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Smart Alert System for Driver Drowsiness Using EEG and Eyelid Movements

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Abstract: In the present trend suggestsdriving and navigation support systems are getting importance because it is crucial in supporting drivers in several conditions in automobile industry. It is important for driving support systems to detect the status/activity of driver's consciousness. Detecting onset of driver fatigue could prevent the accidents caused by drowsy driving. It is proposed to detect / analyze the driver fatigue by the application of dedicated physiological indicators such as electroencephalography and also facial features such as eyelid movements based on template matching using neural network technique for closed eyes versus opened eyes. EEG signal is one of the most predictive and reliable measurements by the analysis of alpha, beta and theta band power etc, which are considered as direct factors associated with human drowsiness. The parameters such as blink duration and opening time changes reliably with increasing drowsiness.

Key words: Fatigue · Template Matching · Alertness Monitoring

INTRODUCTION

Driver drowsiness is considered to be an important cause which leads to serious traffic accidents [1]. Based on police reports,the US National Highway Traffic Safety Administration (NHTSA) conservatively estimated that a total of 100,000 vehicle crashes each year are the direct result of driver drowsiness [2]. These crashes resulted in approximately 1,550 deaths, 71,000 injuries and $12.5 billion in monetary losses [3]. In the year 2009, the US National Sleep Foundation (NSF) reported that 54% of adult drivers have driven a vehicle while feeling drowsy and 28% of them actually fell asleep [4]. The German Road Safety Council (DVR) claims that one in four highway traffic fatalities are a result of momentary driver drowsiness [5]. Recent studies presented evidence that driver sleepiness accounts for 6% of crashes, 15% of fatal crashes and 30% of fatal crashes on rural roads. Analysis of accident data clearly indicates the fatigue as major factor in road accidents, particularly during night [6] and long hours of driving.

The General Consensus Is That the Three Main Determinants of Fatigue as Follow:

- Lack of sleep
- Time of day or circadian factors
- Time spent performing a task

Drowsiness affects mental alertness [7], decreasing an individual's ability to operate a vehicle safely and increasing the risk of human error that could lead to fatalities and injuries. Furthermore slow reaction time decreases awareness and impairs judgment. Long hours in monotonous driving environments make truck drivers particularly prone to drowsy-driving crashes. Operational requirements are diverse and factors such as work schedules, duty times, rest periods, recovery opportunities and response to customer needs can vary widely. In addition, the interaction of the principal physiological factors that underlie the formation of sleepiness, namely the homeostatic drive for sleep and circadian rhythmsare complex. While these challenges preclude a singlesimple solution to the problem, there is reason to believe that driver drowsiness can nevertheless be effectively managed, thus resulting in a significant reduction in related risk and improved safety. Addressing the need for a reduction in crashes related to driver drowsiness in transportation will require some innovative concepts and evolving methodologies. Within any comprehensive and effective fatigue management program, an on-board device that monitors driver state in real time may have real value as a safety net. Drowsy drivers exhibit certain observable behavior, including eye gaze, eyelid movement, pupil movement [8,9], head movement and facial expression. Non-invasive techniques are currently being employed to assess a driver's

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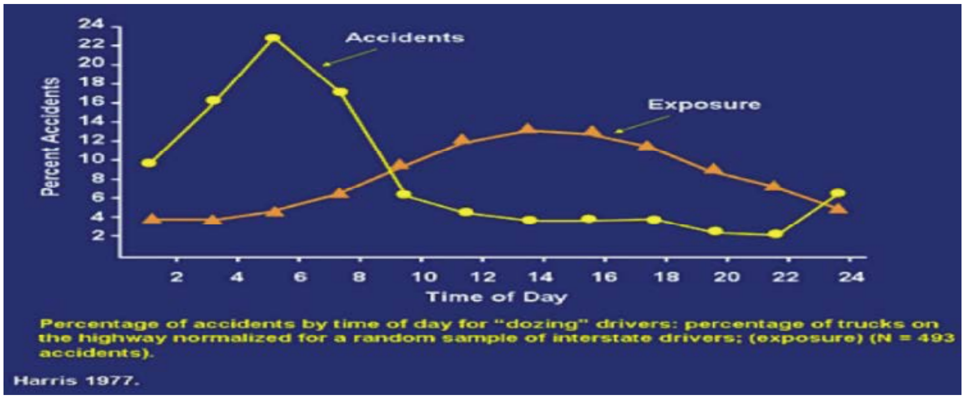

Fig. 1: A Survey report.

alertness level through the visual observation of his/her physical condition using a remote camera and state-of-the-art technologies in computer vision. Recent progress in machine vision research and advances in computer hardware technologies have made it possible to measure eye gaze and eyelid movement [10] accurately and in real time using video cameras.

The technologies monitor usually on-line and in real time bio-behavioral aspects of the operator; for example, eye gaze, eye closure, pupil occlusion, head position and movement, brain wave activity and heart rate. To be practical and useful as driver warning systems, these devices must acquire, interpret and feedback information to the operator in real world driving environments. As such, there exists a need and, thus ongoing efforts are underway, to validate operator-based, on-board fatigue monitoring technologies in a real-world naturalistic driving environment. The aim of the present work was to give a relevant solution to this problem by developing unobtrusive, in-vehicle, real-time drowsy driver detection and fatigue alerting system.System that detect drowsiness when driver is becoming drowsy and sound a warning promise to be a valuable aid in preventing accidents.

The Figure 1 indicated that the percentage of accidents during the early morning is more compared to other time of the day when the test is done on the random sample of drivers.

MATERIALS ANDMETHODS

It is proposed to develop EEG analysis based detection system for drowsiness detection and alarm the driver accordingly. The EEG is acquired using scalp surface electrodes affixed on scalp surface and leads are connected to the instrumentation amplifier. To obtain a high signal-to-noise ratio, the used instrumentation amplifier is characterized by high common mode rejection ratio and a low input bias current. It is also proposed to use facial features such as eyelid movements for detecting the drowsiness based on template matching using ANN technique as in Fig. 2 [11] for closed eyes versus opened eyes. In this paper we are considering the two parameters such as EEG and eyelid movements for the detection of drowsiness level of the driver. These two parameters are acquired from the driver using webcam and EEG electrodes respectively. The acquired data are collected in the data acquisition system block and are pre-processed by using instrumentation amplifier and image processing techniques for EEG and eyelid images respectively. These pre-processed data are considered as real time data.

The images of closed eyes are learnt using ANN [12] technique and stored as a database for template matching [13]. These images will be compared with the real time data of eyelid movements and the RMS values of the acquired EEG signals will be estimated in the processing module using Lab VIEW tool and the drowsiness level is detected and the alarm signal will be activated by the alert system which contains the beeper and LED circuit as shown Fig 3 and 4.

System Requirements: The requirements for an effective drowsy driver detection system are as follows:

- A non-intrusive monitoring system that will not distract the driver.
- A real-time monitoring system, to insure accuracy in detecting drowsiness.
- A system that will work in both daytime and nighttime conditions.

Implementation: The requirements specification activity is entirely in the problem domain. Design is the first step in moving from problem domain towards the solution

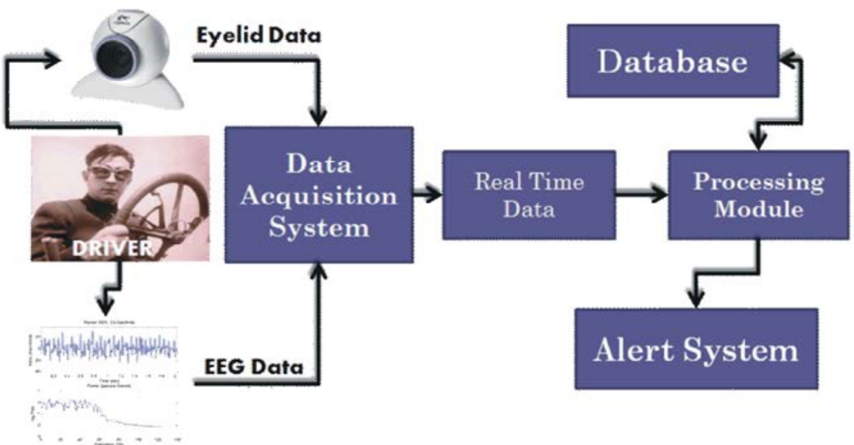

Fig. 2: Fundamental Block diagram of smart alert system

Display and Alarm Signal Block Diagram

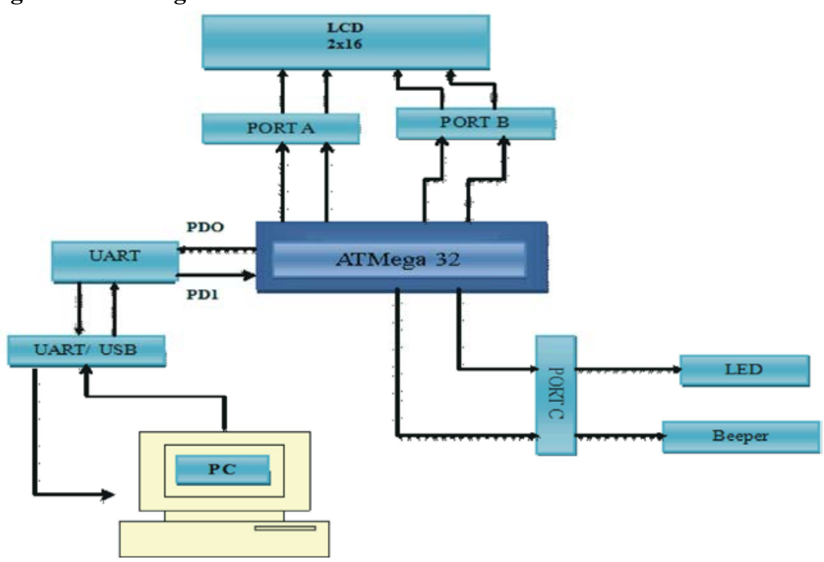

Fig. 3: Block diagram indicating LCD and LED display Beeper signal indication

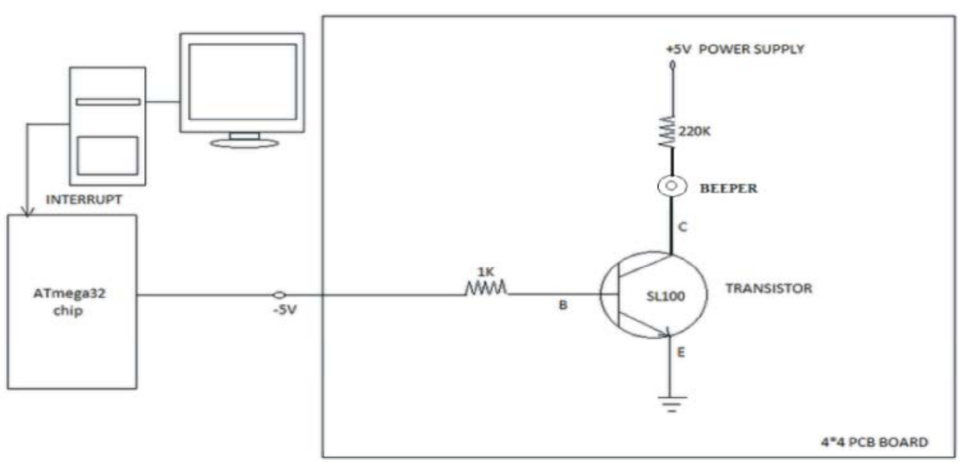

Fig. 4: Beeper circuit to indicate drowsy state of driver

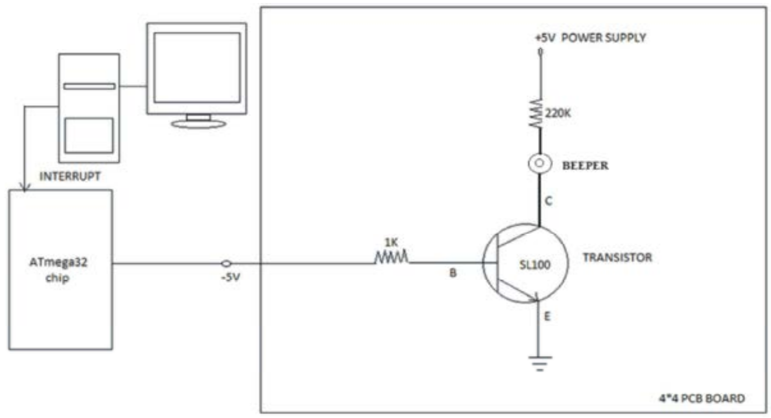

Fig. 5: LED circuit to indicate drowsy state of driver

Flow Chart for Image Acquiring, Detection and Alerting the Driver

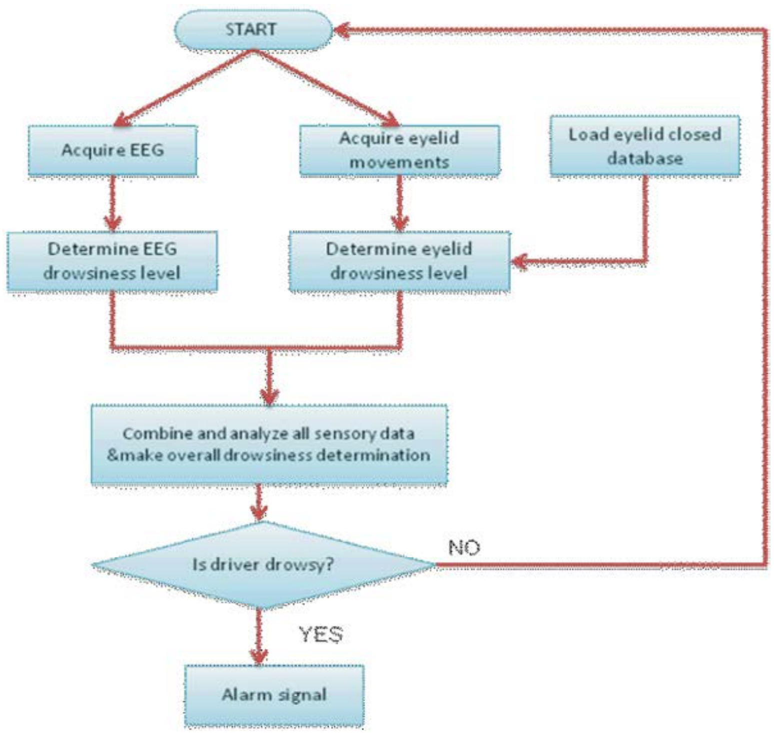

Fig. 6: The flowchart representing clear picture about the acquiring, detection and alerting process of the system.

domain. A design can be object oriented or function oriented. Design concept for eyelid is as follows: creating an exhaustive image data base from individual photos with different angles, extracting the closed eye images from captured image and recognize the closed eye image from image data base for a given target image. The design concept includes acquiring the EEG data signals, calculating the RMS value and based on the threshold value determine the drowsiness level as shown in Fig 5 and 6.

Image Processing Techniques

Image Acquisition: A digital image is produced by one or several image sensor which, besides various types of light-sensitive cameras, includes range sensors, tomography devices, radar, ultra-sonic cameras, etc. Depending on the type of sensor, the resulting image data is an ordinary 2D image, a 3D volume, or an image sequence as shown in Fig. 7. The pixel values typically corresponds to light intensity in one or several spectral bands (gray images or colour images), but can also be

Image Extraction

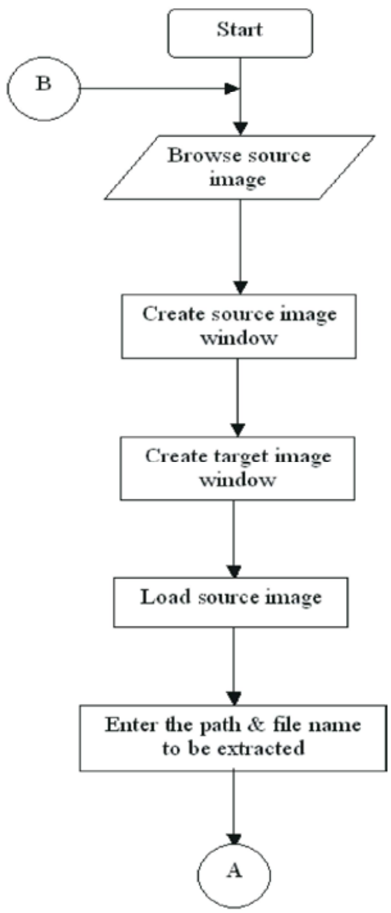

Fig. 7: Flow Chart for Image extraction

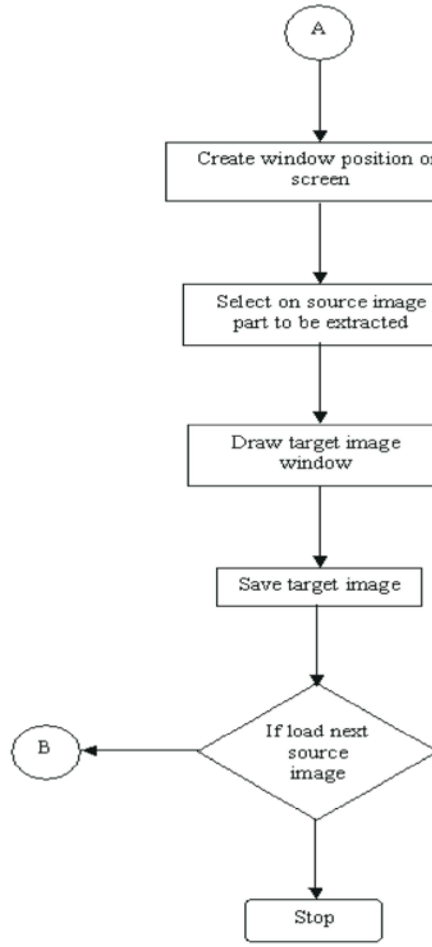

Fig. 8: Flow Chart for Image extraction (Cont...d)

related to various physical measures, such as depth, absorption or reflectance of sonic or electromagnetic waves.

Pre-Processing: Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is necessary to process the data in order to assure that it satisfies certain assumptions implied by the method. Examples are Re-sampling in order to assure that the image coordinate system is correct. Noise reduction in order to assure that sensor noise does not introduce false information [14].Contrast enhancement to assure that relevant information can be detected. Scale - space representation to enhance image structures at locally appropriate scales.

Feature Extraction: Image features at various levels of complexity are extracted from the image data. Typical examples of such features are: lines, ridges and edges. Localized interest points such as corners, blobs or points as shown in Fig 8 [15]. More complex features may be related to texture, shape or motion.

Detection/Segmentation: At some point in the processing a decision is made about which image points or regions of the image are relevant for further processing. Examples are Selection of a specific set of interest point segmentation of one or multiple image regions which contain a specific object of interest.

Face Detection Technique: Due to the human face is dynamic and has a high degree of variability; face detection is considered to be a complex task in computer vision. Face detection is a necessary step in all face processing systems and its efficiency influences the overall performance of drowsiness detection systems. Researchers classified the face detection techniques using the following approaches: the top down model

Template Matching

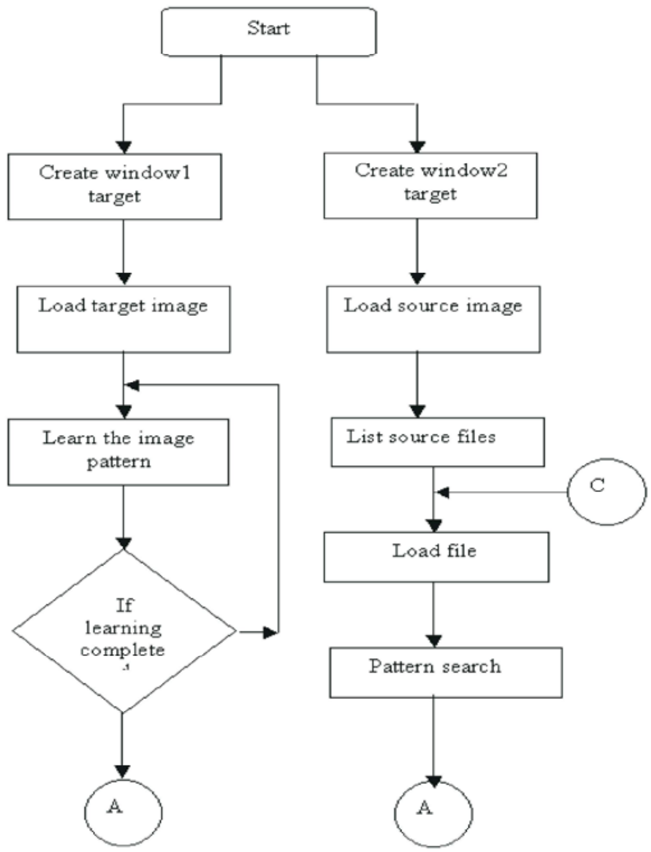

Fig. 9: Flow chart for template matching

based approach (search different face model at different scales level), bottom up feature based approach (searches the image for a set of facial features), texture based approach (faces are detected by examining the spatial distribution of gray or colour information), neural network approach (detects faces by sampling different regions and passing it to neural network), colour based approach (labels each pixel according to its similarity to skin colour and face shape), motion based approaches (use image subtraction to extract the moving foreground from the static background).

Besides, another major classification categorizes the face detection algorithms into the following approaches: feature-based [16], image-based and template matching. The general classification for face detection algorithms and supported tools are presented by Hjelm and it can be divided into three categories: feature based, template matching and image based.

Template Matching: Many of the applications of computer vision simply need to know whether an image contains some previously defined object, or in particular, whether a predefined sub-image is contained within a test image. The sub-image is called a template and should be an ideal representation of the pattern or object which is being sought in the image as shown in Fig. 9 and 10.

Template matching is a fundamental method of detecting the presence or the absence of objects and identifying them in an image. A template is itself an image that contains a feature or an object or a part of a bigger image and is used to search a given image for the presence or the absence of the contents of the template. This search is carried out by translating the template systematically pixel-by-pixel all over the image [17] and at each position of the template the closeness of the template to the area covered by it is measured. The location at which the maximum degree of closeness is achieved is declared to be the location of the object detected.

The template matching technique involves the translation of the template to every possible position in the image and the evaluation of a measure of the match between the template and the image at that position. If the similarity measure is large enough then the object can be

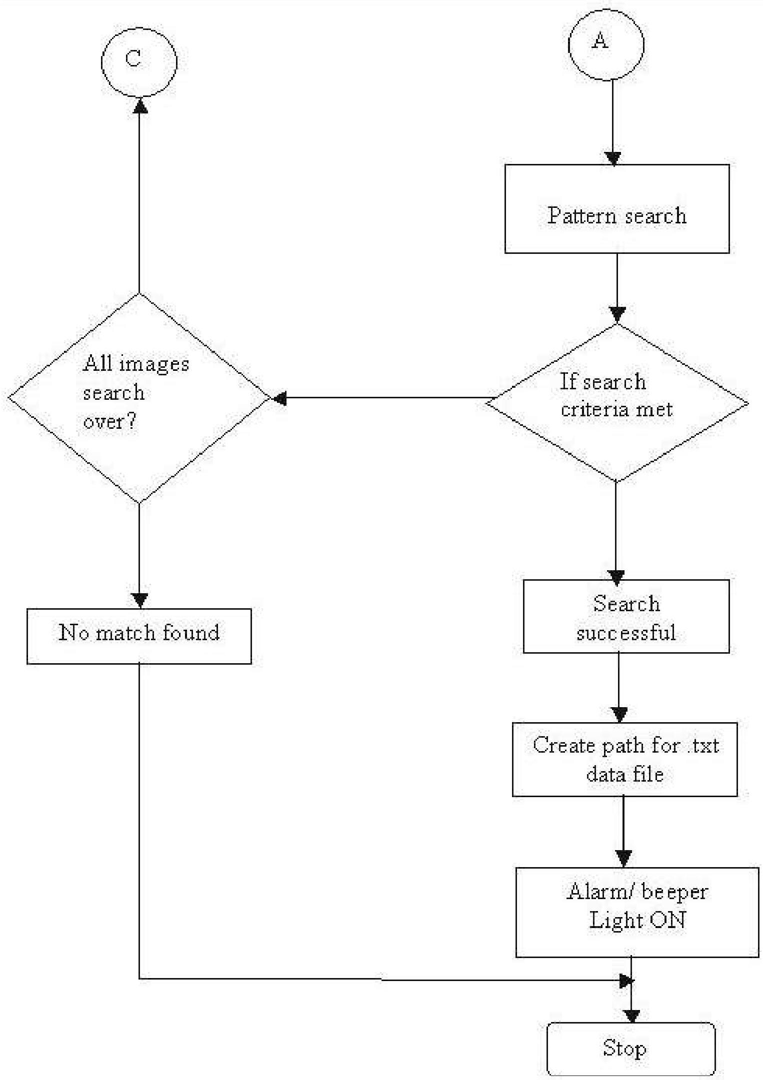

Fig. 10: Flow chart for template matching (cont…d)

assumed to be present.Template matching is a technique in digital image processing for finding small parts of an image which match a template image. The comparison of a picture or other data with a stored program or template, for purposes of identification or inspection. It can be used in manufacturing as a part of quality control, a way to navigate a mobile robot, or as a way to detect edges in images. The basic method is to perform template matching is to loop through all the pixels in the search image and compare them to the pattern. This method is normally implemented by firstly creating a sub image (the template), we will call this sub image 'w(x,y)' where x and y represent the coordinates of each pixel. We then simply move the center of this sub image w over each (x,y) point in a candidate image, which we will call 'o(x,y)' and calculate the sum of products between the coefficients in o and the corresponding neighborhood pixels in the area spanned by the filter mask. This method is sometimes referred to as Linear Spatial Filtering.

RESULTS

The results for EEG are obtained by changing the numeric values in the front panel of the program.

Drowsy EEG: If the numeric value is varied from 4 to 7 it shows that the person is drowsy. 4-7 Hz is the frequency range of the theta wave which indicates the drowsiness of a person as shown in Fig 11 and 12.

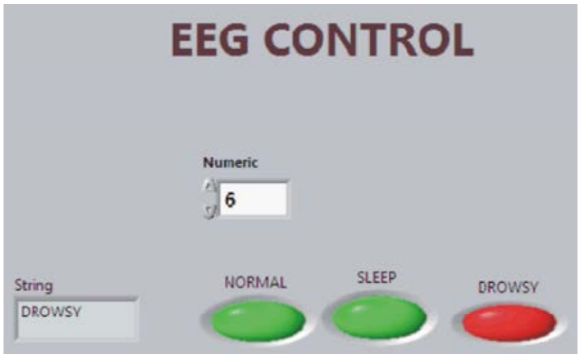

Fig. 11: Output window for drowsy EEG.

Fig. 12: Output window for normal EEG.

Eye Opened

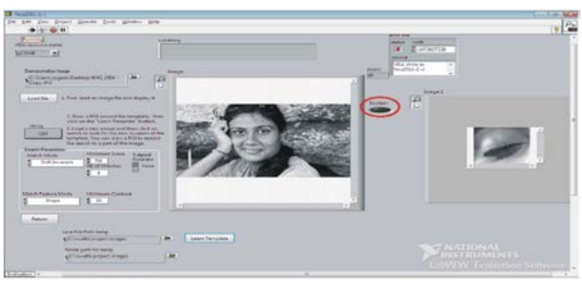

Fig. 13: Open eye tracing window

Eye Closed

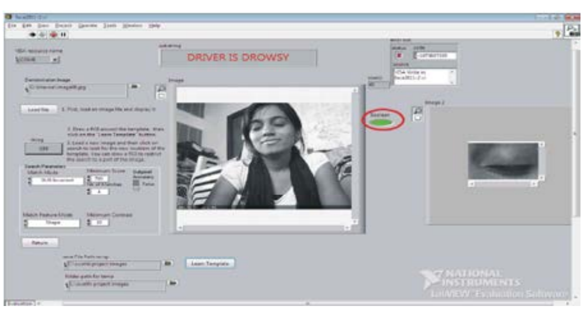

Fig. 14: Drowsy eye tracing window.

Normal EEG: If the numeric value is varied above 7 it shows that the person is in normal condition [18]. This can be shown in the below figure.

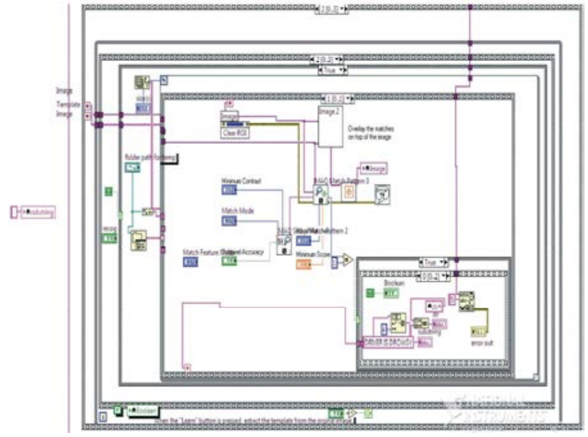

Fig. 15: Lab view program for drowsy detection using eyelid movements

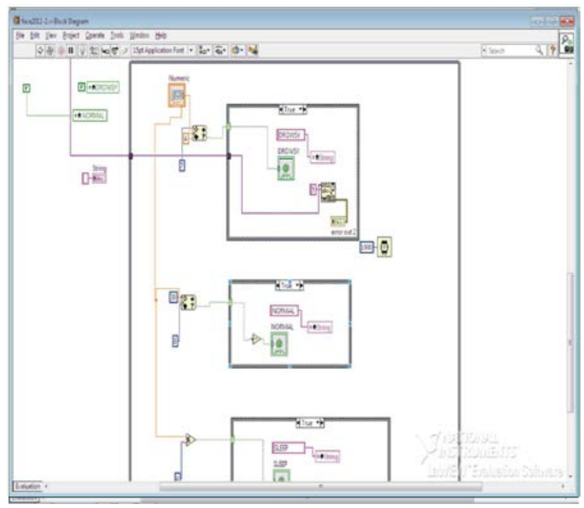

Fig.16: Lab view program for drowsy detection using EEG.

The above Figure 13 and 14 indicated the eye tracking window. The part encircled by red indicates that the person's eye is open [19], which indicates that the person is not drowsy. This can be identified by observing the colour of the Boolean part indicated. If there is no glow in thecolour indicates that the driver is not drowsy.

Drowsy Detection Using Eyelid Movements:

- Initialize the ports for serial communication.
- In IMAQ two buffers are created i.e. creating tool for capturing image.
- List all the database files in while loop.
- In demonstrate image -load IMAQ real time image file
- For learning draw a rectangular box on the image to be learnt, after this extract image and learn it. Then save the image in the database.

- Recognition -all the demonstrated images compared with database images, if any particular closed eye is found then the alerting signal will be sent to hardware.
- Dispose of images -clear the entire buffer to load the images.

Drowsy Detection Using EEG: Comparing with respect to threshold value for the state of drowsy, sleep and normal.

- For the three states there are LED's which will be in green colour, if any abnormality is found in EEG signal it turns to red by sending the alerting signal to the hardware.

CONCLUSION

This paper intended to provide a detecting and alerting system for drowsy drivers which are in the present scenario leading to number of collisions. This idea will help the drivers from overcoming one of usual human tendency by alerting them with beeper sound during their drowsiness. During the monitoring, the system is able to decide if the eyes are opened or closed. When the eyes have been closed for too long, a warning signal is delivered.

In addition, during monitoring, the system is able to automatically detect any eye localizing error that might have occurred. In case of this type of error, the system is able to recover and properly localize the eyes.

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