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Adaboost를 이용한 얼굴인식

조선대학교 대학원

전자공학전공

정 문 영

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이 논문을 전자과석사학위 청구논문으로 제출함.

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정 문 영

정문영의 전자과 석사학위 논문을 인준합니다.

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Face Detection using Adaboost

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Nowadays computer just like a blindman, it only can accept the information from keyboard or mouse rather than achieving and handling message by itself from the real world. For the sake of letting computer recognize the world and getting message by itself, machine vision appears. Meanwhile, in order to achieving better performance in programs solving by computer itself, artificial intelligence develops. Now the performance of computer plays a great role in daily life, people get more and more interest in computer communication.

So far, new type of machine vision doesn't depend on traditional input device. The cost performance of computers raising and cost of getting video reducing make the system of computer vision can be used in embedded system. It means that the system of computer vision can be installed in any electronic product. In the future, electronic products with high vision system will make our life more convenience.

Face vision processing is an important part of computer vision processing. Face analysis includes face recognition and face detection. The purpose of face analysis is to achieving

user's identity and property (like face emotion analysis). Face recognition can be used in criminal identity recognition, bank and CIQ monitoring and so on. Hence, this paper is focused on face detection.

Face detection uses a method to detect face image. Now face detection is different from previous one that detected face in simple background. For using face detection in practice, face detection system must have the ability to detect face fast and exactly.

In this paper, a fast and efficient face detection method is presented which relies on the Adaboost algorithm and the features of Haar. We can calculate each part of face image's characteristic value and compare the characteristic value with non-face image's characteristic value at the same position by using rectangle features. At the same time, we can train a classifier that made up of several rectangle features which could separate face and non-face images exactly by utilizing the boosting algorithm, the process of face detection is depicted in Fig.1.

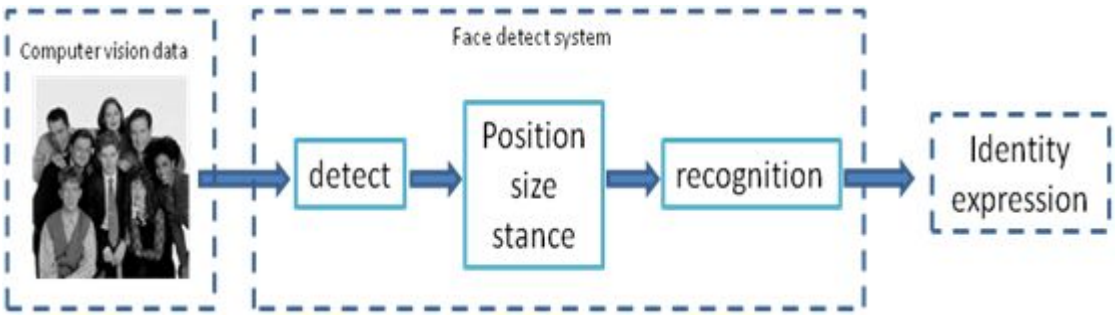


Fig. 1. Face analyse flow.

1. Introduction

Face detection method can be classified into four families: knowledge-based face detection, feature invariant face detection, template matching face detection, appearance-based face detection. Moreover, face detection still can be briefly divided into two classes: one class is based on image characteristic, the other class is based on image itself. In this paper, Adaboost face detection method regards to both of the two classes. In 1996, Rowley proposed nerve network face detection method[1] before Kohonen exploiting vector approach algorithm[2]; Then Sung and Poggio in MIT used database method to realize the face detection[3]; Moreover, SVM(Support Vector Machine) face detection algorithm mentioned by Heiselet and HMM(Hidden Markov Model) is utilized by Nefian[4].

Adaboost (Adaptive Boosting) method is stemmed from PAC learning method, which is mentioned in 1984 by Valiant [5]. Adaboost algorithm developed for a long period. In 1990, Adaboost method was first proposed by Schapire[6]. After one year, Freund proposed a better boosting method improved original Adaboost method[7]. At weak train, it just need the right rate to be move than 50%, then used some weak classifiers to boost a strong classifier.

2. Face Detection Theory and Background

2.1 Face Detection Difficulty

It is easy for people to recognize the faces by eyes, however, it is difficult for computer to detect and distinguish the faces due to the fact that face detection is a complex progress. First, the shapes of people's faces are various and complex because the emotion, eyes and mouths are always changing. Second, people's faces usually changed with respect to the outside environment. The glasses and hair type also mark the characteristic of the faces (Fig. 2).

Fig. 2. Different color skin, face envelop, face circumgyrate affect face detection.

Face detection technology develops fast, but it still has many problem needed to be

solved. In high dimension, it is difficult to build up a prefect face detection model. Therefore, how to effectively describe face needs to be researched by us. Detecting face in complex background is very important. By using NN, SVM and Bayesian classifiers to detect faces in image can obtain reasonable results.

Nowadays, face detection algorithm is weak in complicated poses, illumination and covered images. Hence, developing high capability face detection method is important and necessary. Face detection classifier made up of different kinds of classifiers can effectively improve face detection results effectively.

We always want to do real time face detection. Hence, face detection method must be simple and fast. As the develop of image processing, mode identify, artificial intelligence and biology psychology, face detection technology will be developed.

2.2 Face Detection Method

Face detection methods includes: knowledge-based method, feature invariant method, template matching method and appearance-based method.

Of course there still exists other face detection methods besides the four methods described above. Moreover, face detection still can be briefly divided into two classes: one class is based on image characteristic, the other class is based on image itself.

2.2.1 Knowledge-Based Method

This method uses representative knowledge of face to make a regulation code. Usually these regulation codes include face characteristics between each other.

Face knowledge can be concluded as four sorts such as contour regulation, apparatus distributing regulation, symmetry regulation, and movement regulation. First, in contour regulation, face contour looks like a ellipse so that face detection can be treated as ellipse detection. For a image, edge detection is done first, then ellipse ones are found out in order to achieve the face image. Secondly, in apparatus distributing regulation, people's face are distinguished according to a geometry regulations. Detecting face is same with detecting these geometry regulations. A face mode is made first and then apparatus’s position is detected. Thirdly, in symmetry regulation, there are some symmetric properties in face and apparatus. Finally, the last one is movement regulation.

If the input of images are image sequences, then we can distinguish the features between the changed image sequences and the unchanged image sequences. In this case, we can detect the faces based on the unchanged image sequences such as the static background images.

2.2.2 Feature Invariant Method

This method is to find out the unchanged characteristic when outside environment changed and to use these unchanged characteristic to detect face.

In this paper, Adaboost method belongs to unchanged characteristic method. After this

chapter, we can know how dose the unchanged characteristic method work.

2.2.3 Template Matching Method

Template matching method is a sutra model recognition method. Pre-treatment can make parameters to be a standard face images. First, pre-treatment images need to be uniformed the size and gray. Second, we calculate the input of images and the correlation value of the standard faces. At last, the foundation correlation value and threshold value is used to judge whether or not there exists faces in the images. This method is mature however, the detect rate is low.

2.2.4 Appearance-Based Method

Appearance-based method is similar with template matching method. But this method's model is learned from the practice study rather than from the definition of some researchers.

2.3 Face Images Data-Base

Face data-base can be used to do face detection train and test. Most face detection methods need face training data-base. Usually, face data-base used in face detection is small, just like MIT data-base, Yale data-base, CMU data-base.

Here are some familiar face recognition data-base, which described in Table 1.

Table 1.Face image data-base

Data-base	describe	Internet address
MIT	There are 16 people's faces, everyone has 27 face images at different ray, different scale, different face angle.	http://www.nist.gov/humanid/feret
Yale	Different ray condition, emotion face with eyeglass	http://cvc.yale.edu
Purdue AR	3276 faces at different ray condition	http://rvl1.ecn.purdue.edu/~aleix/aleix_face_db.html

A MIT's representative face data-base is presented in Fig.3. Each fave image size is 20 × 20.

For face detection, there are two important criterion: correct detection rate and false detection rate. The former one delegates the fraction of correct detected face images in all the images, while the latter one means the fraction of the wrong detected face images occupied in all the images. Hence, if the correct detection rate of a image is 100% and the false detection rate of the image is 0%, this face detection image can be considered perfect.

Fig. 3. MIT data-base face images.

3 AdaBoost Method Summarize

3.1 PAC Learning Method

PAC(Probably Approximately Correct) learning model is traditional learning model. PAC is mentioned at 1984 by Valiant. Weak train and strong train are mentioned in PAC learning method, where weak train can be improved to be strong train by using Boosting method. In 1990, Schapire raised Adaboost method. And then Freund proposed a better boosting method after one year.

In weak train, we just need right rate to be a little bigger than 50%. Moreover, we combine these weak classifiers into a strong classifier. Adaboost method is based on rectangle characteristic or Gabor Characteristic. In this paper, we use rectangle characteristic.

3.2 Rectangle Characteristic

3.2.1 Rectangle Conception

Adaboost is a machine learning algorithm, boosting from a simple weak train. It's still can be used to improve other learning algorithms. On face detection, we train weak classifier and make a strong classifier by boosting weight D through AdaBoost algorithm, which is based on face rectangle characteristic f.

The kernel of Adaboost algorithm is using some characteristic value to make a strong

classifier. On face detection, the characteristic value can be simple rectangle characteristic or Gabor (LogGabor) characteristic value. In this paper, we use simple rectangle characteristic.

The edge of simple figures can be detected by characteristic rectangle, but only the direction of horizontal, vertical and diagonal of the edge can be detected. As shown in Fig. 4, some simple face characteristics can be described by characteristic rectangle. The color of two side of nose is darker than the color of middle of nose, and the color of eyes is darker than the color of the skin below eyes. For a detector whose size is 20 x 20, there are more than 160,000 characteristic rectangles, so we must find a method to find the best characteristic rectangle and make it to be a strong detector to detect face. We choose simple rectangles to get model. The value of characteristic rectangles is the subtraction of the value of white pixel and the value of black pixel. We make six kinds of rectangles in our system as shown in Fig. 5.

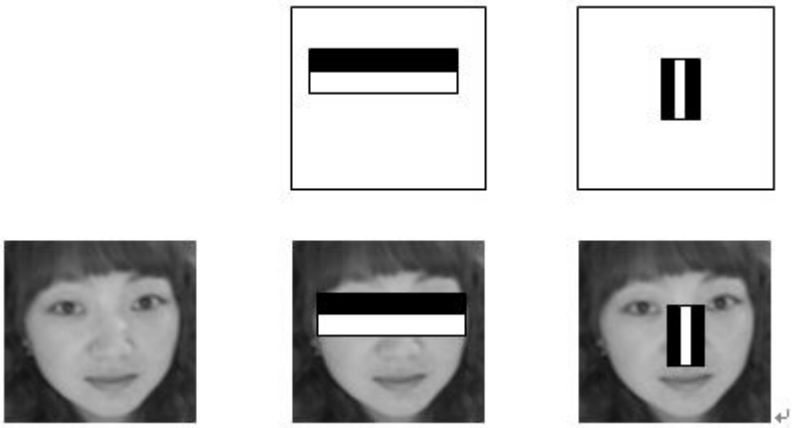


Fig. 4. Characteristic rectangles in 20 x 20 detector.

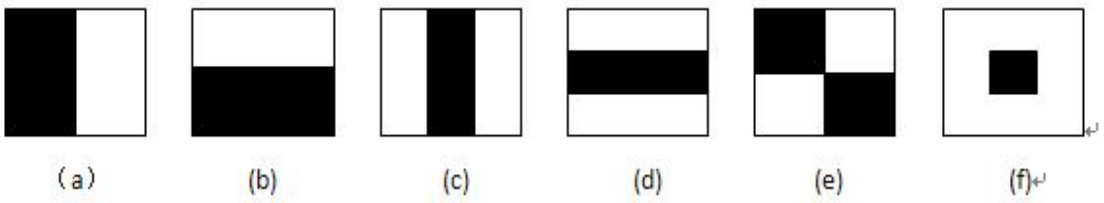


Fig. 5. Edge features are shown in subfigures (a) and (b), line features are presented in subfigures (c) and (d), symmetry features are depicted in subfigure (e), and center features are presented in subfigure (f).

For getting the value of image characteristic, first, we make an integral image [9]. Every pixel value is the sum of the value of the pixels on the left and upside of itself and the value of itself (Fig. 6).

1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1
1	1	1	1	1

(a)

1	2	3	4	5
2	4	6	8	10
3	6	9	12	15
4	8	12	16	20
5	10	15	20	25

(b)

Fig. 6. (a) Original image data, (b) integral image data.

3.2.2 Rectangle method in program

We make a program to explain how to achieve classifier by choosing rectangle characteristic and how to detect face image. As shown in Fig.7, the rectangle characteristic dose not have the capability of classification. However, the rectangle characteristic chosen by the program from Fig.8 possess this capability [10, 11, 12].

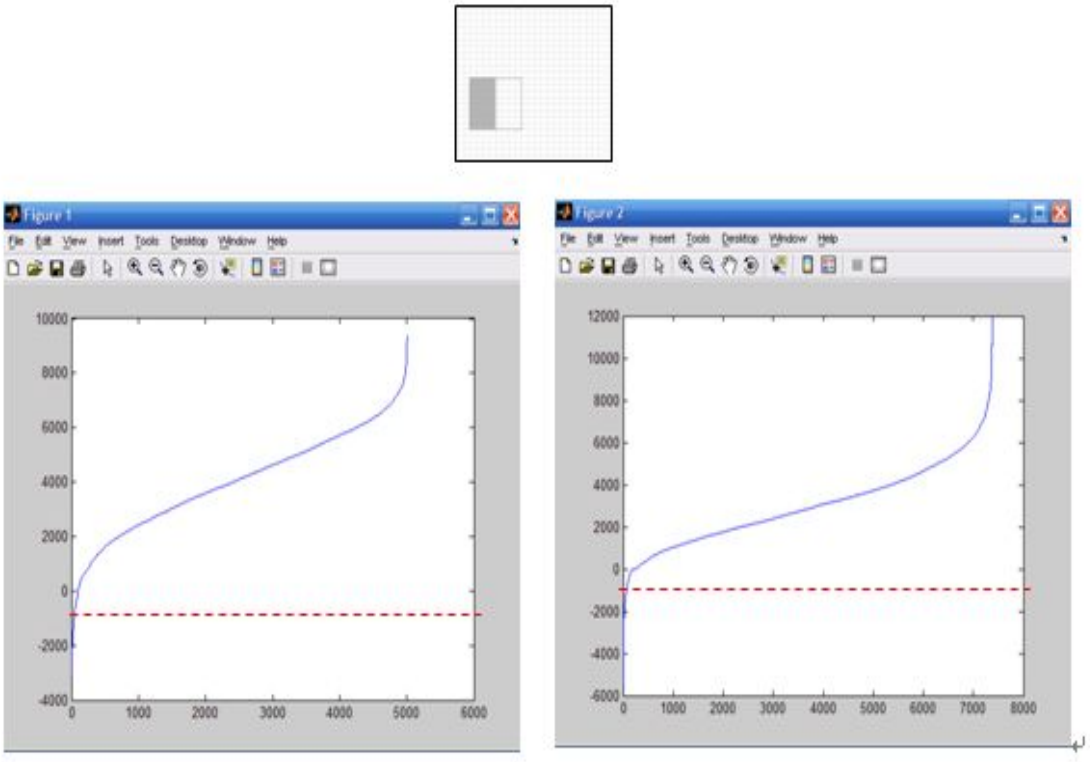


Fig. 7. Characteristic A, the coordination of rectangle is (12,3) (19,10).

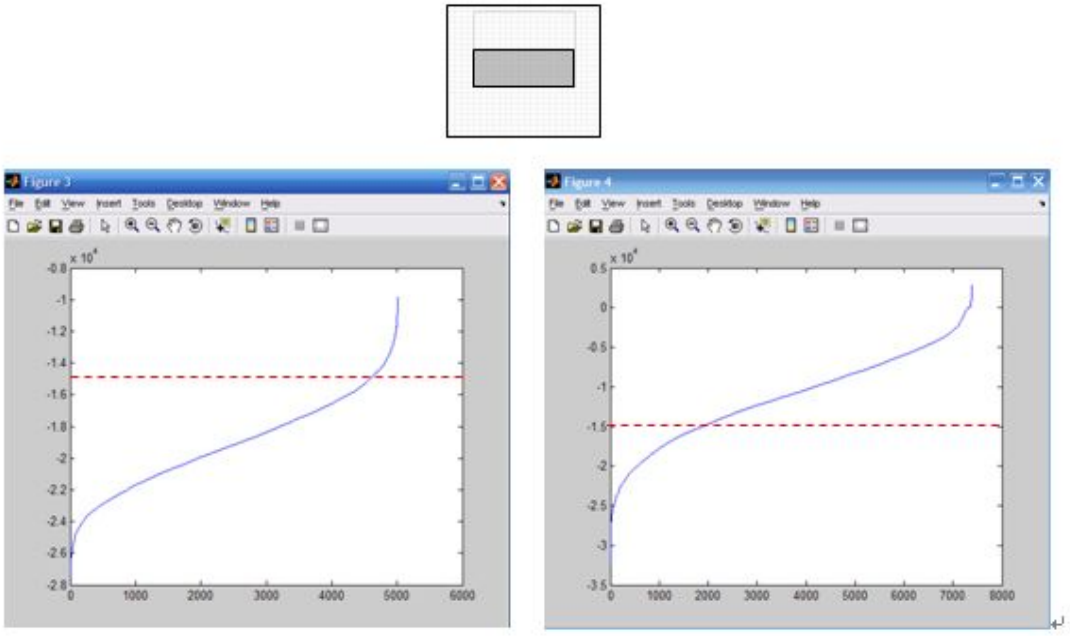


Fig. 8. Characteristic B, the coordination of rectangle is (2,5) (15,20).

Seen from Figs. 7 and 8, the value of rectangle characteristic A and B are similar. In particular, in Fig. 7, the value of rectangle characteristic of the face and the non-face image are almost same (the face value is 1.92% and the non-face value is 2.79%). It means that characteristic A does not have the ability to differentiate face and non-face image [13].

However, in Fig. 8, the value of rectangle characteristic of the face and the non-face image are different (the face value is 91.77% and the non-face value is 25.58%). Hence, characteristic B has enough ability to separate face and non-face image [14]. The kernel of Adaboost is finding the value of characteristics like the value of characteristics B to make a strong classifier.

Table 2. Characteristic A, B statistics for all data image characteristic value

characteristic	characteristic A			characteristic B		
DATA	face	nonface	D-value	face	nonface	D-value
DATA number	5006	7381	——	5006	7381	——
sum	20109037	22052891	-1943854	-83456764	-83456764	-12267233
mean	4016.99	2987.79	1029.2	-19121.85	-11306.97	-7814.88
A left of 0 percent B left of -15000 percent	1.92%	2.79%	0.87%	91.77%	25.58%	66.19%

3.3 AdaBoost Train Algorithm

3.3.1 Train Arithmetic

Given a characteristic concourse and a train concourse including positive swatch (face) and a negative swatch (non-face), any machine learning method can be trained to be a classifier [15]. However, we can obtain more than 30000 characteristic value in the 20 x 20 detector by changing the position and size of 6 characteristic rectangles (seen from Fig. 5). It is impossible for computer to calculate so much characteristic value. We want to choose a few characteristic value to make a strong classifier [16]. The data form of Adaboost algorithm is described in Fig. 9.

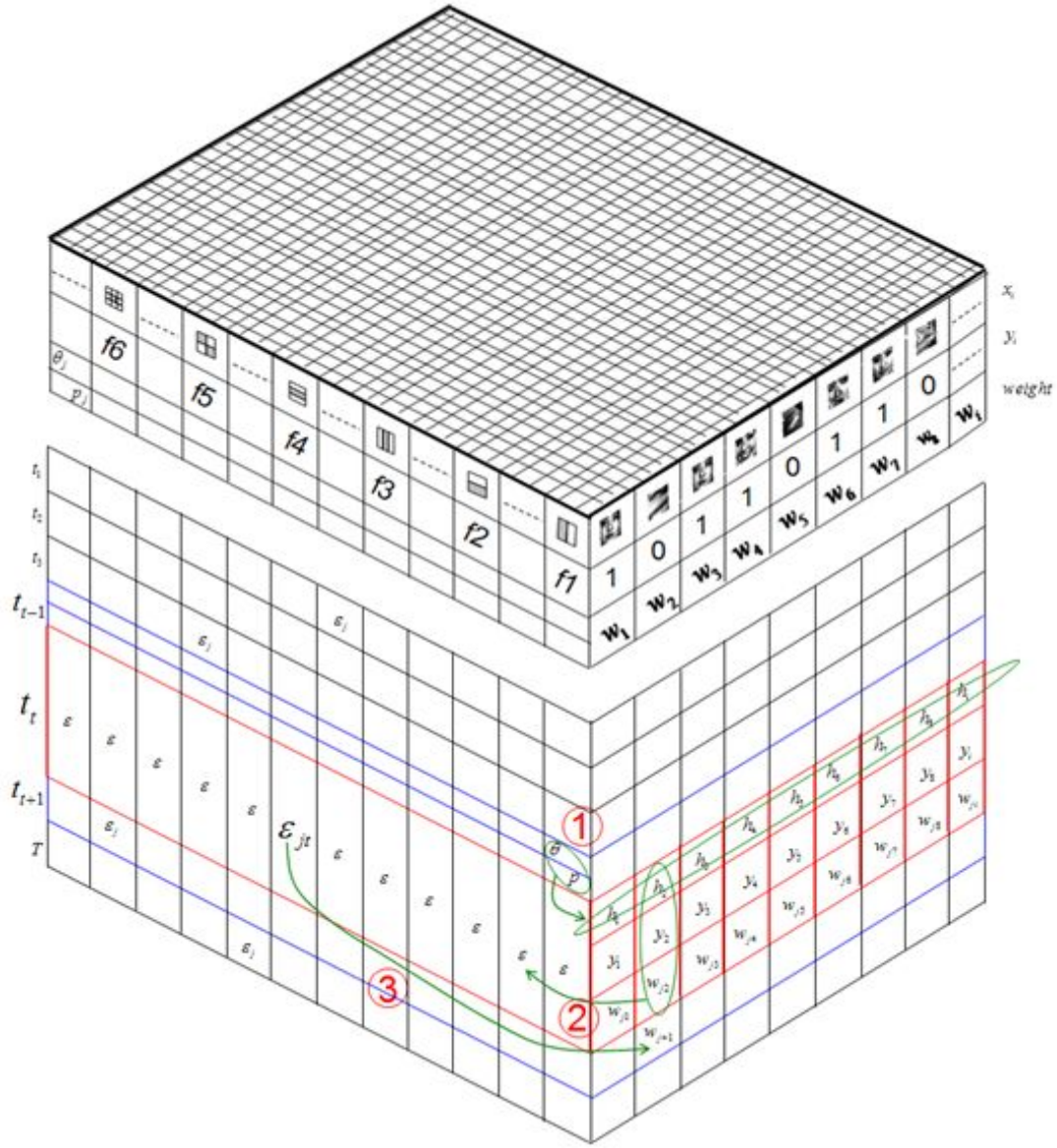


Fig. 9. The data form of Adaboost algorithm.

A. Data Image

There are some train data (x_1, y_1), (x_2, y_2), $(x_3, y_3) \ldots\ldots (x_n, y_n)$, here $y_i = 0$ means non-face image, $y_i = 1$ means face image [17]. "n" is total number of train data (second line, in Fig. 9).

B. Initialize Weight

Weight marks each data's heft in all train data. Hence, the total weight value of face image and non-face image must be 1.

$$\sum_{i=1}^{n} w_{fi} + w_{ni} = 1 \tag{1}$$

The total weight of face data must equal to the total weight of non-face data [18].

$$\sum_{i=1}^{f} w_{fi} = \sum_{i=1}^{nf} w_{ni} \tag{2}$$

Therefore, each face weight and non-face weight is : (third line, Fig. 9)

$$\begin{aligned} w_{fi} &= \tfrac{1}{2f} \\ w_{ni} &= \tfrac{1}{2nf} \end{aligned} \tag{3}$$

C. Weak Classifier

Weak Classifier $h(x, f, p, \theta)$ is made up of characteristic value f, threshold value is θ and p is delegated inequality symbol [19].

$$h(x,f,p,\theta)=\begin{cases}1 & f(x)<\theta \\ 0 & other\end{cases}, \text{ (p equal to '<')}$$

Or

$$h(x,f,p,\theta)=\begin{cases}1 & f(x)>\theta \\ 0 & other\end{cases}, \text{ (p equal to '>')} \quad (4)$$

Here, we define a value θ for each character f_j, for all data image. We treat θ as a standard value to judge f_j whether or not delegate a face. We only need the rate of weak classifier to be bigger than 50%. Many people choose θ to be mean characteristic value.

$$\theta=\frac{1}{n}\sum_{i=1}^{n} f_{ji} \quad (5)$$

Now, we need to judge p. We suppose p is ">" symbol, then we use (4) to calculate h for each f_j to all images. Of course some result is right, some is wrong [20]. We calculate the accuracy rate c_j. If c_j < 50%, we change p to "<" symbol. The situation is shown in Fig.10.

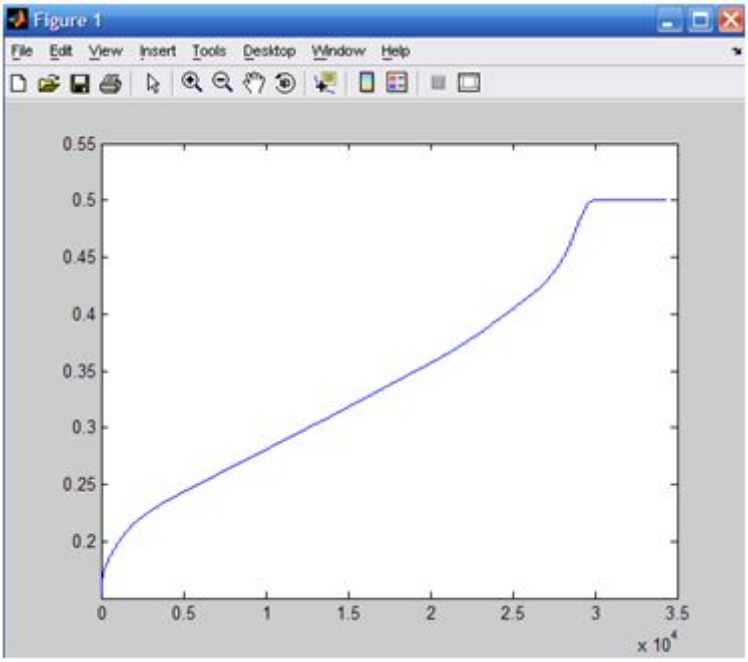


Fig. 10. Error rate small than 50%.

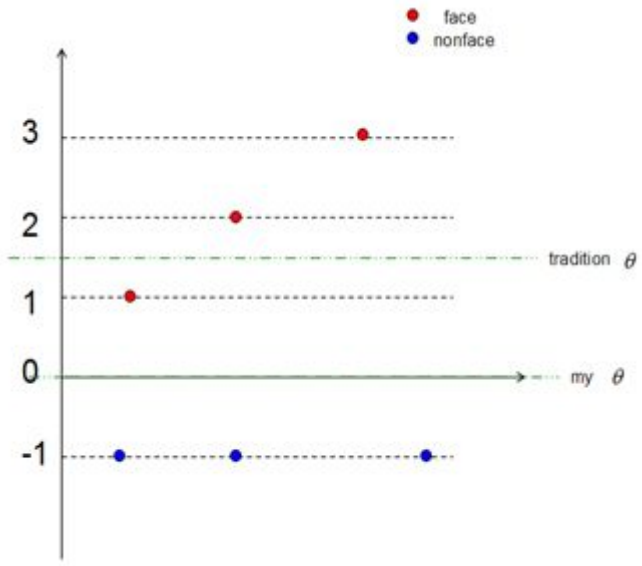


Fig. 11. Tradition method θ, new method θ.

Seen from Fig.11, we arrange every characteristic f_j 's value for all face and non-face image. Then we judge θ as mean value between each f_i and each f_j before finding out the best θ, witch can separate face and non-face image [21].

D. For t=1,……T

We train T times to get T weak classifier from each character f_j.

At first, weight is initialized and uniformed to be 1 after every train.

$$W_{t,j,i} = \frac{w_{t,i}}{\sum_{j=1}^{n} w_{t,j}} \tag{6}$$

For each character f_j, we train a weak classifier $h(x, f, p, \theta)$ shown in the step 1 in Fig. 9, and then we calculate the error rate of adding weight of weak classifiers, which

is described in equation (7).

$$\varepsilon_f = \sum_i^n W_{t,j,i} \mid h(x, f, p, \theta) - y_i \mid \tag{7}$$

And then we choose the best weak classifier $h_t(x)$ which has the smallest error rate ε_f :

$$\varepsilon_t = \min_{f,p,\theta} \sum_i^n W_{t,j,i} \mid h(x, f, p, \theta) - y_i \mid \tag{8}$$

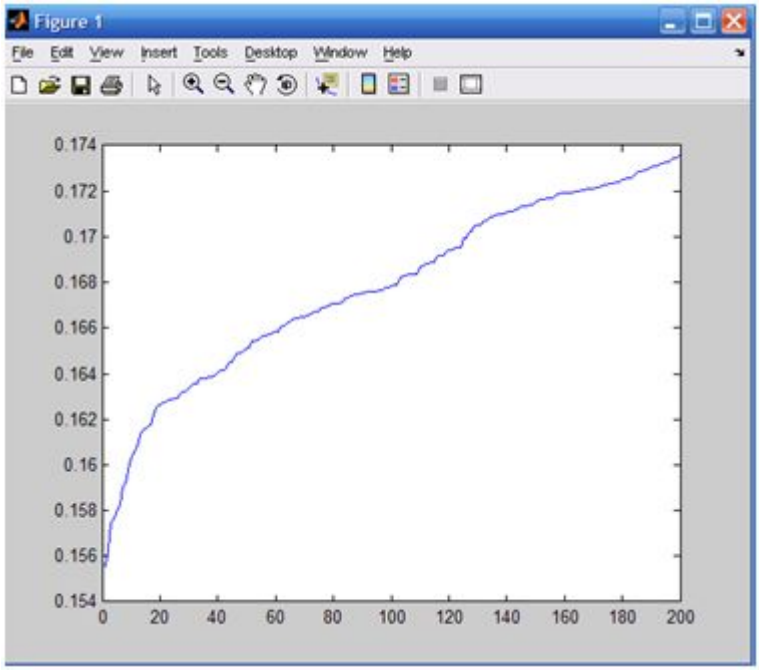


Fig. 12. ε_t 's trend at 200 loop train.

We must adjust weight at every train time, which is presented in equation (9).

$$w_{t+1,i} = w_{t,i}\beta_t^{1-e_i} \tag{9}$$

Here , $e_i = 0$ means that x_i is sorted correctly, $e_i = 1$ means that x_i is sorted wrong.

$$\beta = \frac{\varepsilon_t}{1-\varepsilon_t}$$

E. Strong Classifier

$$S(x) = \begin{cases} 1 & \sum_{t=1}^{T} a_t h_t(x) \geq \frac{1}{2}\sum_{t=1}^{T} a_t \\ 0 & other \end{cases} \quad \left(a_t = \log\frac{1}{\beta_t} \right) \tag{10}$$

Fig. 13 tells us the total process of Adaboost face detection algorithm.

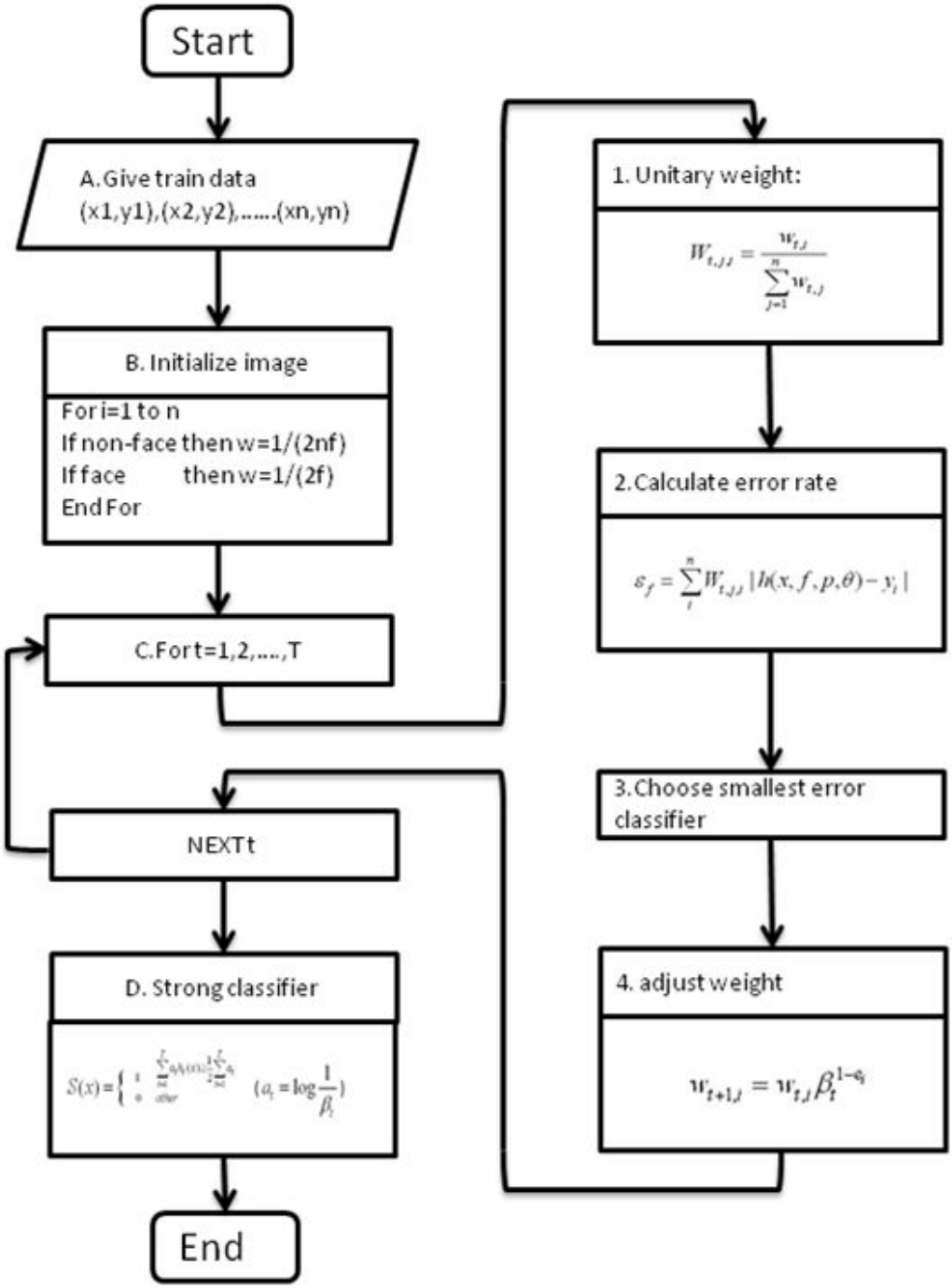


Fig. 13. Basic arithmetic flow chart.

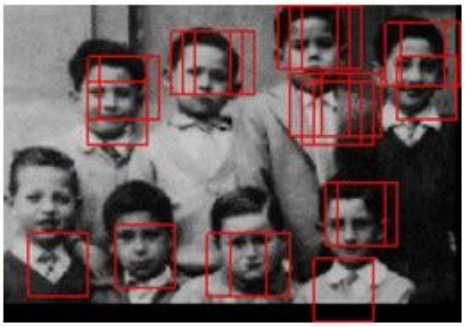
3.4 Test Result and Analysis

We have already established a face detection system, including data training and data pre-treatment. For testing image detection result and Adaboost algorithm, we have analysed the face detection system. The result of test on image is shown in Fig.14.

Because the environment of face detection is various and complex, different face detection programs are different to be compared with each other.

If there are enough characteristic rectangles and enough training times, Adaboost face detection algorithm can get a high accuracy rate, which can be approximate to 100%.

a



b

c

d

Fig. 14. (a, b, c, d) Image test result, tested image come from FERET.

4. Conclusions

In this paper, we trained 2706 standard face images from MIT and 4381 non-face images in order to detect face images.

Adaboost face detection method is an outstanding face detection method in image or video detection. When we detect face on image, we need to detect every pixel of the image. However, we don't need to detect all the pixel when detect face on video. First, we detect face around the position that has been judged as face. Then, we detect face on other position in order to save time.

We use Matlab program to test Adaboost algorithm and in this paper, we only use front face images as train data, so we can detect positive face image. Meanwhile, if we change train data, we can judge the sex, the age and the emotion of people by using this system.

In conclusion, Adaboost method is fast, robust and reliable, and significantly improves on the feature candidates provided by the global search. Though demonstrated on faces, the approach is clearly applicable to a wide variety of image interpretation tasks.

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저작물 이용 허락서

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본인이 저작한 위의 저작물에 대하여 다음과 같은 조건 아래 조선대학교가 저작물을 이용할 수 있도록 허락하고 동의합니다.

- 다 음 -

1. 저작물의 DB구축 및 인터넷을 포함한 정보통신망에의 공개를 위한 저작물의 복제, 기억장치에의 저장, 전송 등을 허락함
2. 위의 목적을 위하여 필요한 범위 내에서의 편집·형식상의 변경을 허락함. 다만, 저작물의 내용변경은 금지함.
3. 배포·전송된 저작물의 영리적 목적을 위한 복제, 저장, 전송 등은 금지함.
4. 저작물에 대한 이용기간은 5년으로 하고, 기간종료 3개월 이내에 별도의 의사표시가 없을 경우에는 저작물의 이용기간을 계속 연장함.
5. 해당 저작물의 저작권을 타인에게 양도하거나 또는 출판을 허락을 하였을 경우에는 1개월 이내에 대학에 이를 통보함.
6. 조선대학교는 저작물의 이용허락 이후 해당 저작물로 인하여 발생하는 타인에 의한 권리 침해에 대하여 일체의 법적 책임을 지지 않음
7. 소속대학의 협정기관에 저작물의 제공 및 인터넷 등 정보통신망을 이용한 저작물의 전송·출력을 허락함.

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저작자: 정 문 영 (서명 또는 인)

조선대학교 총장 귀하