# The System of Face Detection Based on OpenCV

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**Abstract:** Face detection technology has widely attracted attention due to its enormous application value and market potential, such as face recognition and video surveillance system. Real-time face detection not only is one part of the automatic face recognition system but also is developing an independent research subject. So, there are many approaches to solve face detection. Here the modified AdaBoost algorithm based on OpenCV is presented, and experiments of real-time face detecting are also given through two methods of timer and dual-thread. The result shows that the method of face detection with dual-thread is simpler, smoother and more precise.

**Key Words:** Face detection, AdaBoost algorithm, OpenCV, Timer, Dual-thread

## 1 INTRODUCTION

With the development of the application of E-commerce, face detection is a key link of the automatic face recognition system and has more extensive application situation than face recognition system. As a result, face detection has the important and potential application in terms of content-based retrieval, digital video processing, video detection, etc. In addition, face detection is to detect and extract face, which is a fundamental issue in many computer vision applications. And the extracted face information includes size, position, posture, expression, and so on.

However, face detection is more challenging because of those unstable characteristics, for example, glasses and beard will impact the detecting effectiveness. Moreover, different kinds and angles of lighting will make detecting face generate different kinds of shininess and different areas of shadows, which have influence on detecting effectiveness.

To overcome these difficulties, investigators have done a lot of research from various respects, and they main include three stages. At the first stage, research was done to increase the detecting precision and to present more viewing angles. The example-based learning method[1] by Sung and so on in MIT and the SNoW-based learning system[2] have been studied. At the second stage, the detecting speed was increased based on skin color and edge characteristic by the technology of hierachical processing and neural network to cater to the speed in practical application[3][4]. At the third stage, a system of real-time face detection based on Boosting[5] proposed by P. Viola and so on in 2001 was the main mark of this stage. Afterwards, researchers not only combine the AdaBoost algorithm and Cascade algorithm but also study lots of Boosting algorithms to improve the precision and speed of face detection[3] [6].

## 2 FUNDAMENTALS

The basic thought of face detection is to get the face features by the statistical or intellectual methods to construct face model and compare to the matching level of detecting region and face model. After that, the possible face region will be got.

Algorithm of AdaBoost face detection includes choosing features which are Harr-like features and calculating features with integral image[7]. Extended Harr-like features are chosen to enhance detecting precision, which is divided into edge feature, linear feature and center surround feature. And the above features comprise feature module, in which there are two kinds of rectangle, white and black, as in Fig 1.

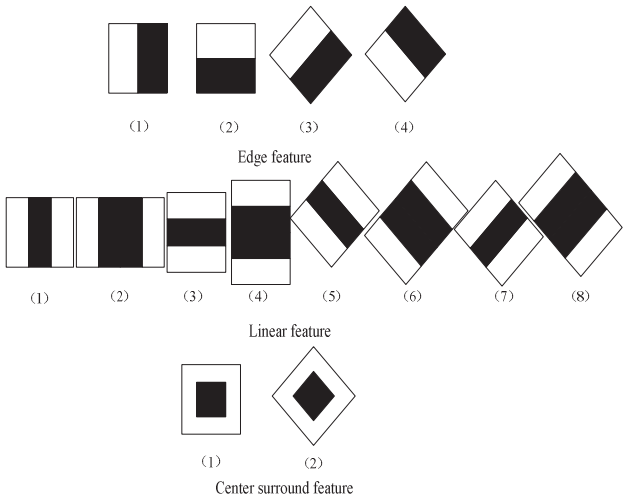


Fig 1. Extended Harr-like features

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Integral image is a method used to quickly calculate the characteristic value[8]: the difference between the sum of white pixels and the sum of black pixels. In Fig 2, it shows that the characteristic value composed by II and IV is the variation between the sum of IV pixels and the sum of II pixels. The former is the difference between the sum of integral image value of A and D and the sum of integral image value of B and C. The later is the sum of integral image value of B and integral image value of A.

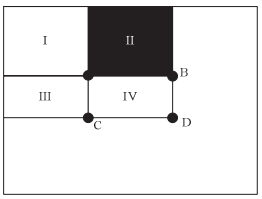

Fig 2. Four arrays figure

Modified algorithm of AdaBoost face detection is an iterative method, and its core idea is that different classifiers (weak classifiers) in the same training set are trained and mustered to make for a stronger final classifier (strong classifier)[9]. Next, different training sets are got by adjusting to the weighting of each sample.

The flow chart of algorithm is shown, as in Fig 3.

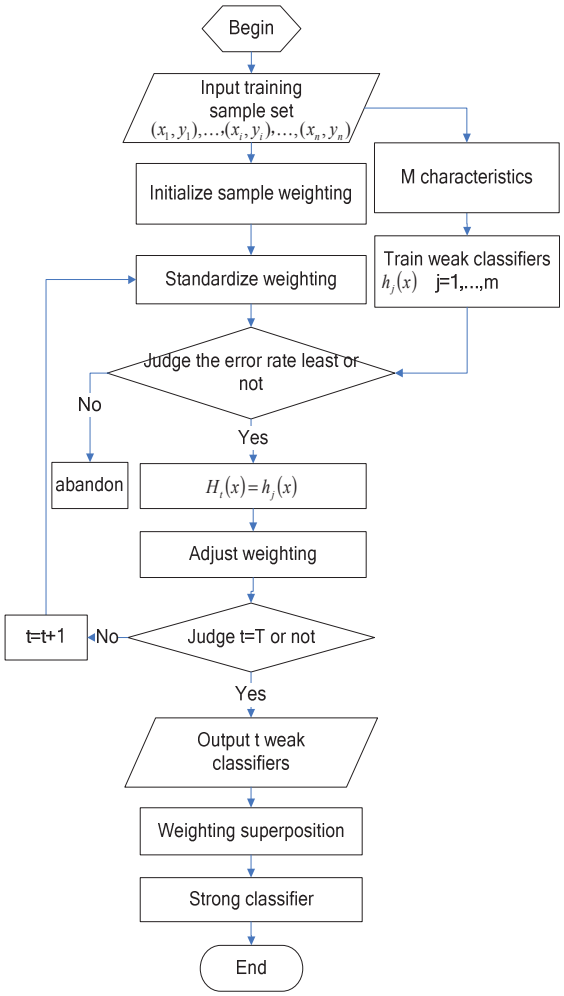

Fig 3. Modified algorithm flow chart

In Fig 3, a group of training sets: $(x_1,y_1),\ldots,(x_i,y_i),\ldots,(x_n,y_n)$ are inputted, and $x_i$ is sample image, including positive sample and negative sample, and $y_i$ is the classifying result, which meets the following condition: $y_i \in \{0,1\}$. Now, M features are taken for weak learning algorithm and each weak classifier $h_j(x)$ is trained according to each feature (j=1,...,m). Next, weighting value is initialized to be $w_{1,1}=1/n$, and the training period is T. Every period, a weak classifier which has the least error rate $E_j$ ( See the following equation(1)) is found( See the following equation(2)) by standardized sample weighting value $w_{t,i}$ ( See the following equation(3)).

$$E_j=\sum_{i=1}^{n} w_{t,i}\left|h_j(x_i)-y_i\right|, \tag{1}$$

$$H_t(x)=h_j(x), \tag{2}$$

$$w_{t,i}=w_{t,i}\Big/\sum_{i=1}^{n} w_{t,i}, \tag{3}$$

And then, sample weighting is adjusted (See the following equation(4)) to reduce the weighting of weak classifier classifying true samples and make false samples stand out. In this way, false classification in the last iterative period is pointed out and samples of the false classification receive attention in this period. At the same time, samples of the false classification will be trained more intensively by weak classifiers in the next period. Finally, the strong classifier is reached and the output function is shown in the following equation(5).

$$w_{t+1,i}=\begin{cases} w_{t,i}\beta_t & H_t(x_i)=y_i \\ w_{t,i} & other \end{cases}, \tag{4}$$

where $\beta_t=\dfrac{E_t}{1-E_t}$, and

$$H(x)=\begin{cases} 1 & \sum_{t=1}^{r}\alpha_t H_t(x)\le \frac{1}{2}\sum_{t=1}^{r}\alpha_t \\ 0 & other \end{cases}, \tag{5}$$

where $\alpha_t=\log\dfrac{1}{\beta_t}$.

## 3 FACE DETECTION WITH TIMER AND DUAL-THREAD

Face detection with both timer and dual-thread are finished in Microsoft Visual Studio 2008, installing OpenCV2.1 SDK. The final experiment result is to really-time detect face and to save detected face into three forms of color image, gray image and histogram equalization in specified folder.

### 3.1 Face Detection with Timer

Timer can be designed to control time using WM_TIMER message map. And the function SetTimer() can be used to set timer intervals and in the response

function OnTimer() processing statements can be added to finish timer operation.

After detecting, cascade classifier is added, referring to the file "haarcascade_frontalface_alt2.xml" in OpenCV. Then, the camera is started to reach video stream, and timer function is set, for example, SetTimer (1, 100, NULL) means timer intervals are 100ms. After that, capture and detect each frame of images in timer response function OnTimer(UINT_PTR). While detecting, if there are faces, the detected faces will be marked, shown and saved. The flow chart of system is shown, as in Fig 4.

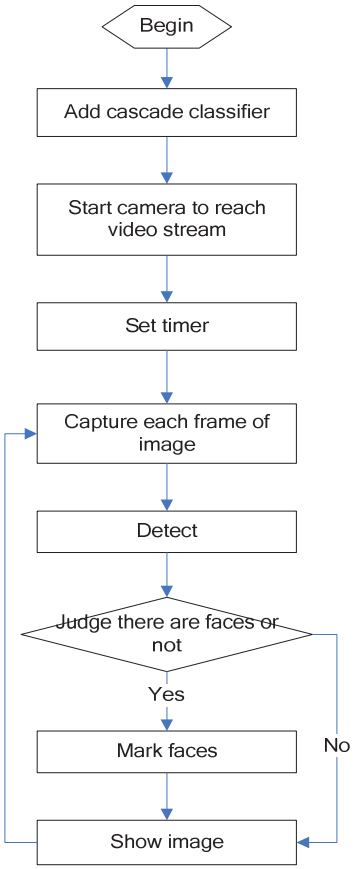


Fig 4. The flow chart of system

The detected result is shown, as in Fig 5.

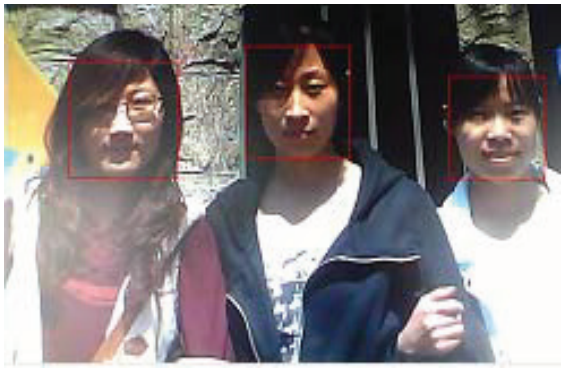

Fig 5. The detected result

### 3.2 Face Detection with Dual-thread

Thread is an execution unit in the process. All threads in a process are in the virtual address space of the process and use the same virtual address space, global variable and system resources[10], so that, communication among threads is more convenient. Moreover, the use of multi-thread is general, practical, realizing parallel processing and avoiding utilizing CPU for long time.

The main thread in this experiment is used to add cascade classifier, referring to the file "haarcascade_frontalface_alt2.xml" in OpenCV, too. Then, the camera starts to reach video stream and sub-thread is created. Meanwhile, each frame of image is captured and shown in sub-thread. In order to show video fluently, time intervals from beginning to end of detecting face are served as latency. The flow chart of system is shown, as in Fig 6.

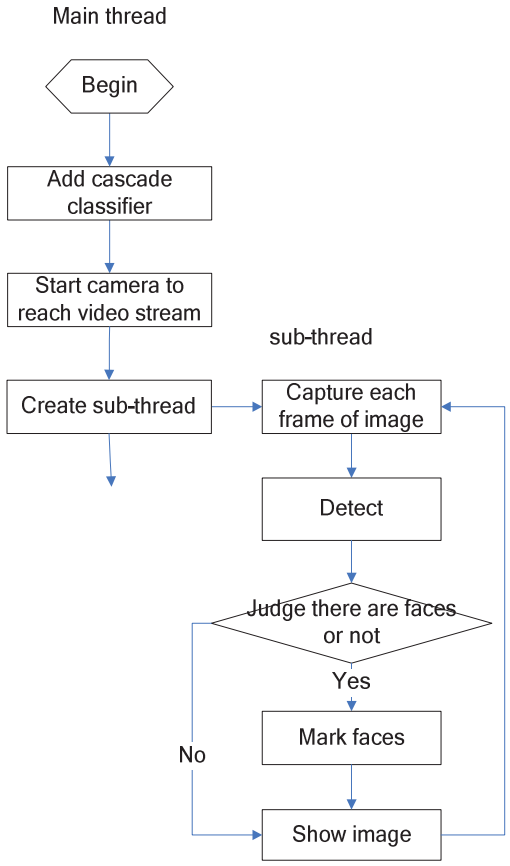


Fig 6. The flow chart of system

The detected result is shown, as in Fig 7.

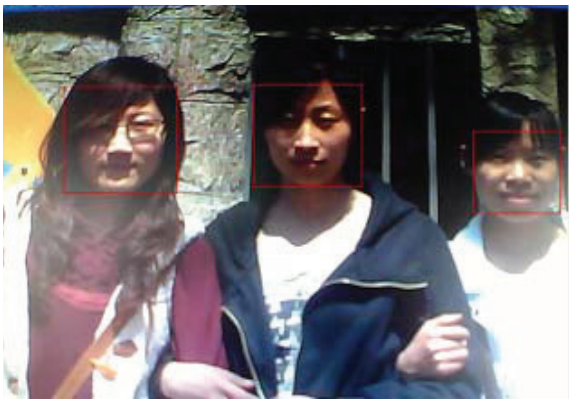

Fig 7. The detected result

Fig 8. Error detecting result

## 4 RESULT ANALYSIS

The above two experiments results show that two methods of face detection can detect face accurately and reach the requirement if there are faces in video. In other words, the effectiveness of both methods is the same if static image is used to detect face.

Although detecting face with dual-thread is more sophisticated than timer, the response speed of program is faster and the video is more fluent, which satisfies the desire of precision as two threads run and detect face at the same time. Moreover, tasks can be stopped at any time and priority of each task can be set one by one to optimize property if dual-thread is used. But, it should be noted that multiprocessors had better be used because switching between threads increases the usage of CPU.

While detecting face with timer, which is simple and utilizes less CPU, the precision is as low as the function Sleep(), which the least precision is only 30ms. What's more, time intervals must meet all operations included. As a result, time intervals between each frame image are longer and the video is not fluent, which doesn't satisfy the desire of precision. And priority in multi-task operation system of message is lower, so that message can not be responded in time. So, timer can be used to realize low-precision task instead of the application of controlling at real time.

In conclusion, the effect of face detection with dual-thread is better than that with timer if program is run on multiprocessors. At the same time, face detection based on modified AdaBoost algorithm can easily take "not face" for face, as in Fig 8. It is needed to find a combination of AdaBoost algorithm and other algorithms[11]. In this case, it can be better to detect face in complicated and colour images[12][13]. So, improving the precision of the detecting algorithm is important in next work.

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