

Research of Face Recognition System Based on Visual Intelligent Monitoring

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Abstract

The key technology of intelligent face recognition based on the visual monitoring was researched. Firstly, obtained the real-time scene by video camera, and the background difference method was used to judge whether there is a character goal in monitoring region, in view of the existing target, the color space of YCgCr and YCgCb were chosen to detect skin color, the geometric constraints that the aspect ratio of facial contour is 0.8 to 1.85 was used to realize the positioning of face region. Then the improved 2DPCA algorithm was used for face recognition, and data matching with the established database of face to determine the validity character identity. Finally the identification results were sent to the mobile terminal through the control system. System test results show that the processing speed of face recognition is 7 s/times, and the accuracy of face recognition results was 85%, which can provide technical support for the identity intelligent recognition of visual monitoring.

Keywords: Visual Monitoring, Face Recognition, 2DPCA, Intelligent System

1. Introduction

With the rapid development of intelligent information technology, the need of safe intelligent monitoring is increasing. In various industries, the demand for video monitoring increases gradually, such as business places, private space, bank counter, governmental security agencies, traffic detection, forestry disaster monitoring, *etc.*, in where have high environmental security requirements, so the development of video real-time intelligent monitoring technology is necessary to realize the security of environment [1].

In recent years, the identity identification and monitoring technology rise gradually that using all kinds of biological information of human, with the development of computer vision technology and sensor technology, the recognition for the human body characteristics has become a hot research. For example, identity identification using face, iris, retina, voice, fingerprint and so on, in which the facial recognition technology received sought after because it's not involved person infringement. Therefore, facial recognition has been widely applied in the aspect of business, crime and so on today [2].

Existing related research abroad are: the city and battlefield monitoring VSAM system has been in the trial stage which developed by the United States department of defense and scientific research institution of colleges and universities, the research that the tracking of vehicles and pedestrians and the identification of its reciprocal action were proceeded by University of Reading, the real-time visual surveillance system of the university of Maryland also made a lot of progress, companies such as IBM and

Microsoft also gradually apply the gesture recognition interfaces based on visual to business [3-4]; Major domestic research institutes and colleges and universities has also done a lot of research in video image processing. The existing research will promote the rapid development of the visual intelligent application [5].

The visual monitoring key technology of facial intelligent recognition was researched. The real-time scene video was obtained by camera, and the background difference method was used to judge whether there is any target within the monitoring region, then according to the existing character target, the YCgCr and YCgCb color space was determined by the color feature analysis, which was used for skin detection, the geometric constraints was made through the conclusion that the aspect ratio of facial contour is 0.8 to 1.85, which realized the extraction of face region. Then the improved 2DPCA algorithm was used to realize the face recognition, and matching to the face data in the established database, so as to determine the legitimacy of the face, finally the notification information of the identification results was sent through the control system, the test results show that the proposed intelligent system has higher identification accuracy, can provide the technical support for the development of visual intelligent monitoring technology.

2. Description of Algorithm

2.1. Background Difference Method

Firstly, the background difference method was used for the characters detection of monitoring range. The main idea of the background difference method is the subtraction of the current image and the background image of the video, and then the absolute value of the difference is taken, a threshold value was set on this basis, if is greater than the threshold, the pixels are considered to be the point of the moving target, otherwise will be considered the points of the background [6].Assumes that the threshold value is T , the background image is B , the current image is f , the output image is D , the formulization as follows.

$$D(i, j) = \begin{cases} 1 & |B(i, j) - f(i, j)| > T \\ 0 & |B(i, j) - f(i, j)| \leq T \end{cases} \quad (1)$$

The target detection result using this algorithm is shown in Figure 1.



Figure 1. Processing Results of Background Difference Method

2.2. Face Detection Methods

Skin color feature is the important feature of the human body surface, but there are some factors influence the color of the human face, such as individual differences, the color of the light source and the highlights and shadows caused by the different illumination angle, so the choice of the appropriate color space to detect the skin color is particularly important. Aimed at the yellow race in Asia, through the analysis of characteristics of skin color, the $YCgCr$ and $YCgCb$ color space were selected for the face skin color detection. In $YCgCr$ color space, when meeting the constraint conditions.

$$\begin{cases} Cg < 128 \\ Cg > 85 \\ Cr > 250 - Cg \\ Cr < 280 - Cg \end{cases}$$

That is to say when the image pixels on: $Cg \in [85 \ 128]$, $Cr \in [250 - Cg \ 280 - Cg]$, consider the pixels as skin color points, otherwise not. In color space, when meeting the constraint conditions.

$$(Cg - 107)^2 + (Cr - 110)^2 < 450 \quad (2)$$

That is to say when the image pixels on the roundness of center(107,110) and radius $\sqrt{450}$, consider the pixels as skin color points, otherwise not. So combining the $YCgCr$ and $YCgCb$ color space to detect the color skin [7]. The detection effect of skin color is shown in Figure 2.

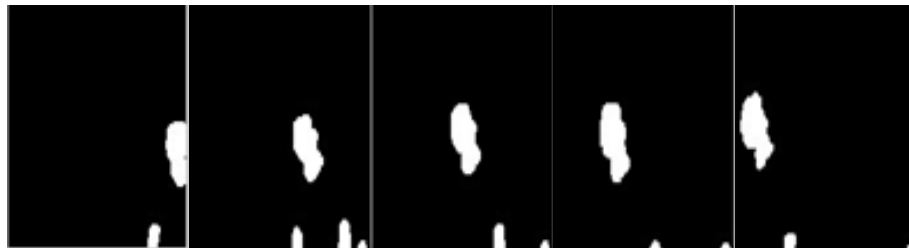


Figure 2. Effect Picture of Skin Color Detection

In addition, because the length and width of the face contour meet a certain proportion, so through the statistical analysis of data, setting the geometric constraints for face recognition, when aspect ratio of connected domain greater than 0.8 and less than 1.85, consider the connected domain as the face region. The computational results of the algorithm are shown in Figure 3.

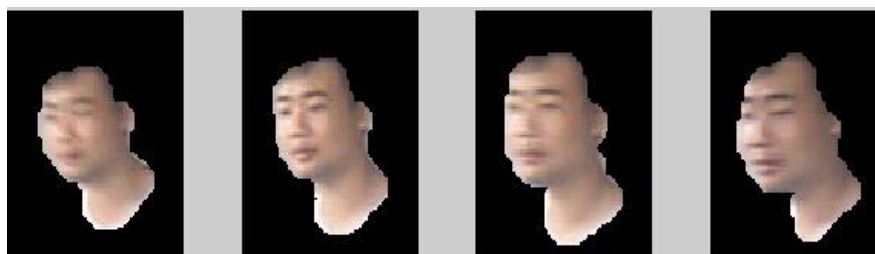


Figure 3. Detection Result of Face Region

2.3. The Improved 2DPCA Face Recognition Algorithm

(1) 2DPCA face recognition algorithm. 2DPCA is a face recognition method based on the statistics science, the training stage of the traditional 2DPCA is to build the feature subspace of all kinds of face image, and the recognition stage is to project the identified image onto the feature subspace for comparison. When there are many different types of characters in the samples library, if the different types of training samples put in the same feature subspace, because of the small Euclidean distance inside the class, but the Euclidean distance between the different types is larger relatively, and the threshold T is determined by the largest Euclidean distance between samples, so often can cause large false recognition threshold value T .

(2) The 2DPCA algorithm based on multiple feature subspace. According to the characteristics of the traditional 2DPCA algorithm, the 2DPCA recognition algorithm based on multiple feature subspace was put forwarded in this research. In training phase, according to the different types of samples, different feature subspaces were constructed respectively. While in recognition phase, firstly projected the identified image onto the feature subspace constituted by the first kind of samples, if the match is successful, is to identify the first group of the image sample libraries. Otherwise, continue to project it onto the feature subspace constituted by the second kind of samples, if the match is successful, is to identify the second group of the image sample libraries. Otherwise continue to project it onto the next feature subspace, and so on. If matching failure in all the feature subspace of samples, is to identify the image is not character in sample library, which is defined as illegal character. The steps of the algorithm are as follows.

Setting the total face of training sample is N , the category number is C , the number of images contained in the c kind of sample is N_c , the i th sample in the c kind shows as A_{ci} , the size of each image is $m \times n$. Firstly, calculated the average of the c kind of characteristics samples.

$$\bar{A}_c = \frac{1}{N_c} \sum_{i=1}^{N_c} A_{ci} \quad (c = 1, 2, \dots, C) \quad (3)$$

And then defined the covariance matrix of the samples in c kind.

$$G_c = \frac{1}{N_c} \sum_{i=1}^{N_c} (A_{ci} - \bar{A}_c)^T (A_{ci} - \bar{A}_c) \quad (4)$$

The facial image matrix G_c of training sample is a nonnegative definite symmetric matrices of the size of $n \times n$, the criterion solving the optimal feature vector of the C kind of samples is same to the method of the traditional 2DPCA algorithm.

$$J(X_c) = X_c^T G_c X_c \quad (5)$$

$$X_c = \arg \max J(X_c) \quad (6)$$

Where $J(X_c)$ is the generalized global spread criterion function, X_c is the n -dimensional unit vector. Make $J(X_c)$'s maximum unit vector X_c as its optimum eigenvector, actually is the feature vector corresponding to the biggest feature of G_{ci} . The vector corresponding to the first d maximum eigenvalues were selected as a set of optimum eigenvector, used to represent the cast shadow subspace of the c kind of samples [8].

$$\begin{cases} \{X_{c1}, X_{c2}, \dots, X_{cd}\} = \arg \max J(X_c) \\ X_{ci}^T X_{cj} = 1 & i = j \\ X_{ci}^T X_{cj} = 0 & i \neq j \end{cases}$$

Given a sample A , and projected it onto the feature subspace of the c kind of samples, to get a set of projection vector.

$$Y_{ck} = AX_{ck} \quad k = 1, 2, \dots, d \quad (7)$$

The principal component weight of the original image is Y_{ck} , the dimension is m , and the face feature matrix to extract is.

$$Y_c = [Y_{c1}, Y_{c2}, \dots, Y_{cd}] \quad (8)$$

Y_c is a matrix of $m \times d$, is the projection characteristic matrix in feature subspace of sample A_c in the c kind sample[9].

In recognition phase, firstly, the feature subspace projection was carried out for each sample image in the c kind of sample database to get their feature projection matrix. And then calculated the Euclidean distance between any two matrix, $Y_{ci} = [Y_{c1}^{(i)}, Y_{c2}^{(i)}, \dots, Y_{cd}^{(i)}]$ and $Y_{cj} = [Y_{c1}^{(j)}, Y_{c2}^{(j)}, \dots, Y_{cd}^{(j)}]$.

$$dis(Y_{ci}, Y_{cj}) = \sqrt{\sum_{k=1}^d (Y_{ci}^{(k)} - Y_{cj}^{(k)})^2} \quad (9)$$

Setting the threshold of the c kind samples is.

$$T_c = \frac{\max dis(Y_i, Y_j)}{2} \quad (10)$$

Given an image to identify B , its feature projection matrix was determined as $Z_c = [Z_{c1}^{(i)}, Z_{c2}^{(i)}, \dots, Z_{cd}^{(i)}]$, and calculated and Euclidean distance between matrix Z_c and each sample matrix $Y_{ci} = [Y_{c1}^{(i)}, Y_{c2}^{(i)}, \dots, Y_{cd}^{(i)}]$ ($i = 1, 2, \dots, N_c$).

$$dis(Z_c, Y_{ci}) = \sqrt{\sum_{k=1}^d (Z_{ci}^{(k)} - Y_{ci}^{(k)})^2} \quad (i = 1, 2, \dots, N_c) \quad (11)$$

If the minimum value $dis_{\min}^{(c)}$ of $dis(X_c, Y_{ci})$ satisfies the condition $dis_{\min}^{(c)} \leq T_c$, is to identify the image B belongs to the c kind characters in sample library, otherwise, continue to project the image for identifying onto the feature subspace of the $c+1$ kind of samples, then calculating the Euclidean distance between the projection matrix Z_{c+1} and each sample matrix $Y_{c+1,i}$ ($i = 1, 2, \dots, N_{c+1}$) of the feature subspace in the $c+1$ kind of samples, and comparing it with the threshold T_{c+1} , if $dis_{\min}^{(c+1)} \leq T_{c+1}$, that is to say the image for identifying B belongs to the $c+1$ kind character in sample library, and so on. If in all kind of the feature subspace are not satisfied the condition $dis_{\min} \leq T$, is to identify the image B does not belong to any kind of characters in sample library [10-11].

3. Intelligent System Design

3.1. System Structure

The hardware system was designed by the single chip computer STC12C5A60S2 and the Huawei GTM900 - B module. The GTM900 - B module was used for wireless data transmission and message sending and receiving. As the lower computer, the single chip computer realized the real-time serial communication with PC through the RS232 level switch, which is to receive the control signals from the upper computer. Meanwhile, as a control side, the single chip computer also controls the behaviors and contents of the message sending and receiving by the GTM900 - B module [12]. The hardware system structure is shown as Figure 4.

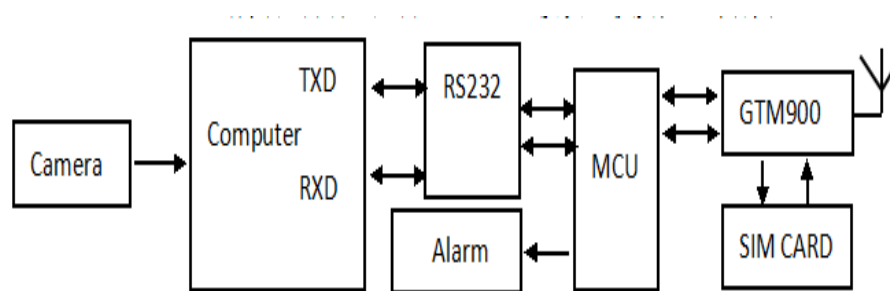


Figure 4. Hardware System Structure

3.2. System Hardware Structure

The real-time face detection monitoring program was carried out by upper computer PC, and real-time communicating with the MCU microcontroller through serial port and RS232 level conversion (serial port 1). When the test result is legitimate personnel, PC does not send any signal values, now the MCU and GTM900 - B module are in the standby state. When the test results is suspicious personnel, PC sends a signal value 0 to MCU, when receiving the signal 0, the MCU sends the AT command through serial port 2 to control the GTM900 - B sending the corresponding message to the mobile phone of the head of the household to remind the householder, which realizing the monitoring function. When the test results are illegal personnel, PC sends a signal value 1 to MCU, when the MCU detects the signal value 1, the audible and visual alarm circuit is started to alarm for illegally entering, and sends the AT command through serial port 2 to control the GTM900 - B sending the corresponding message to the mobile phone of the head of the household to warning the householder, The control system hardware is shown in Figure 5.

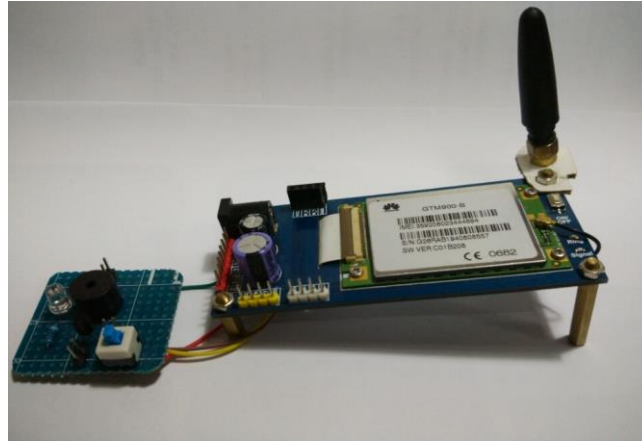


Figure 5. Control Module Hardware of Message Sending

3.3. System Software Design

The system developed based on the platform of Matlab, the software of the system includes background program and sample database. The background program is divided into two parts, the training sample program and the identify sample program. The sample database uses the face images with size of 100×80 . Each character's sample number is 150. Part of the facial screenshots in sample database is shown in Figure 6.

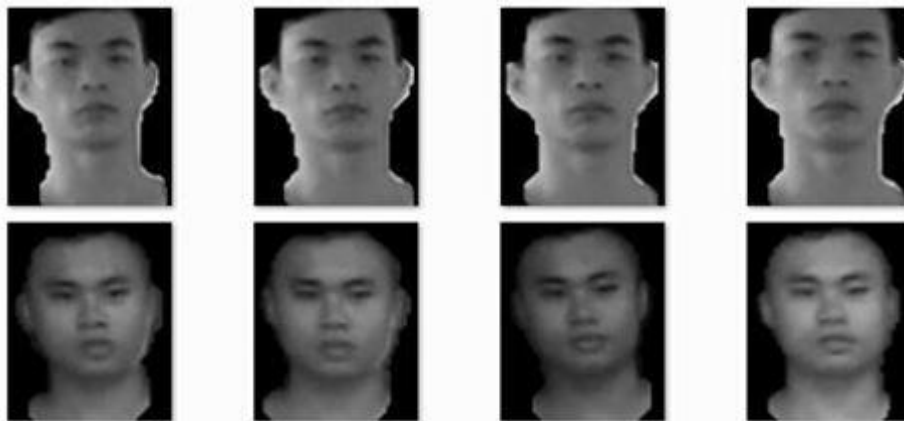


Figure 6. Part of the Facial Screenshots in Sample Database

Finally, the GUI interface of the software was designed based on the platform of Matlab. There are two function buttons, training sample and video recognition. The function of the training sample was realized through the 2DPCA algorithm. And in the video recognition function, 5 processes are included, such as video recording, remove the background, face detection, face recognition and message sending. The video recording was realized by the function of getsnapshot owned by Matlab, the length of the video for a period is 8s on average. The function of message sending is sending the face recognition output signal to the GSM module for processing. In addition, the algorithms used for background removing, face detection and face recognition have been discussed above, not repeat here. The software interface includes the result of the sample training, part results of the video capture, background difference and face

detection, and the final recognition results. The software interface is shown in Figure 7.

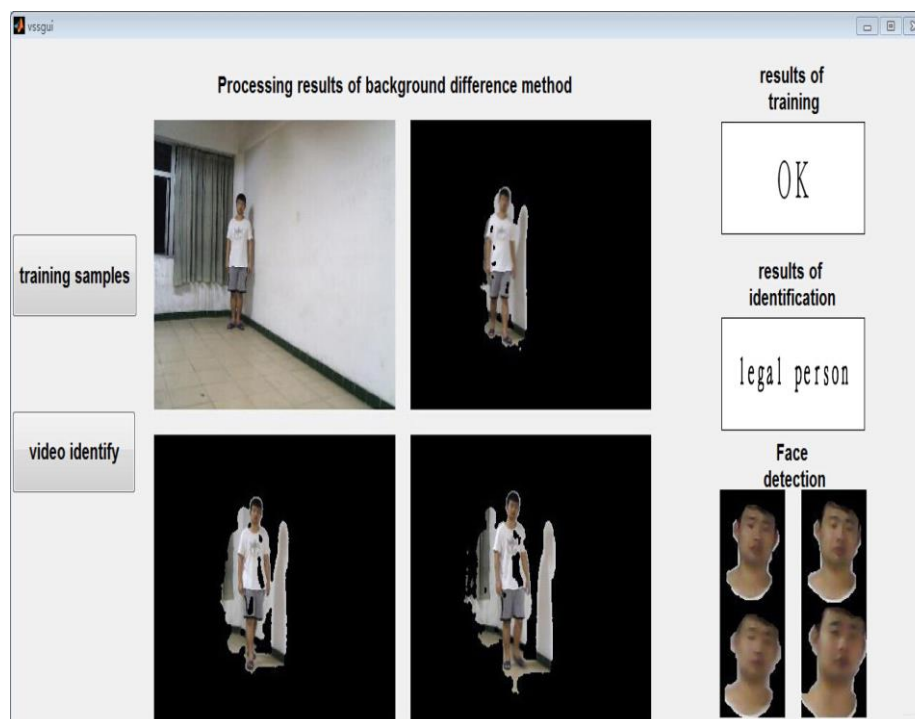


Figure 7. Intelligent System Interface

4. Experiment and Analysis

The identification process of this intelligent recognition system is shown in Figure 8. Some experiments was designed to test and analyze the system, firstly arranged the test scene in a fixed space, and then some different characters were selected to the detection range for monitoring test, finally analyzed the system test results.

Some different faces were selected for 100 experiments, which the legitimate faces is 25 and the illegal faces is 75, the video average length for testing is 8s, the test results show that the average speed recognition speed is 7s/times, and the accuracy of the identification and judgment is 85%.

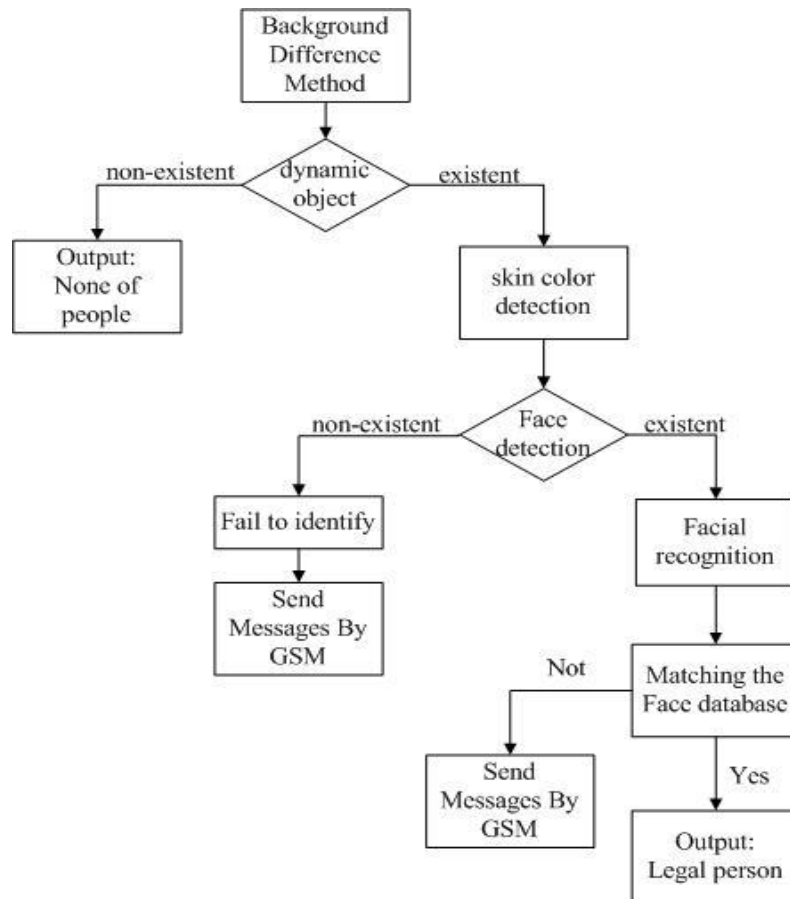


Figure 8. Flow Chart of the System

5. Conclusion

The key technology of intelligent face recognition based on visual monitoring was studied in this paper, the background difference method was adopted to judge whether there is a target in the monitoring area, the characters color feature analysis was carried out, and the YCgCr and YCgCb color space were selected for skin color detection, the constraint conditions that the aspect ratio of the facial contour is 0.8 to 1.85 was determined for the extraction of face region, then the 2DPCA algorithm was improved, and the 2DPCA algorithm based on multiple subspaces was proposed for face recognition, finally send the notification message of the identification results through the control system. The system experiment was proceeded, the result shows that the system identification accuracy is above 85%, which can provide the theoretical basis and technical support for the face recognition of the visual intelligent monitoring.

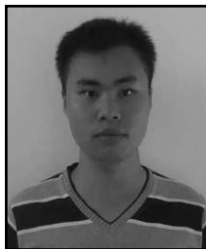
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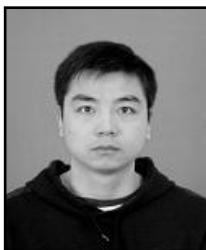
References

- [1] G. Zhenghua, "Research on a Real-time Method of Face Detection for Smart Video Surveillance", Zhe Jiang: Zhe Jiang University, (2008).
- [2] S. J. Julier and J. K. Uhlmann, "Unscented Filtering and Nonlinear Estimation", Proceedings of the IEEE Aerospace and Electronic Systems, (2004).
- [3] W. Kangkang, M. Long and Z. Yukun, "Research on Multi-manifold Discriminant Analysis in Face Recognition", Computer Application and Software, vol. 31, no. 10, (2014), pp. 189-192.
- [4] X. Yi and B. Kejin, "Research and Realization on Face Detection in Intelligent Video Surveillance", Computer Measurement and Control, vol. 21, no. 11, (2013), pp. 2921-2923.
- [5] L. Shangguo, "A Design of Intelligent Monitoring System Based on Biometrics", Journal of Chengdu University (Natural Science Edition), vol. 28, no. 1, (2009), pp. 56-58.
- [6] Z. Jia and L. J. Yong, "Moving target detection based on background difference and information entropy", Laser and Infrared, no.5, (2014), pp. 563-566.
- [7] Z. Zhengzhen and S. Yuexiang, "Skin color detecting based on YCgCb and YCgCr color space", Computer Engineering and Applications, vol. 46, no. 34, (2010), pp. 167-170.
- [8] H. Zhang, "Face Tracking and Face Recognition in Monitoring System", Shanghai: Shanghai Jiao Tong University, (2013).
- [9] S. Haifeng, W. Danyang and W. Hui, "Face tracking and recognition system for video surveillance", Computer Engineering and Applications, vol. 50, no. 12, (2014), pp. 175-179.
- [10] Z. Quanbing, H. Xiang and X. Zhengyuan, "Face Recognition Based on Monogenic Feature and Sparse Representation", Journal of South China University of Technology (Natural Science Edition), vol. 42, no. 8, (2014), pp. 58-62.
- [11] X. Yan and W. Weilan, "Research on Face Detection Technology Based on Vision Motion", vol. 31, no. 1, (2014), pp. 434-437.
- [12] L. Hongli and L. Wenguang, "Realization of Serial Communication on PC and Micro Controller Based on Matlab", Computer Applications and Software, vol. 23, no. 6, (2006), pp. 73-77.

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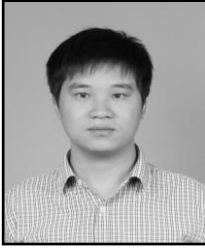
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