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BIOMETRIC OBSERVANCE OF EYE PATTERN USING ALGORITHMS AND DIGITAL IMAGE PROCESSING

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ABSTRACT

In this paper, we describe a non-intrusive vision-based system for the detection of eye pattern of driver fatigue. The system uses a color video camera that points directly towards the driver's face and monitors the driver's eyes in order to detect micro-sleeps (short periods of sleep).The critical points at which driver fatigue related collisions happen are between 2am to 6 am and midafternoon between 2pm to 4 pm when our "circadian rhythm" or body clock is at its lowest point. If a driver persists in fighting sleep while driving the impairment level is the same as driving while over the drink drive limit. Eventually a driver will drift in and out of consciousness and experience "micro sleeps" which can last for up to 10 seconds. In this time a driver has no control of the vehicle. Drivers can experience such a micro sleep with their eyes wide open. Biometric Observance of Eye Pattern Using Algorithms and Digital Image Processing, has been developed, using a non-intrusive machine vision based concepts. The system uses the webcam or digital camera that points directly towards the driver's face and monitors the driver's eyes in order to detect fatigue. In such a case when fatigue is detected, a warning signal is issued to alert the driver.

This paperdescribes how to find the eyes, and also how to determine if the eyes are open or closed. The system deals with using information obtained for the face cropped version of the image to find the edges of the face, which narrows the area of wherethe eyes may exist. Once the face areais found, the eyes are found by computing the circular Hough Transform. The circular Hough Transform detects the circles in the image and hence encircles the iris. In this way, the iris of the driver is continuouslymonitored and tracked. If the circle is not detected for any fixed number of consecutive frames, then eyes are assumed to be closed. In this condition, the system draws the conclusion that the driver is falling asleep and issues a warning signal.

The international statistics shows that a large number of road accidents are caused by driver fatigue. Therefore, a system that can detect oncoming driver fatigue and issue timely warning could help in preventing many accidents, and consequently save money and reduce personal suffering..can determine whether the eyes are open or closed. If the eyes are found closed for 5 consecutive frames, the system draws the conclusion that the driver is falling asleep and issues a warning signal. The algorithm is proposed, implemented, tested, and found working satisfactorily.

KEYWORDS: Eye Tracking By Binarization, Eyes Detected using CHT, Localization of the eyes Eye Tracking Using Hough Transform.

INTRODUCTION

A large number of automobile accidents are caused due to driver fatigue. The U.S. National Highway Traffic Safety Administration has indicated that driver fatigue is responsible for as many as 240,000 motor vehicle accidents a year in the U.S.A. alone. Sleep deprivation and sleep disorder are becoming common problems for car drivers in a society in which people seem not to have enough time to perform all the activities they need to carry out on a daily basis. By monitoring the driver's symptoms, we can determine driver fatigue early enough as to take preventive course to avoid an accident due to lack of awareness.

The cropped images are then processed by CHT to detect the circles (iris) in the image. Based on the output of this tracked eyes, the decision rule is made, whether the alarm procedure is activated or returns to the start where it re-initializes and the process starts over again. Adaptive binarization is an addition that can help make the system more robust. This may also eliminate the need for the noise removal function, cutting down the computations needed to find the eyes. This will also allow adaptability to changes in ambient light.

The system does not work for dark skinned individuals. This can be corrected by having an adaptive light source. The adaptive light source would measure the amount of light being reflected back. If little light is being reflected, the intensity of the light is increased. Darker skinned individual need much more light, so that when the binary image is constructed, the face is white, and the background is black.

A previous version of the system [1] used computer vision techniques to extract and track eye locations throughout the entire video sequence. However, the techniques described in this paper have significant forward steps towards improved accuracy and robustness in the process of detecting driver fatigue.

Localizing the eyes at the first frame is the most computationally expensive phase of the tracking system. In this phase, the system has no previous information about the eye locations in the image. The system has to find the area of the image that will be used in subsequent frames in order to track the eyes. During the tracking phase, the search space is reduced as the system has an approximate knowledge of the eye's position from the previous frame. This tracking can be done at a relatively low computational cost. In order to detect failure in tracking, general constraints such as the distance between the eyes and the horizontal alignment of the two eyes are used. To make sure that the correct feature is being tracked, the eyes should be relocated periodically, even if no failure has been detected. By determining whether the eyes are open or closed during eye tracking, we can determine if there are any micro-sleep symptoms that can help us determine driver fatigue.

RELATED WORKS

There have been several studies about motor vehicle driver fatigue [3]. There are even some commercial systemsin the market that detect and signal driver unawareness. Most of these systems monitor driver's steering patterns. When these patterns are unusual, a warning signal is issued. Facial feature extraction is an active research area in computer vision. Yoo [4] proposed an approach that takes into account facial symmetry in order to find the placement of the face in an image. Sophisticated methods such as eigenspace matching [5], contour tracking using snakes [6], deformable template [7], and ellipse fitting techniques are computationally very expensive. Skin color based detection [8,9] is a widely used technique to extract face region from background images. Eye tracking is also being widely studied due to its potential applications in multi-modal user interfaces [10,11].

This paper describes advances made to the vision-based system for the detection of driver fatigue described originally in [1,2]. The essentials of micro-sleep detection are present in this new version of the systems, however a significantly different detection technique has been used in order to increase the accuracy and robustness.

OVERVIEW OF THE SYSTEM

Two well-differentiated functional phases have been defined: The Eye Tracking and the Fatigue Detection. The eye tracker receives the first frame from the camera. At this point, it is assumed that there is no previous knowledge about the locations of the eyes. We use the initial frame to localize the eyes within' the entire input image. It may be the case that due to unfavorable illumination conditions or head orientation in the initial image, the eye localization may fail. In this case, we have to grab a new initial frame and apply the localization algorithm in order to find the positions of the eyes. This process is repeated until we are confident about the positions of the eyes. After the portion of the image containing the driver's eyes is estimated, the system enters into its tracking mode. In this mode, the search space for eyes in subsequent input frames is reduced to a small area surrounding the eye regions. This is based on the assumption that the driver's head exhibits very small displacements in the time required to grab and process consecutive input frames. During tracking, error-detection is performed in order to recover from possible tracking failures. If an error occurs, the system gets out of tracking mode and recalculates the locations of the eyes from the current image frame.

The fatigue detection phase is closely related to the tracking phase. The information obtained from processing each consecutive input frame in the eye-tracking phase is fed directly to the fatigue detection phase if no tracking error has occurred. This phase is responsible of extracting the information from the image of the eye that will determine signs of micro-sleeps. At each frame, when the eyes are localized, the system determines whether the eyes are open or not. Thus, we are able to tell when the eyes have been closed for too long. In practice, we count the number of consecutive frames during which the eyes are closed. If this number gets too large, we issue a warning signal.

THE EYE TRACKER

As described in [1], an eye tracking system can be divided into three functional units: localization of the eyes, tracking of eyes, and estimation of the tracking error.

Localization of the eyes

In order to reduce the search space and to avoid any kind of distracting features, the first step we followed was to extract the driver's face from the input image.

In [1], we had used a symmetry based approach similar to [4], in which it is assumed that there exists a horizontal symmetry on human faces and that we could reduce the search space for eyes by focusing our attention on a stripe of image around this symmetry line. This approach, although very fast, showed to be quite fragile because the system expected that the driver's face be in a totally frontal view every time the system entered into the face detection step. Moreover, the technique gave information about the possible left and right margins of the face but was incapable to provide any prediction of the upper and lower margins of the face.

We have adopted an approach that uses skin color in-formation in order to predict and track the position of the driver's face. Skin color models have shown to be very successful to segment human faces in noisy images.

To determine the vertical position of the eyes on the face, we use the observation that eye-regions correspond to regions of high intensity gradients, as suggested in [13]. This method was implemented in [1,2] and it is preserved intact in this version of our system. We create a vertical gradient-map, G(x, y) from the estimated region of the face. Any edge-detection method can be used. We chose to use a Sobel vertical edge kernel convolution. We then do a horizontal projection over *G(x, y)* by summing the gray level of pixels along the horizontal rows:

$$H(y) = G(x, y) \qquad (1)$$

where*H(y)* is the horizontal projection histogram value at pixel row y over the gradient image. Since both eyes are likely to be positioned at the same row, *H(y)* will have a strong peak on that row.After estimating the position of the eyes in the image and using the original 640x480 input frame, we use gray scale correlation over the eye region in order to find the exact position of the iris. Gray scale correlation is a pattern matching technique that allows us to search for a pattern in an image. Models were created and stored in a database using rectangular areas of well-known sample eye images from different persons and at different face angles (see Figure 1, 3). A search is performed by assigning a match score to each pixel in the target image, based on how closely the model matches the region around that pixel.

Figure 1 ***Figure 2***

Figure 2 is binary image of figure 1.

Figure 3 Figure 4

Face in Different face angles

Figure 4 is binary image of figure 3

Eye Tracking By Binarization:

In this method the face image is first converted into binary image and then functions are created to extract the eye location. These functions include:

- To convert the image into a binary picture.
- To find an accurate Centre of the face (in the x-direction).
- To find the top of the face.
- To find the Centre of the face.
- To find the left and right edges of the face.
- To remove the black blobs in the binary picture.
- To calculate the horizontal averages.
- To identify the valleys among the horizontal averages.
- To find the indexes (y-coordinates) of the vertical position of the eye.
- To store the eye data into a text file.
- It is found that this method has following flaws.
- Eye tracking system is based on intensity changes on the face, highly reflective object behind the driver, can be picked up by the camera, and be consequently mistaken as the eyes.
- Value of threshold cannot be unique as complexion of the drivers is different.
- It provides first two significant intensity changes. (1. Eyebrow, 2.upper edge of eye), assuming that the driver has uniform forehead (little hair covering forehead), which cannot bethe case every time.
- This method has 80% efficiency.

Eye Tracking Using Hough Transform:

Hough Transform is used to detect lines, circles or other parametric curves. An extended form of General Hough Transform, Circular Hough Transform (CHT), is used to detect circles, irrespective of the intensity variation in the original RGB image. The complete details about which is discussed in the chapter 5.It is found that the CHT, when applied to the image gives the accurate position of eyes with the 90% accuracy.

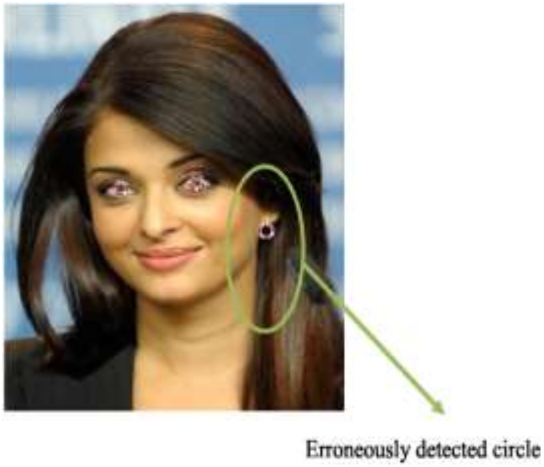

Figure 5: Circle similar to iris

Figure 6: Eyes Detected using CHT

Finding tracking errors

In order to recover from tracking errors, we make sure that the distance between the eyes remains reasonably constant. We also restrict the eyes to be horizontally close to each other. If any of the geometrical constraints is violated, we relocalize the eyes in the next frame.

Figure 7: Open eyes samples

As we had stated earlier in this paper, this system (as in [1,2]) detects micro-sleeps symptoms in order to diagnose driver fatigue.

Figure 8: Closed eye samples

Figure 9 shows how the system signals a "fatigue alert" when the eyes have been closed for several consecutive input frames (5-6 seconds).

Figure 9:Fatigue Alerts

RESULTS AND FUTURE WORKS

The main development of software has taken place in the MATLAB development environment. Using this to create algorithms and a working structure for the driver fatigue detection system, a modular function structure was developed with the code required to gain maximum benefit of code reused.

Currently there is no adjustment in zoom or direction of the camera during operation. Future work may be to automatically zoom in on the eyes once they are localized. This would avoid the trade-off between having a wide field of view in order to locate the eyes, and a narrow view in order to detect fatigue.

CONCLUSION

We have presented a non-intrusive real-time eye tracking pattern. The arrangement is able to localize and track the pupil of a driver as soon as he/she sits in front of the camera. During tracking, the system is able to automatically detect any tracking error that might have occurred. In case of a tracking error, the system is able to recover and resume the proper tracking. The system is able to automatically diagnose fatigue by monitoring the eyes for micro-sleeps. This is achieved by counting the number of consecutive frames in which the eyes are found to be closed.

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