Vision-based Real-time Driver Fatigue Detection System for Efficient Vehicle Control

D.Jayanthi, M.Bommy

Abstract— **In modern days, a large no of automobile accidents are caused due to driver fatigue. To address the problem we propose a vision-based real-time driver fatigue detection system based on eye-tracking, which is an active safety system. Eye tracking is one of the key technologies, for, future driver assistance systems since human eyes contain much information about the driver's condition such as gaze, attention level, and fatigue level. Face and eyes of the driver are first localized and then marked in every frame obtained from the video source. The eyes are tracked in real time using correlation function with an automatically generated online template. Additionally, driver's distraction and conversations with passengers during driving can lead to serious results. A real-time vision-based model for monitoring driver's unsafe states, including fatigue state is proposed. A time-based eye glance to mitigate driver distraction is proposed.**

Keywords— **Driver fatigue, Eye-Tracking, Template matching, Fatigue Detection.**

I. INTRODUCTION

The increasing number of transportation accidents has become a serious problem for society. The traffic accidents will be largely decreased if finding a judging rule to determine whether drivers stay awake or not, and make a warning to the drivers when they begin to fall asleep, so it is meaningful to research fatigue detection algorithm which is also a key technology in smart vehicles driving. The ***driver fatigue*** problem has become an important factor for causing traffic accidents. Driver fatigue is a major cause of car accidents, since sleepy drivers are unable to make rapid decisions, and they may have slower reaction times. As a result, many governments have education program to alert people to the dangers of driving while tired, and drivers are encouraged to avoid conditions which may lead to driver fatigue. Therefore, how to supervise and avoid fatigue driving efficiently is one of the significant problems.

Recently many safety systems are followed to avoid transportation accidents. Passive safety systems such as seat belts, airbags, and crashworthy body structures help reduce the effects of an accident. In contrast, active safety systems help drivers avoid accidents by monitoring the state of the vehicle, the driver, or the surrounding traffic environment and providing driver alerts or control interventions. The proposed system focuses on the detection of drowsiness among fatigue-related impairments in driving based on eye-tracking – an active safety system.

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Nowadays, there are many fatigue detection methods appearing and the best is tracking eye in real time using webcams to detect the physical responses in eyes. It is indicated that the responses in eyes have high relativity with driver fatigue.

II. PROPOSED SYSTEM

Vision-based real-time driver fatigue detection for the effective vehicle control is proposed in this paper. The system detects the driver fatigue based on eye tracking which comes under an active safety system. At first, an ordinary color webcam is used to capture the images of the driver for fatigue detection. The first frame is used for initial face detection and eye location. If any one of these detection procedures fails, then go to the next frame and restart the above detection processes. Otherwise, the current eye images are used as the dynamic templates for eye tracking on subsequent frames, and then the fatigue detection process is performed. If eye tracking fails, the face detection and eye location restart on the current frame. These procedures continue until there are no more frames.

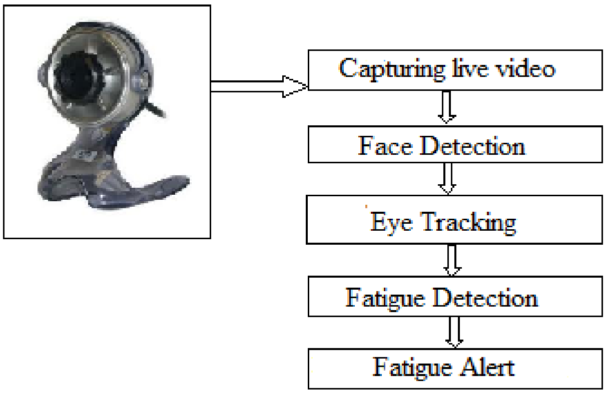

Fig. 1 Block Diagram of Proposed System

Fig. 1.1 shows the flow diagram of the proposed system that describes about Eye tracking and Driver Fatigue Detection. The live video is captured and stored in the database. From each of the frame the skin is extracted to detect the face of the driver alone from the frame by eliminating the objects bounding the driver and stored in a separate database. After face detection has been done the eyes are configured by giving the control points around the eyes. The eye template is then cropped and stored. With the stored template as reference we track the eyes of the driver continuously in the live video using dynamic template matching. If the eyes of the drivers are closed for a continuous number of frames then the driver is said to be in fatigue state and an alarm is raised.

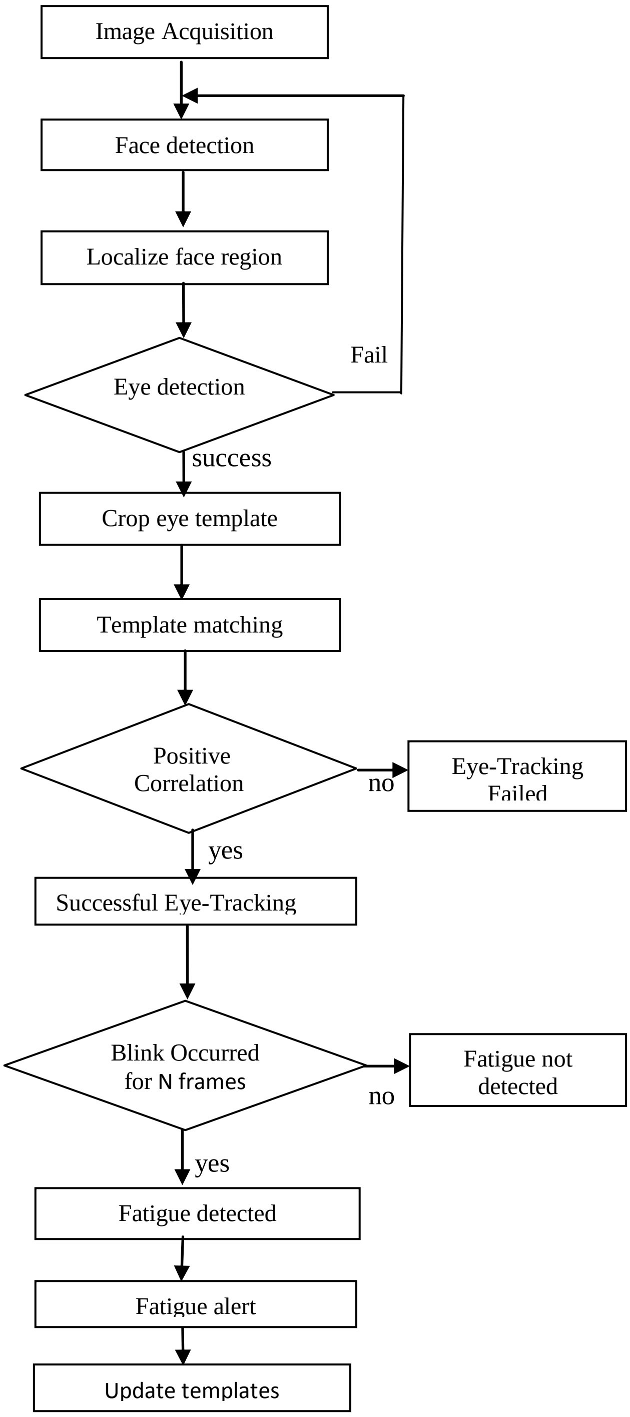

Fig 1.1 Flowchart of the proposed system

III. Modules

This section contains the following modules namely,

A. Face Detection.

B. Eye-Tracking using Dynamic template matching.

C. Fatigue detection.

A. Face Detection

Face detection is the main step in the driver fatigue detection systems. Face detection is a process that aims to locate a human face in an image. The process is applied on stored image or images from a camera. Human face varies from one person to another. This variation in faces could be due to race, gender, age, and other physical characteristics of an individual. Here face detection is done by skin color model. The use of skin color analysis for initial classification of an image into probable face and non face regions stems from a number of simple but powerful characteristics of skin color. Firstly, processing skin color is simpler than processing any other facial feature. Secondly, under certain lighting conditions, color is orientation invariant. The major difference between skin tones is intensity e.g. due to varying lighting conditions and different human race. In order to distinguish the skin color of the user's face from the other image regions in the image, the distribution of the skin color in the chromatic color space must be known prior to employing the system for detecting the human face. Skin color models vary with the skin color of the people, video cameras used and also with the lighting conditions. Skin pixels clustered in the chromatic color can be represented in chromatic color space using a Gaussian distribution.

The skin color distribution using the Gaussian model N $(m,\sum^2)$ is represented as in Equation (3) and (4).

$$\bar{r} = \frac{1}{N}\sum_{i=1}^{N} r_i \,, \tag{1}$$

$$\bar{g} = \frac{1}{N}\sum_{i=1}^{N} g_i \,, \tag{2}$$

Where $m = (\bar{r},\bar{g}),$ (3)

$$\Sigma = \begin{bmatrix} \sigma_{rr} & \sigma_{rg} \\ \sigma_{gr} & \sigma_{gg} \end{bmatrix} \tag{4}$$

Using the skin color model we filter out the incoming video frames to allow only those pixels with high likelihood of being skin pixels.

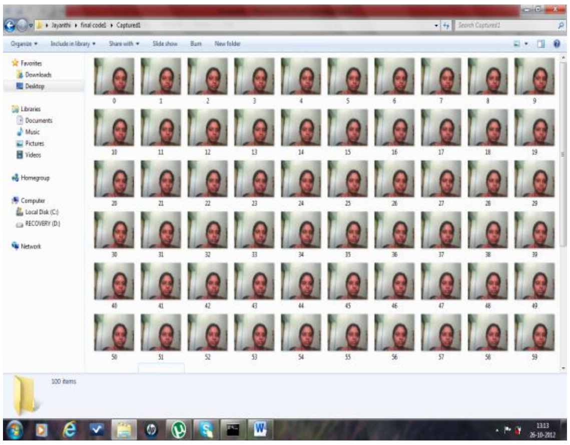

Fig. 2 Original Image

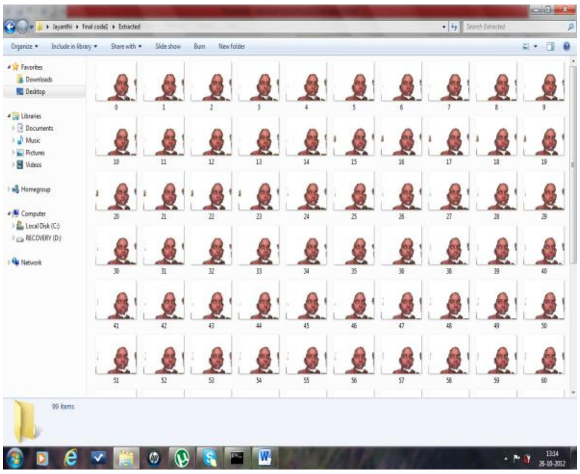

Fig. 3 Skin Extracted Image

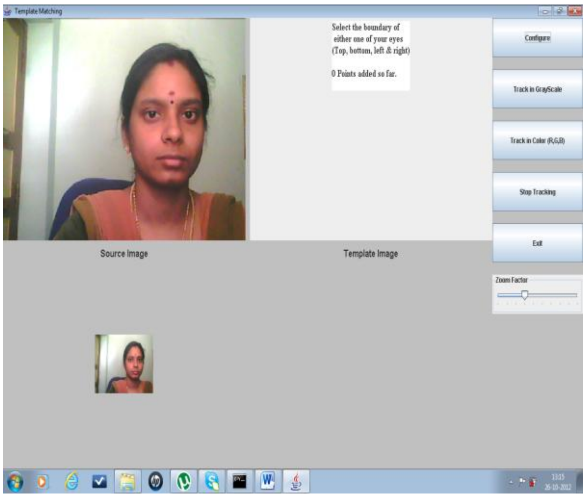

Fig. 4 Face Detection

B. *Eye-Tracking using Dynamic Template Matching*

Eye-Tracking has got two phases namely eye tracking and dynamic template matching is done. Because the value of pixels in eye region is relatively lower than other region of face. We calculate the average gray value along X axis and roughly find the eye region. Thus by symmetrical characteristics of eyes we obtain the eye templates.

After we get the eye templates, we use gray scale correlation over 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 original position by expanding 10 pixels in up, down, left, and right directions. The Equation (5) and (6) represents the correlation formula:

$$\rho = \frac{N\sum_{i=1}^{N} I_i M_i - \sum_{i=1}^{M} I_i \sum_{i=1}^{N} M_i}{\sqrt{N\sum_{i=1}^{N} I_i^{2} - (\sum_{i=1}^{N} I_i)^2}\sqrt{N\sum_{i=1}^{N} M_i^{2} - (\sum_{i=1}^{N} M_i)^2}} \quad \ldots..(5)$$

Or use difference between I and M to calculate the similarity, like,

$$\rho = \sum_{m=1}^{M}\sum_{n=1}^{N} I(m,n) - M(m,n) \quad \ldots\ldots\ldots \quad (6)$$

Where N is the number of pixels in the model, M is the model, and 1 is the image against which the pattern is being compared, p is the match score.

If p (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 o f p is below the acceptance level of match score or the distance between two newly updated eyes doesn't satisfy the constraints of the eyes, it will restart the face and eye detection procedures. Thus from the eye templates obtained we get the states of eyes i.e. opened or closed.

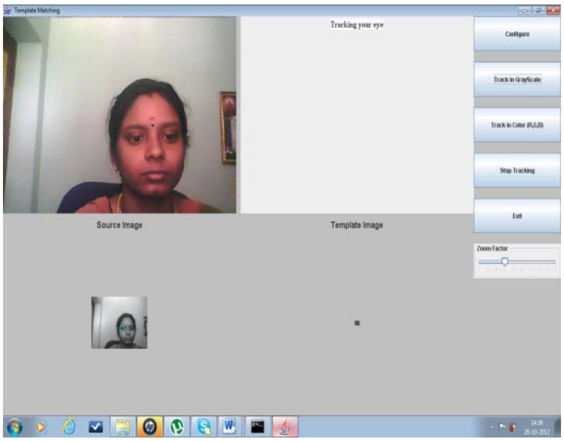

Fig. 5 Tracking of Open Eye

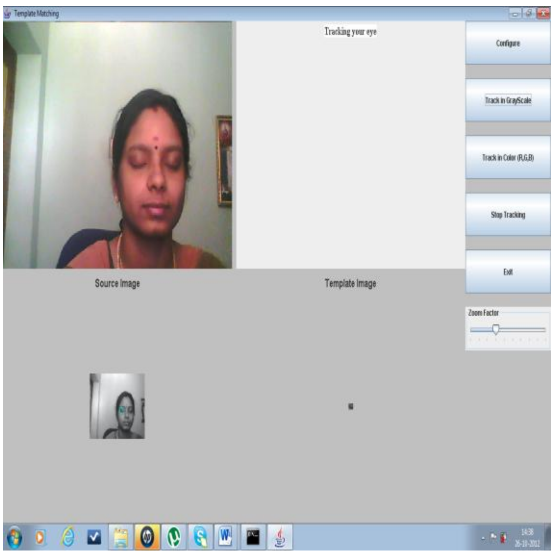

Fig. 6 Tracking of Closed Eye

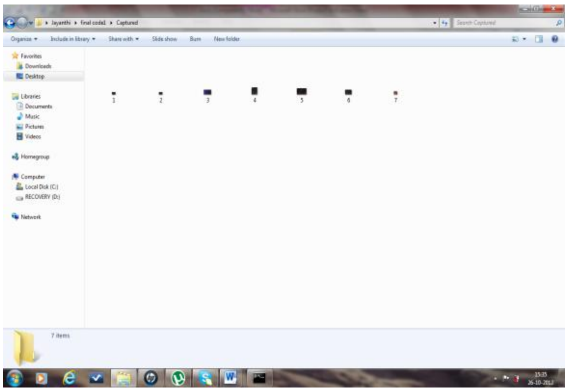

Fig. 7 Sample eye templates

C. Fatigue Detection

Once the face of the driver is detected and the eye of the driver is successfully tracked, we continuously monitor the variations of the eye. A pattern matching technique is then used for detecting whether the eyes of the driver are open or closed. Based on the blink threshold and the detection threshold the open and closed variations of the eye are judged. If the eyes remain closed for a certain period of time (3 to 4 seconds), the system determines that the person has fatigue and gives a warning signal. The system also checks for tracking errors; once an error is detected, the system returns to the face detection stage. The main focus is on the detection of micro-sleep symptoms. This is achieved by monitoring the eyes of the driver throughout the entire video sequence.

At this stage, the colours of the eyeballs in the eye templates are used directly for fatigue detection. Since the property that the eyeball colours are much darker is a quite stable feature, the eye templates are converted to the greyscale model. The original darker eyeballs become brighter ones in the converted image. According to the observation, the saturation values of eyeball pixels normally fall between 0.00 and 0.14. This observation is used to distinguish whether a pixel in an eye template is viewed as an eyeball pixel. When the eyes are open, there are some eyeball pixels. When the eyes are closed, there are no eyeball pixels. By checking the eyeball pixels, it is easy to detect whether the eyes are open or closed.

Update the eye coordinate position each time the frame is successfully tracked, and take this coordinate as the reference of next search range, if it is an eye-open area, take it as next template, then repeat. This is a method which updates template and search range instantaneously to match eye-area dynamically. During the track process, if matched areas in several continuous frames are no longer eye-area, it seems tracking is fail and the algorithm needs restart. So far the eye localization and its state detection of driver video sequences has already been finished, which supply basis for fatigue detection.

The blink detection algorithm first checks to make sure that a decent correlation exists, then looks for 8 frames in a row where the average darkness of the template image is at least 12 pixels greater than the average darkness of the source image, whereupon it outputs the message "Fatigue Detected ". If the eye tracker has a low correlation or a blink is detected, the frame counter is set back to 0. An alert is made to the driver once the fatigue state is detected.The system simultaneously checks for fatigue detection. In case the eyes of the subject remain closed for unusually long periods of time, the system gives a fatigue alert. The fatigue alert persists as long as the person doesn't open his eyes. In case all the matches fail, the system decides that there is a "tracking failure" and switches back to the face localization stage. As the face of the driver doesn't move a lot between frames, we can use the same region for searching the eyes in the next frame.

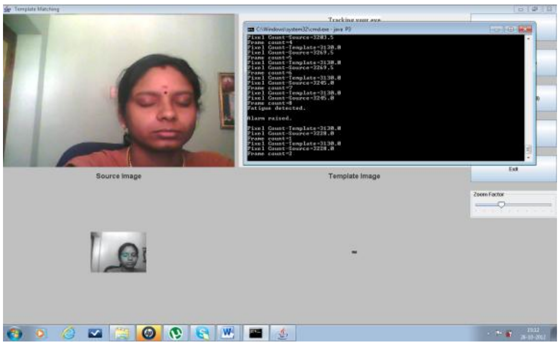

Fig. 8 Fatigue Detection – Alarm Raised

IV. CONCLUSION

In this paper, the face is detected and eyes are tracked from the captured image. Then the eye templates were trained as normal and drowsy eye template using neural network. Finally, it is detected do the eyes are drowsy and the fatigue alert is given. However, there will be some false detection, where the results are not good when there is quick head-movement or large head rotation and there is a long distance between drivers face and the camera. So, future work will be done based on drivers quick head-movement and make it feasible to detect driver's eye state with distance adjustable.

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