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DRIVER FATIGUE DETECTION BASED ON THE DISTANCE OF EYELID

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ABSTRACT

A vision-based real-time driver fatigue detection method is proposed in this paper. Firstly, The face is located using the characteristics of skin colors, then the eyes are detected by projections and finding connected components and are used as the dynamic templates for eye tracking in the following frame. Finally ,it can decide whether the driver is fatigue by detecting the distance change of the eyelid. The average correct rate for eye location and tracking can reach 98%, the correct rate for fatigue detection is 100%, the average precision rate is 90%.

1. INTRODUCTION

Driver fatigue problem is one of the important factors that cause traffic accidents. The National Police Administration in France concludes that 14.9 percent of accident causing human hurt and 20.6 percent of accident causing death is fatigue-related. In china the number of accident that caused by fatigue is the highest not only in absolute figure but also in proportion. Therefore, how to supervise and avoid fatigue driving efficiently is one of the significant problems.

2. CHARACTERISTICS OF FATIGUE DETECTION

Fatigue detection is a process that detects driver fatigue in real time and generate some warning alarms for driving safety. It has the following characteristics and demands: 1) it should be non-disturb and non-contact with driver or it would be an extra burden to the driver;2) it has to be real time to guarantee detecting fatigue in time;3) it should not be affected by light changes;4) it should not have nocuous radiation and moving facilities.

Nowadays, there are many fatigue detection methods appearing and the best is tracking eye in real time using one or two cameras to detect the physical responses in eyes. It is indicated that the responses in eyes have high relativity with driver fatigue , so after we study the characters of the driver's eye, we decide to use the distance of eyelid for driver fatigue detection.

3.FATIGUE DETECTION

The characteristics of the driver's eyes when driving are as follows: (1) the position of the driver is relatively fixed so the range of eye's movement is small;(2) the images of the driver are usually frontal. So we bring forward the fatigue detection method that detects and tracks eyes. The method contains four phase: face location, eye detection, eye tracking ,fatigue detection. The flow chart of the method is depicted in figure 1.

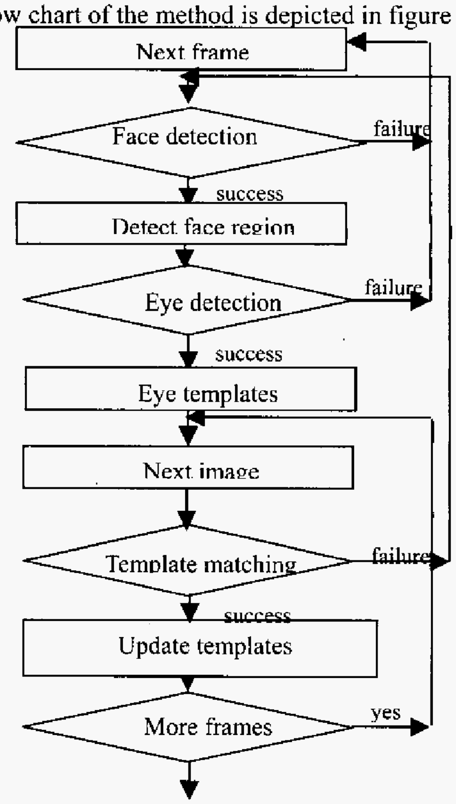


Figure1.Flow chart of fatigue detection

The first image is used for face location and eye detection .if any one of these detection procedures fails, then go to the next frame and restart the detection processes. Otherwise, the subsequent images are used for eye tracking based on the obtained eye images in the current image as the dynamic templates. if eye tracking fails ,the eye detection restart on the present image.

3.1. Face location

Because the background is complex and changeful, we can't search eyes in the whole image directly , So we firstly find the location of face , reduce the range that we detect eyes, doing this can improve the tracking veracity and speed and reduce the affect of the background.

It is common to think that different people have different skin-colors is due to the existence of different races. However, what really occurs is a larger difference in brightness / intensity but not in color .It is verified that the human skin-colors are clustered in color space, as illustrated in Figure 2.

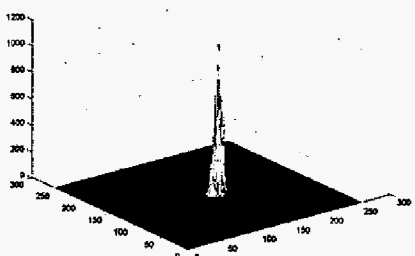


Figure 2. skin-color distribution in YCbCr space

we can see that the skin-color distribution in YCbCr space can be approximated by a Gaussian model. Namely, the distribution of Cb and Cr is a planar Gauss distribution :

$$f(cb,cr)=\frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\exp\{\frac{-1}{2(1-\rho^2)}$$

$$\left[\frac{(cb-\mu_1)^2}{\sigma_1^2}-2\rho\frac{(cb-\mu_1)(cr-\mu_2)}{\sigma_1\sigma_2}+\frac{(cr-\mu_2)^2}{\sigma_2^2}\right]\}$$

Where,

μ_1 :the mean of cb, μ_2 :the mean of cr

σ_1 :the variance of cb, σ_2 :the variance of cr

ρ :the correlation coefficient of cb and cr.

It is proved that two marginal distribution of planar Gauss distribution are one dimension Gauss distribution so we can obtain the following formula:

$$f(cb)=\frac{1}{\sqrt{2\pi\sigma_1}}\exp\left[-\frac{(cb-\mu_1)^2}{2\sigma_1^2}\right]$$

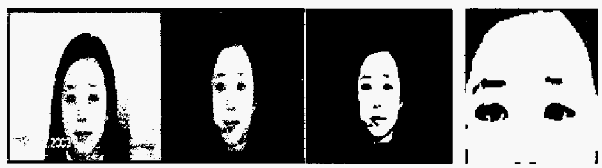
$$f(cr)=\frac{1}{\sqrt{2\pi\sigma_2}}\exp\left[-\frac{(cr-\mu_2)^2}{2\sigma_2^2}\right]$$

there is a σ rule for Gauss distribution variable x:

$$P\{\mu-3\sigma<X\le\mu+3\sigma\}=0.9974$$

Therefore, we can build a skin model, and calculate the mean and variances of cb and cr ,then we can identify whether one pixel belongs to skin-color according to σ rule and obtain the gray image of face(fig.3b).We can binarize the image using adaptive threshold, the threshold T can be gotten from the formulate: $\sum_{t=0}^{T}g(t)\le 0.18G$

Where $g(t)$ is the number of pixel whose gray value is t ,G is the number of pixel whose value is non-zero. finally, we can use projection technique, the characteristics of head and the threshold to find the right and left, the top and bottom boundaries. According to the normal position of the eyes in a face, we can assume that the possible location of eyes will be in the block of the upper three fifths of the face region(fig.3d).



(a) (b) (c) (d)

Figure3. face location. (a) original image (b)gray image (c) binary image (d) eye region

3.2. Eye detection

Because the value of pixels in eye region is relatively lower than other region of the face. We calculate the average gray value along x axis and roughly find the eye region. We reverse the eye region and find the connect region in it. We can define the following parameter: $A,l(x,y),r(x,y),d,\theta$. A is the area of the connect region, d is the distance of the connect regions , θ is the angle of the connect region and horizontal axis, l and r are the centroids of the connect region. We can get the centroid and the area by the following formulate:

$$x=\frac{\sum_{i=1}^{n}\sum_{j=1}^{m}jB[i,j]}{A},y=\frac{\sum_{i=1}^{n}\sum_{j=1}^{m}iB[i,j]}{A}$$

$$A=\sum_{i=1}^{n}\sum_{j=1}^{m}B[i,j]$$

Searching every two connect regions, if $|\theta|\le 15^{0}$, $l(x)<r(x)$ and the discrepancy of A is small, the two regions are eyes (we assume that the driver has a low head rotation) .To further separate the two eyes we use the symmetrical character of the eyes, then change them to gray image as template for tracking(fig.4)

(a) rough location of eye region

(b) eye region after processing

(c) left and right eye templates

Figure4.eye detection

3.3.Eye tracking

After we get the eye templates, we use gray scale correlation over the eye region to find the position of the eye. Assume the coordinates of left-top of the template is (x,y), then the searching area is the original position by expanding 10 pixels in up ,down ,left and right directions. the formula is as following:

$$\rho=\frac{N\sum_{i=1}^{N}I_iM_i-\sum_{i=1}^{N}I_i\sum_{i=1}^{N}M_i}{\sqrt{N\sum_{i=1}^{N}I_i^2-\left(\sum_{i=1}^{N}I_i\right)^2}\sqrt{N\sum_{i=1}^{N}M_i^2-\left(\sum_{i=1}^{N}M_i\right)^2}}$$

where N is the number of pixels in the model, M is the model, and I is the image against which the pattern is being compared, ρ is the match score.

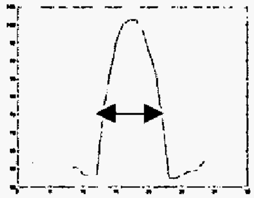
If ρ(a,b) is the maximum value within the search area, the point (a,b) is defined as the most matching position and it is the new position of the eye and the new eye template is updated accordingly for eye tracking in the next frame.

When tracking ,if the maximum of ρ is below the acceptance level of match score or the distance between two newly updated eye doesn't satisfy the constrains of the eyes, it will restart the face and eye detection procedures.

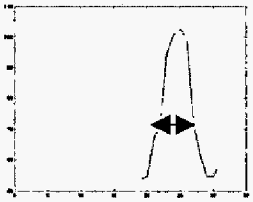
3.4.Fatigue detection

The distance of the eyelid when the eye is open is large and the distance is nearly zero when the eye is closed. Because of the eyelash, the distance of the closed eye obtained by image processing technique is not zero but still less than the distance when it's open(fig.5).

We assume that the driver is awake at the beginning and the distance of the eyelid is regarded as the criterion ,which will be divided by the distance obtained in the following frame .if the result below the threshold ,the eye is considered to be close. If the eyes close over 5 consecutive frames, the driver is regarded as dozing.



(a) the distance of eyelid of open eye



(b) the distance of eyelid of close eye

Figure5. the distance of eyelid

4.EXPERIMENT RESULTS

We tested the two videos obtained from the driver when driving, the format of the input video is 352×288.

4.1. Result of eye tracking

Image	Total frames	Tracking failure	Correct rate
Video1	399	8	97.99%
Video2	433	8	98.19%

Table 1. Result of eye tracking

Table 1 lists the results of eye tracking ,which gives the total frames of the images, the number of tracking failure frames and the correct rate. We can calculate that the average correct rate reaches 98%.

4.2. Result of fatigue detection

Table 2 shows the results of fatigue detection, Correct rate is the ratio between the number of fatigue correctly detected and the number of real dozing, Precision rate is the ratio between the number of fatigue correctly detected and the total number of detected dozing. As can be see from the table, the Correct rate can reach 100%and the average precision rate is 90%.

	Video1	Video2
Close eyes	115	118
Detected closed eyes	0	2
Detected open eyes	5	7
Real dozing	4	3
Detected fatigue	5	3
Correct detect	4	3
Correct rate	100%	100%
Precision rate	80%	100%

Table2. Results of fatigue detection

5. CONCLUSION

This paper proposes a vision-based real-time driver fatigue detection method. It uses one camera tracking eyes in real time and the distance of eyelid to judge whether the driver is drowsy. The experiment results show that it has high correct rate and precision rate. of course, there will be some false detection when there is quick head-movement or large head rotation. however, in most time the driver's head moves slowly and always looks forward.

6.REFERENCES

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