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A Real Time Intelligent Driver Fatigue Alarm System Based On Video Sequences

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ABSTRACT
In automobiles advanced controllers are equipped to control all the data. In this work a new technology is considered as driver fatigue detection system. Developing intelligent system to prevent car accidents and can be very effective in minimizing accident death toll. One of the factors which play an important role in accidents is the human errors including driving fatigue. Relying on new smart techniques; this system detects the signs of fatigue and sleepiness in the face of the person at the time of driving by capturing the video sequences of the driver. Then, the frames are transformed from YUV space into RBG spaces. It is one of the inexpensive and unobtrusive method where face, eyes are detected and edge detection and histogram normalization are performed on the captured frames using MATLAB as a tool.The face area is separated from other parts with high accuracy in segmentation, low error rate and quick processing of input data distinguishes this system from similar ones.
Key Words Used: Eye Detection, Edge Detection, Face Posture, Face Detection, Viola Jones Algorithm

I. INTRODUCTION

Image processing usually refers to digital image processing. Image processing is any form of signal processing for which the input is an image, such as a photograph or video frame; the output of image processing may be either an image or, a set of characteristics or parameters related to the image.Most image-processing techniques involve treating the image as a two-dimensional signal and applying standard signal-processing techniques to it.

Driving is a complex task where the driver is responsible of watching the road, taking the correct decisions on time and finally responding to otherdrivers' actions and different road conditions.

Vigilance is the state of wakefulness and ability to effectively respond to external stimuli. It is crucial for safe driving. Among all fatigue related accidents, crashes caused by fell-asleep-drivers are common and serious in terms of injury severity. According to recent statistics driver fatigue or vigilance degradation is the main cause of 17.9% of fatalities and 26.4% of injuries on roads. Vigilance levels degrade mainly because of sleep deprivation, long monotonous driving on highways and other medical conditions and brain disorders such as narcolepsy. The study states that the cause of an accident falls into one of the following main categories:

(1) Human
(2) Vehicular
(3) Environmental.

The driver's error accounted for 93% of the crashes.The other two categories of causative factors were cited as 13% for the vehicle factor and 3% for environmental factors. It is important to note that in some cases; more than one factor was assigned as a causal factor. The three main categories are related among each other, and human error can be caused by improper vehicle or highway design characteristics. The recognized three major types of errors within the human error category:

(1) Recognition
(2) Decision
(3) Performance

Decision errors refer to those that occur as a result of a driver's improper course of action or failure to take action. A recognition error may occur if the driver does not properly perceive or comprehend a situation. To perform all these activities in time and accurately its necessary that driver must be vigilant. The aim of this paperis to develop a computer vision method able to detect and track the face of a driver in a robust fashion, also determine the status of the eyes, and with the highest precision possible. It is to serve as the bases of an automatic driver fatigue monitoring system

II. USES AND APPLICATIONS

- It is non intrusive system
- Used to reduce death troll caused by driver fatigueness or negligence

III. TECHNIQUES

Previously this method of fatigue detection was done through medical techniques by placing electrodes on the driver body which receives the signals from the brain based on which it is determined whether the driver is feeling drowsy or not. This method proved to be very inconvenient for the person driving because of the wires.

In those techniques some traditional techniques which are adopted from the medical stream are:

- Electroencephalograms(EEG)
- Electrooculography (EOG)
- Electromyogram(EMG)

ExistedReal Time Systems

A real-time system is one in which the correctness of the computations not only depends on their logical correctness, but also on the time at which the result is produced. That is, a late answer is a wrong answer. For example, many embedded systems are referred to as real-time systems. Cruise control, telecommunications, flight control and electronic engines are some of the popular real-time system applications where as computer simulation, user interface and Internet video are categorized as non-real time applications.

Electronic Engineis a real time system Consider a computer-controlled machine on the production line at a bottling plant. The machine's function is simply to cap each bottle as it passes within the machine's field of motion on a continuously moving conveyor belt. If the machine operates too quickly, the bottle won't be there yet. If the machine operates too slowly, the bottle will be too far along for the machine to reach it. Stopping the conveyor belt is acostly operation as the entire production will come to halt. Thus the range of motion of the machine coupled with the speed of the conveyor belt establishes a window of opportunity for the machine to put the cap on the bottle. This window of opportunity imposes timing constraints on the operation of the machine. Software applications with these kinds of timing constraints are termed as real-time applications. Here, the timing constraints are in the form of a period and deadline.

IV. FACE DETECTION

In geometric or feature based methods, facial features such eyes, nose, mouth and chin are detected. Properties and relations such as areas, distances, and angles between the features are used as descriptors of faces. Although this class of economical and efficient in achieving data reduction and is insensitive to variations in illumination and viewpoint, it relies heavily on the extraction and measurement of facial features. Unfortunately, feature extraction and measurement techniques and algorithms developed to data have not been reliable enough to cater to this need.

Presently available face detection methods mainly rely on two approaches. The first one is local face recognition system which uses facial features of a face e.g. nose, mouth, eyes etc. to associate the face with a person. The second approach or global face recognition system use the whole face to identify a person.

A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database.

Fig 1: Detecting of Face

V. EYE DETECTION

The use of template matching is necessary for the desired accuracy in analysing 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 feature to allow for some slight movement by the user or the camera that would not be feasible if motion analysis were used alone. The normalized correlation coefficient, also implemented in the system proposed by is used to accomplish the tracking

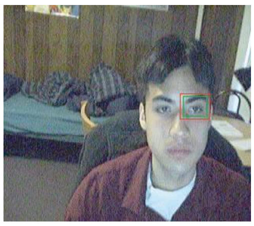

Fig 2: Detection of Eye

VI. EYE POSITION DETECTION

Naturally the first step is analysing the blinking of the user is to locate the eyes. To accomplish this the difference in 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. This functions to 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 labelling procedure is applied next to recover the number of connected components in the resultant binary image. Under the circumstances in which this system was optimally designed to function, in which the users are for the most part paralyzed, this procedure yields only a few connected components, with the ideal number being two (the left eye and the right eye). In the case that other movement has occurred, producing a much larger number of components, the system discards the current binary 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. A number of experimentally-derived heuristics are applied to these statistics to pinpoint the exact pair that most likely represents the user's eyes.

VII. HISTOGRAM EQUALIZATION:

Histogram equalization is a technique for adjusting image intensities to enhance contrast. Let f be a given image represented as a mr by mc matrix of integer pixel intensities ranging from 0 to L − 1. L is the number of possible intensity values, often 256. Let p denote the normalized histogram of fwith a bin for each possible intensity. So

$$p_n = \frac{\text{number of pixels with intensity n}}{\text{total number of pixels}}$$

wheren = 0, 1...L −1 : (1)

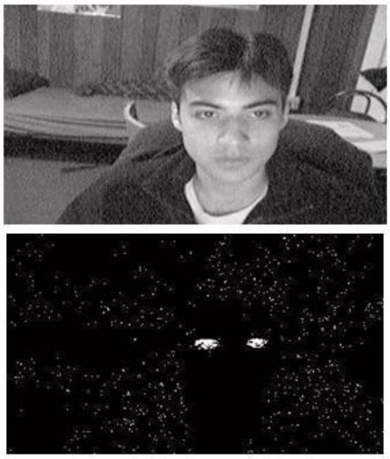

Fig 3: Detection of Open Eyes In Histogram

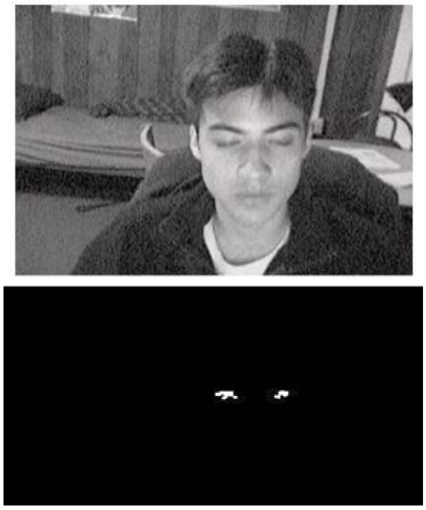

Fig 4: Detection of closed eyes in Histogram

The histogram equalized image g will be defined bygi,j = floor((L − 1)$\sum^{fi,j}{}_{=0}$) : (2)

Where floor() rounds down to the nearest integer. This is equivalent to transforming the pixel intensities, k, of f by the function

$_{=0}$),

The motivation for this transformation comes from thinking of the intensities of f and g as continuous random variables X, Y on [0, L − 1] with Y defined by
Y = T(X) = (L − 1)$\int_0$ px(x)dx :(3)

Where pX is the probability density

function of f. T is the cumulative distributive function of X multiplied by (L−1). Assume for simplicity that T is differentiable and invertible. It can then be shown that Y defined by T(X) is uniformly distributed on
[0, L−1], namely that $pY(y) = \frac{1}{L-1}$

$$\int_0^y pY(z)dz = \text{probability that } 0 \le Y \le y$$

$$= \text{probability that } 0 \le X \le T^{-1}(y)$$

$$= \int_0^{T^{-1}(y)} pX(w)dw : (4)$$

$$\frac{d}{dy}\left(\int_0^y py(z)dz\right) = pY(y) =$$

$$pX(T^{-1}(y))\frac{d}{dy}(T^{-1}(y) : (5)$$

Note that $\frac{d}{dy}T(T^{-1}(y)) = \frac{d}{dy}y = 1,$

$$so \frac{dT}{dx}|x = T^{-1}(y)\frac{d}{dy}(T^{-1}(y))$$

$$= (L-1)pX(T^{-1}(y))\frac{d}{dy}(T^{-1}(y))$$

$$= 1 : (6)$$

Which means $pY(y) = \frac{1}{L-1} : (7)$

Our discrete histogram is an approximation of pX(x) and the transformation in Equation1 approximates the one in Equation 2. While the discrete version won't result in exactly flat histograms, it will flatten them and in doing so enhance the contrast in the image.

VIII. EDGE DECTION

Edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. The same problem of finding discontinuities in 1D signal is known as step detection and the problem of finding signal discontinuities over time is known as change detection. Edge detection is a fundamental tool in image

IX. METHODOLOGY

In our proposed system we use MATLAB software and a web cam. MATLAB is a proprietary language developed by Math Works. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-**use** environment where problems and solutions are explained in familiar mathematical notation.Typical uses include Math and computation.In our proposed system MATLAB software is used to compare the images in the machine language to warn the driver about his fatigueless. Camer**a** captures the video sequences and images of the driver to check if the driver is in fatigue position or not. Thus recognize the fatigue in a driver provided by the camera. An efficient algorithm is introduced for the same. This algorithm detects the fatigue in three ways firstly by detecting the face, then next by detecting the eyes from the detected face, finally by detecting the position of the eyes whether it is in an open or in closure position using this algorithm. Then it gives the output as an alarm to warn the driver which avoids the occurrence of accident.

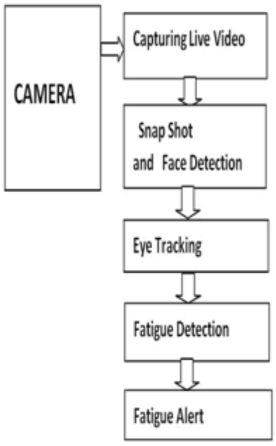

Fig 5: Block diagram

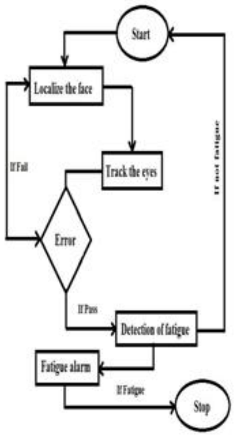

Fig 6: Flow Chart

The algorithm used is Viola jones algorithm. The problem to be solved is detection of faces in an image. A human can do this easily, but a computer needs precise instructions and constraints. To make the task more manageable, Viola–Jones requires full view frontal upright faces. Thus in order to be detected, the entire face must point towards the camera and should not be tilted to either side. While it seems these constraints could diminish the algorithm's utility somewhat, because the detection step is most often followed by a recognition step, in practice these limits on pose are quite acceptable.

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The above flow chart determines the process of fatigue detection. This algorithm detects the fatigue in three ways firstly by detecting the face, then next by detecting the eyes from the detected face, finally by detecting the position of the eyes whether it is in an open or in closure position using this algorithm. Then it gives the output as an alarm to warn the driver which avoids the occurrence of accident. The algorithm has four stages:

1.Haar Feature Selection
2.Creating an internal image
3.Adaboost Training
4.Cascading Classifiers

9.1. Haar Features

All human faces share some similar properties. These regularities may be matched using HaarFeatures

A few properties common to human faces:

The eye region is darker than the upper-cheeks. The nose bridge region is brighter than the eyes.
Composition of properties forming matchable facial features:

1. Location and size: eyes, mouth, bridge of nose
2. Value: oriented gradients of pixel intensities Rectangle features:
3. Value = Σ (pixels in black area) - Σ (pixels in white area)
4. Three types: two-, three-, four-rectangles, Viola & Jones used two-rectangle features

9.2. Creating an Integral Image

An image representation called the integral image evaluates rectangular features in constant time, which gives them a considerable speed advantage over more sophisticated alternative features. Because each feature's rectangular area is always adjacent to at least one other rectangle, it follows that any two-rectangle feature can be computed in six array references, any three-rectangle feature in eight, and any four-rectangle feature in nine.

9.3. cascading classifiers

The cascade classifier consists of stages, where each stage is an ensemble of weak learners. The weak learners are simple classifiers called decision stumps. Each stage is trained using a technique called boosting.

9.4 Adaboost training

AdaBoost short for "Adaptive Boosting" It can be used in conjunction with many other types of learning algorithms to improve their performance. The output of the other learning algorithms ('weak learners') is combined into a weighted sum that represents the final output of the boosted classifier.

X. RESULTS

Fig 7: Face and Eyes Being Detected

Fig 8: Cropped Detected Eyes

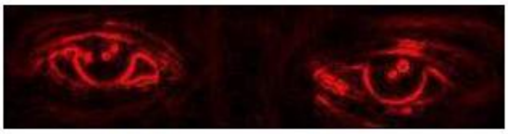

Fig 9: Edge Detected Eyes Part

Fig 10: Cropped Detected Eyes

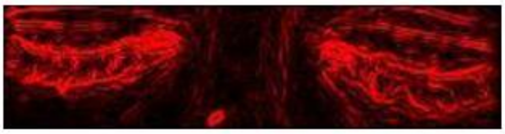

Fig 11: Edge Detected Eyes Part

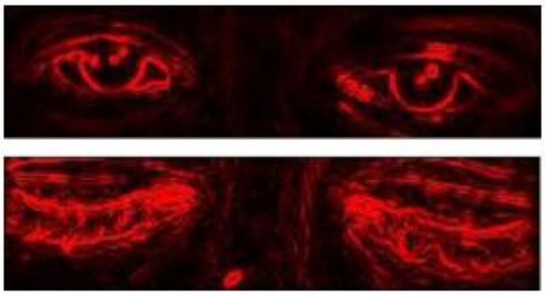

Fig 12: Comparing Edge Detected Image With Database Edge Detected Image

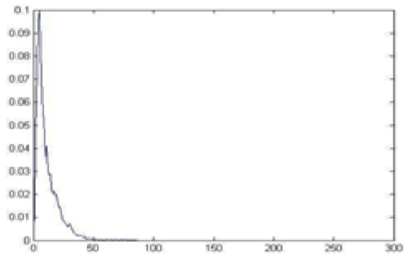

Fig 11: During Eyes Open

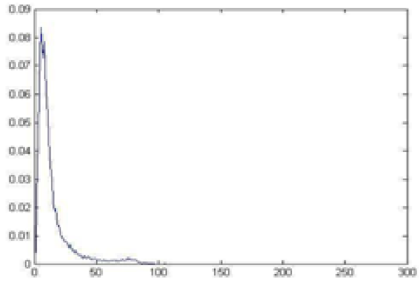

Fig 12: During Eyes Close

XI. CONCLUSION

Face detection systems are being introduced now a days in many vehicles.The automatic initialization phase (involving the motion analysis work) is greatly simplified in this system, with no loss of accuracy in locating the user's eyes and choosing a suitable open eye template. Given the reasonable assumption 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. Another improvement is this system's compatibility with inexpensive USB cameras. These USB cameras are more affordable and portable, and perhaps most importantly, support a higher real-time frame rate of 30 frames per second.

Future scope:

This technique is very useful in recognizing the driver fatigue using the viola Jones algorithm and haar features. It can be highly used in vehicles of the drivers who travel for long distances for a long time by taking video sequences and taking the images from them to compare with default saved image.

In the future we can also make the vehicle to slow down and warn the driver with an alarm which can reduce the accidents more than just about warning the driver.

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