 to verify the status of the data termination transmission, 129–250 to reserve the instruction set for the cmd command, 1–127 is the data. Use “X-X/2 + 1” and “X/2 + 1” to achieve split transmission of data and avoid the appearance of “0”.

(2) Arduino programming

Arduino is used as the slave computer in this system. It needs to be written with the host computer (Raspberry Pi) in programming. Therefore, after the Arduino receives the split data sent by the Raspberry Pi, it needs to synthesize two data into one data.

First need to set the serial port, set the baud rate to 9600, match the raspberry pie, rial.begin(9600). After the serial port is set up, use Serial.read() to receive the data sent by the Raspberry Pi. Since the data obtained from the Raspberry Pi has been split and zeroed out, it is necessary to synthesize two pieces of data after receiving the data, data [i] = data_buffer[2*i] + data_buffer[2*i + 1] − 2.

After the setup is completed, the data is received and processed by the serial communication, and the Adafruit_NeoPixel-master of Arduino is called to control the SK6812. The complete RGB parameters are loaded into pixels.Color() to control the RGB light source.

5 Implementation Case

After the system circuit is completed, testing system functions.

The face image is collected by the Raspberry Pi camera, uploaded to the cloud platform for face recognition, and the returned face parameters are converted by the

Raspberry Pi to obtain the light parameters. After receiving the light parameters, the Arduino performs dimming control on the light source.

The test results are: happy corresponding to yellow light, sad corresponding to blue light, surprised corresponding to purple light (Figs. 9, 10 and 11).

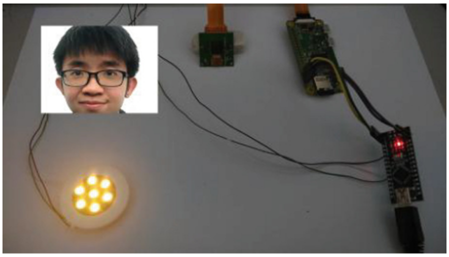

Fig. 9. Happy state (Color figure online)

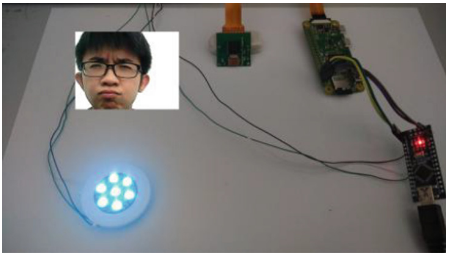

Fig. 10. Sad state (Color figure online)

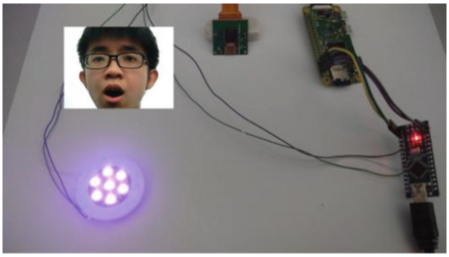

Fig. 11. Surprised state (Color figure online)

6 Summary

The system completes the user's emotions through expression recognition technology and converts them into lights for output. Remind the user's current expression status by changing the color of the light to help the user manage the emotions.

The system collects facial images through a camera and analyzes facial attributes using face++ face recognition cloud platform. After receiving the face parameters, the Raspberry Pi converts according to the emotion-color correspondence and outputs the light parameters through the serial port. After receiving the parameters, Arduino outputs control commands to control the lights. When the user is happy, the light will turn red; when sad, it will turn blue; when surprised, it will turn purple.

Advantages and features: Using face recognition technology to achieve luminaire control, this control method is closer to the concept of "smart" than traditional panel or remote control. Among the key links, face recognition is realized through the cloud platform interface, which is a popular practice in product development, and can guarantee its implementation effect and stability. The Raspberry Pi 0 and Arduino NANO selected by this system are the smallest controllers in the same type of products, which are easy to embed and low in cost.

References

1. Goldin, P.R., Mcrae, K., Ramel, W., et al.: The neural bases of emotion regulation: reappraisal and suppression of negative emotion. Biol. Psychiat. **63**(6), 577–586 (2008)
2. Nicolaou: Electronic performance monitoring: the crossover between self-discipline and emotion management (2015)
3. Sheth, S., Ajmera, A., Sharma, A., et al.: Design and development of intelligent AGV using computer vision and artificial intelligence (2018)
4. Ahonen, T., Hadid, A., Pietikinen, M.: Face description with local binary patterns: application to face recognition. IEEE Trans. Pattern Anal. Mach. Intell. **28**(12), 2037–2041 (2006)
5. Georghiades, A.S., Belhumeur, P.N., Kriegman, D.J.: From few to many: illumination cone models for face recognition under variable lighting and pose. IEEE Trans. Pattern Anal. Mach. Intell. **23**(6), 643–660 (2001)
6. Belhumeur, P.N., Kriegman, D.J.: What is the set of images of an object under all possible illumination conditions?. Kluwer Academic Publishers, Hingham (1998)
7. Brunelli, R., Poggio, T.: Face recognition: features versus templates. IEEE Trans. Pattern Anal. Mach. Intell. **15**(10), 1042–1052 (1993)
8. Samaria, Ferdinando, Young, Steve: HMM-based architecture for face identification. Image Vis. Comput. **12**(8), 537–543 (1994)
9. Lee, D.D., Seung, H.S.: Algorithms for non-negative matrix factorization. In: NIPS, pp. 556–562 (2000)
10. Turk, M., Pentland, A.: Eigenfaces for recognition. J. Cogn. Neurosci. **3**(1), 71–86 (1991)