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DROWSY DRIVER DETECTION SYSTEM

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ABSTRACT

It is known that drivers' drowsiness and fatigue is accompanied by deteriorated vehicle control. According to the latest report of the American National Highway Traffic Safety Administration (NHTSA), the most influential factor in the occurrence of fatal single-vehicle runoff- road crashes is the driver performance-related factor: falling asleep, followed by alcohol use and vehicle speed. A Drowsy Driver Detection System has been developed, using a non-intrusive machine vision based concepts. The system uses a small monochrome security 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.

Keywords: *Drowsiness, Eye blink detection and movement detection*

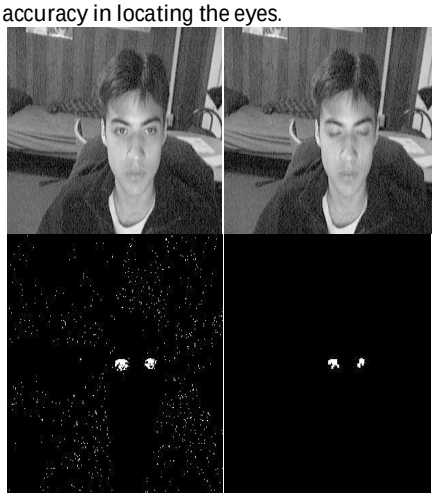
INTRODUCTION

The research here is dedicated for the implementation of the system which is designed for the detection of the human eye and the movement. In many applications such a systems are used for the people who are having limited driving skill and in some cases it is used for the people with some disabilities. The system is to provide the way for the detection of drowsiness incurred to the drivers due to the monotonous job of driving for long hours. The system detects the user's eye blinks and analyzes the pattern and duration of the blinks, using them to provide input to the computer in the form of a mouse click. After the automatic initialization of the system occurs from the processing of the user's involuntary eye blinks in the first few seconds of use, the eye is tracked in real time using correlation with an online template. If the user's depth changes significantly or rapid head movement occurs, the system is automatically reinitialized. The system works with inexpensive USB cameras and runs at a frame rate of 30 frames per second. Variety of work is done on this subject previously. One of the system PERCLOS (Percent Eye Closure) methodology, a video-based method that measures eye closure(Dinges and Mallis, 1998).Some groups have looked at the use of EEG as a method for detecting drowsiness. The biggest drawback associated with EEG as an on-road drowsiness detection device is the difficulty in obtaining recordings under natural driving conditions; making it a somewhat unrealistic option for the detection of fatigue (Antoine Picot, 2010). A user alertness detection system based on Somnolence detection is developed which based on eyes closer, blinking rate of eye & yawning detection of the user (Syed Imran *et al.,* 2010). A Drowsiness Warning System based on the Fuzzy Logic has been also developed (Nidhi Sharma and Banga, 2010). The main contribution of this paper is to provide the robust and inexpensive implementation of the system described by the Grauman. The system is real time system at the rate of 30 frames per second. The system proposed here is very accurate and useful tool to indicate the drowsiness of the driver.

METHODOLOGIES

Initialization: Naturally, the first step in analyzing the blinking of the user is to locate the eyes. So the difference image of each frame and the previous frame is created and then thresholded, resulting in a binary image showing the regions of movement that occurred between the two frames. Next, a 3x3 star-shaped convolution kernel is passed over the binary difference image in an Opening morphological operation which eliminate a great deal of noise and naturally-occurring jitter that is present around the user in the frame due to the lighting conditions and the camera resolution, as well as the possibility of background movement. In addition, this Opening operation also produces fewer and larger connected components in the vicinity of the eyes (when a blink happens to occur), which is crucial for the efficiency and accuracy of the next phase. A recursive labeling procedure is applied next to recover the number of connected components in the resultant binary image.

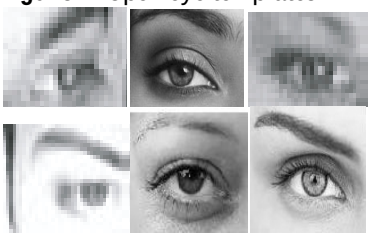
Figure 1: Motion Analysis Phase:
(A) User at frame *f*. (B) User at frame *f* + 1, having just blinked. (C) Initial difference of the two frames *f* and *f*+1. Note the great deal of noise in the background due to the lighting conditions and camera properties. (D) Difference image used to locate the eyes after performing the Opening operation. image and waits to process the next involuntary blink in order to maintain efficiency and accuracy in locating the eyes.



Given an image with a small number of connected components output from the previous processing steps, the system is able to proceed efficiently by considering each pair of components as a possible match for the user's left and right eyes. The filtering of unlikely eye pair matches is based on the computation of six parameters for each component pair: the width and height of each of the two components and the horizontal and vertical distance between the centroids of the two components (Chidanand Kumar and Brojeshwar Bhowmick, 2008). A number of experimentally-derived heuristics are applied to these statistics to pinpoint the exact pair that most likely represents the user's eyes. For example, if there is a large difference in either the width or height of each of the two components, then they likely are not the user's eyes. As an additional example of one of these many filters, if there is a large vertical distance between the centroid of the two components, then they are also not likely to be the user's eyes, since such a property would not be humanly possible. Such observations not only lead to accurate detection of the user's eyes, but also speed up the search greatly by eliminating unlikely components immediately (Dement, 1997 and Yang Ying *et al.,* 2007).

Template Creation: If the previous stage results in a pair of components that passes the set of filters, then it is a good indication that the user's eyes have been successfully located. At this point, the location of the larger of the two components is chosen for creation of the template. Since the size of the template that is to be created is directly proportional to the size of the chosen component, the larger one is chosen for the purpose of having more brightness information, which will result in more accurate tracking and correlation scores. Since the system will be tracking the user's open eye, it would be a mistake to create the template at the instant that the eye was located, since the user was blinking at this moment. Thus, once the eye is believed to be located, a timer is triggered. After a small number of frames elapse, which is judged to be the approximate time needed for the user's eye to become open again after an involuntary blink, the template of the user's open eye is created. Therefore, during initialization, the user is assumed to be blinking at a normal rate of one involuntary blink every few moments. Again, no offline templates are necessary and the creation of this online template is completely independent of any past templates that may have been created during the run of the system (Chidanand Kumar and Brojeshwar Bhowmick, 2008).

Figure 2: Open eye templates



Eye Tracking: As noted by Grauman, the use of template matching is necessary for the desired accuracy in analyzing the user's blinking since it allows the user some freedom to move around slightly Though the primary purpose of such a system is to serve people with paralysis, it is a desirable the camera that would not be feasible if motion analysis were used alone. The normalized correlation coefficient, also implemented in the system proposed by Grauman *et al*., is used to accomplish the tracking (Ji *et al*., 2004). This measure is computed at each frame using the following formula:

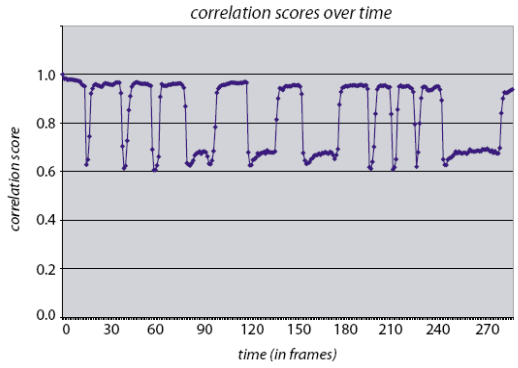
$$\frac{\sum_{x,y}[f(x,y)-\overline{f_{u,v}}][t(x-y,y-v)-\bar{t}]}{\sqrt{\sum_{x,y}[f(x,y)-\overline{f_{u,v}}]^2 \sum_{x,y}[t(x-y,y-v)-\bar{t}]^2}} \quad (1)$$

where $f(x, y)$ is the brightness of the video frame at the point
(x, y), $\overline{f_{u,v}}$ is the average value of the video frame in the current search region, $t(x, y)$ is the brightness of the template image at the point (x, y), and $\bar{t}$ is the average value of the template image. The result of this computation is a correlation score between -1 and 1 that indicates the similarity between the open eye template and all points in the search region of the video frame. Scores closer to 0 indicate a low level of similarity, while scores closer to 1 indicate a probable match for the open eye template. A major benefit of using this similarity measure to perform the tracking is that it is insensitive to constant changes in ambient lighting conditions. The Results section shows that the eye tracking and blink detection works just as well in the presence of both very dark and bright lighting. Since this method requires an extensive amount of computation and is performed 30 times per second, the search region is restricted to a small area around the user's eye. This reduced search space allows the system to remain running smoothly in real time since it drastically reduces the computation needed to perform the correlation search at each frame.

Blink Detection: The detection of blinking and the analysis of blink duration are based solely on observation of the correlation scores generated by the tracking at the previous step using the online template of the user's eye. As the user's eye closes during the process of a blink, its similarity to the open eye template decreases. Likewise, it regains its similarity to the template as the blink ends and the

user's eye becomes fully open again. This decrease and increase in similarity corresponds directly to the correlation scores returned by the template matching procedure. Close examination of the correlation scores over time for a number of different users of the system reveals rather clear boundaries that allow for the detection of the blinks. As the user's eye is in the normal open state, very high correlation scores of about 0.85 to 1.0 are reported. As the user blinks, the scores fall to values of about 0.5 to 0.55. Finally, a very important range to note is the one containing scores below about 0.45. Scores in this range normally indicate that the tracker has lost the location of the eye. In such cases, the system must be reinitialized to relocate and track the new position of the eye. Given these ranges of correlation scores and knowledge of what they signify derived from experimentation and observation across a number of test subjects, the system detects voluntary blinks by using a timer that is triggered each time the correlation scores fall below the threshold of scores that represent an open eye.

Graph 1: Correlation scores for the open eye template.



If the correlation scores remain below this threshold and above the threshold that results in reinitialization of the system for a defined number of frames that can be set by the user, then a voluntary blink is judged to have occurred, causing a mouse click to be issued to the operating system

IMPLEMENTATION

The algorithm used by the system for detecting and analyzing blinks is initialized automatically, dependent only upon the inevitability of the involuntary blinking of the user. Motion analysis techniques are used in this stage, followed by online creation of a template of the open eye to be used for the subsequent tracking and template matching that is carried out at each frame. A large volume of data was collected in order to assess the system accuracy. Compared to the 204 blinks provided in the sequences by Wierwille *et al.,* (1994), a total of 2,288 true blinks by the eight test subjects were analyzed in the experiments for this system. Disregarding the sessions involving the testing of the voluntary blink length parameter for reasons to be discussed later, there were 43 missed blinks and 64 false positives, for an overall accuracy rate of 95.3%. Incorporating all sessions and experiments, there were 125 missed blinks and 173 false positives, for an accuracy rate of 87.4%. See Figure 8 for a summary of the main results of the experiments. The first rate of 95.3% should be considered as the overall accuracy measure of the system because of the nature of some of the extended experiments that inherently function to reduce the accuracy rate. For example, in sessions tested with the default, most natural voluntary blink length of 10 frames (1/3 of a second), there were only 23 missed blinks and 33 false positives out of 1,242 blinks. On the other hand, in sessions tested with a voluntary blink length of 20 frames (2/3 of a second), out of 504 such blinks, more than double the number of blinks were missed (58), and nearly double the number of false positives were detected.

Table I. Result Summary

Total Blinks Analyzed	2288
Overall System Measures	
Total Missed Blinks	43
Total False Positives	64
Detector Accuracy	95.3%
Experimental System Measures	
Total Missed Blinks	125
Total False Positives	173
Detector Accuracy	87.4%

CONCLUSION

Through the experimental design and data analyses of the system, further understanding is expected about highway safety benefits, fleet acceptance, operational utility, and fatigue management practices. We believe that drowsy impaired driving can be successfully mediated by advanced technology. We expect that when combined as one component of a fleet's fatigue management strategy, the public safety benefit will be greatly multiplied. Finally, the learning accomplished by this research should assist the development of similar systems for passenger vehicle drivers, where we observe the largest prevalence of the fatigue crash problem**.**

Here assumption is made that the user is positioned anywhere from about 1 to 2 feet away from the camera, the eyes are detected within moments. As the distance increases beyond this amount, the eyes can still be detected in some cases, but it may take a longer time to occur since the candidate pairs are much smaller and start to fail the tests designed to pick out the likely components that represent the user's eyes. In all of the experiments in which the subjects were seated between 1 and 2 feet from the camera, it never took more than three involuntary blinks by the user before the eyes were located successfully.

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