International Journal of Engineering & Technology, 7 (3.20) (2018) 743-747

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Analysis on Fatigue Recognition System Using Facial Features and HRV

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Abstract

Observing the driver's state of cognizance and weakness is totally important to diminish the amount of road accidents. A simple approach cognitive approach for inspection of driver safety levels by combining facial features and Heart rate Variability (HRV) is discussed.Fatigue detection is performed through Simulation that involves face detection, face localization, eye detection, thresholding and eye blink detection using Matlab and OpenCV. Heart rate was analysed using Signal Acquisition, Filtering, R-R Peak Interval Extraction and heart rate calculation. The simulation was performed using LabVIEW. A simple modelwas analysed using sensors wrapped into steering wheel and from it if the measured pulse rate is lesser than 65 the system detects it as low heart rate which corresponds to drowsiness detection.

Keywords : *Biomedical computing, Electrocardiogram, Fatigue, Medical information systems, Matlab, LabVIEW.*

1. Introduction

A portion of the illnesses or incapacities that may meddle with the sheltered task of vehicles can be found in these classes: Vision Hearing, Cardiovascular ailments, Cerebrovascular Diseases, Musculoskeletal Disabilities Psychiatric clutters, impacts of medications, Alcohol and maturing Issues [1]. Among these issues, weakness and sudden heart assault are the real reasons for mishaps which can't be controlled by driver regardless of whether he/she needs to do.

This helps in spotting the improper working of the heart and take safety measures. Certain of these lives can often be saved if desperate care and cardiac treatment is delivered within the so-called golden hour. So the need for guidance on first hand medical attention becomes inexorable. Hence, patients who are in danger necessitate that their cardiovascular wellbeing to be observed intermittently whether they are inside or outside so crisis fix is possible.When an individual goes amiss from waking into tiredness/rest arrange, the LF to HF control ghostly thickness proportion (LF/HF proportion) drops, though the HF control upsurges related with this status change. So the relative changes in the conduct of a cardiovascular patient while driving a vehicle can be researched with changes in pulse.

2. Preceding Research

There are several techniques exist for this drowsy behaviour detection. The analysis of drowsy driving behaviour by means of performing face detection is the basic step for eye detection [3]. In which, eyes are detected by constructing a threshold on roundness of iris and analyses the eye state for drowsiness detection. The factors like Iris impediment by eyebrows, eyelashes, eyelids, quick lightning replications, specular reflections, Poor concentration, partly captured iris, Out-of image iris, and Off-angle iris motion may occur. Several techniques exist, which detect fatigue based on the fuzzy fusion of blinking features that are extracted from a high frame rate video [7]. Another detection algorithm which proceeds from face detection performs eye detection and calculates eye blink pattern from "Eye blink pattern detection algorithm" [8]. Illumination based approaches also exist which uses an infrared image that remained stable regardless of whether it was used during the day or at night [9]. IR illumination cameras are used to detect the drowsy behaviour by means of dark pupil effect. Although IR based approaches perform reasonably at night time it requires the necessity of installing an IR LEDs setup and maintenance

Even though these techniques are constructive, algorithms are little difficult to perform and of high execution time and cost. Biosignal produced from EEG sensors have to locate on the either side of head using 10-20 method. If we use them, it will make provide body discomfort to driver and difficult to analyze since stress signals will also blend [13].So we propose a hybrid method that combines facial image processing and HRV for detecting drowsiness at the wheel. The proposed system that determines drowsiness from heart rate to monitor the caution of a post-operative patient in driving condition and provides an alert if the value outstrips the predefined threshold.The recognition of QRS from the original Electrocardiogram (ECG) signal deliversevidence about the heart rate as well as various irregularities. This system obtains ECG signal over non-intrusive HR sensors that are enfolded on to the grip of the steering wheel through which it calculates the period interval for the driver's pulses and changes into a heart rate. If the identified HR is lesser than the threshold HR, the model will deliver an immediate alert to the person in prior. The other case if the pulse rate is higher than threshold it will detect it as an attack and provide an immediate alert to the person in advance thereby reducing critical accidents.

3. Experimental Results & Discussion

3.1. Facial Features Analysis Using Matlab

Initial step starts with the acquisition of an image from the camera followed by face tracking and eye detection. If eyes are open then it checks the heart rate of the driving person. If the heart rate is lesser than the predefined threshold then the person is subjected to feel drowsiness.

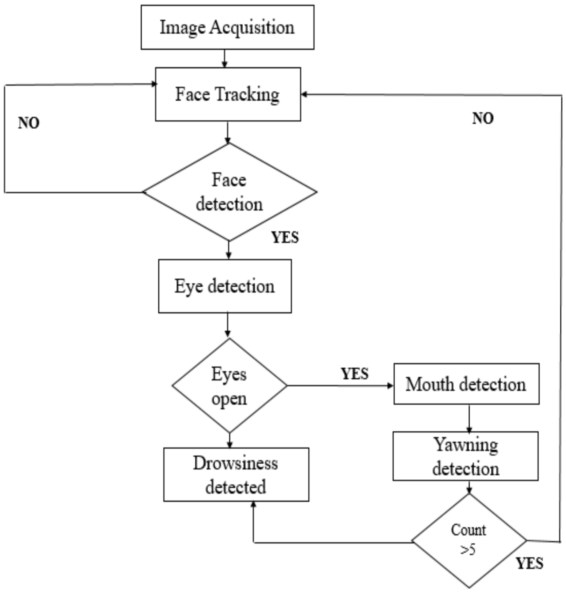


Fig. 1 Face detection flow diagram

The basic process of obtaining Video is achieved through a simple web camera for getting live video as its input and process the video into a set of frames that are process able. The frame grabber provides a set of frames from which the face detection function takes one frame at a time and tries to sense the face of the driving personnel. Eyes detection is performed using extract Eyes function through Region of Interest and fatigue is determined using state of the eyes, open or closed [21].
The sensitivity of camera used is responsible for providing perfection in video stream analysis. The connected webcams are detected by using the imaqhwinfo function. After applying function this is followed by configuringand assigning the video properties bysetting the Frames per Trigger and Returned Color Space properties of the video object. The video acquisition was then obtained using the start (video object) function. To prepare an object FaceDetect here vision CascadeObjectDetector is appliedfor discovering the face. The next step was to crop the image such that only the face is retained stationary for further eye detection. This is attained by imagining the live video feed as individual frames and processing each frame specifically.

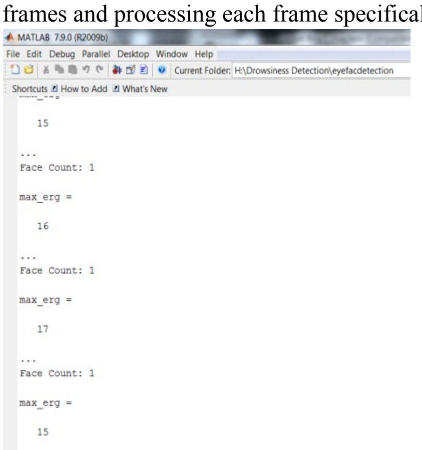
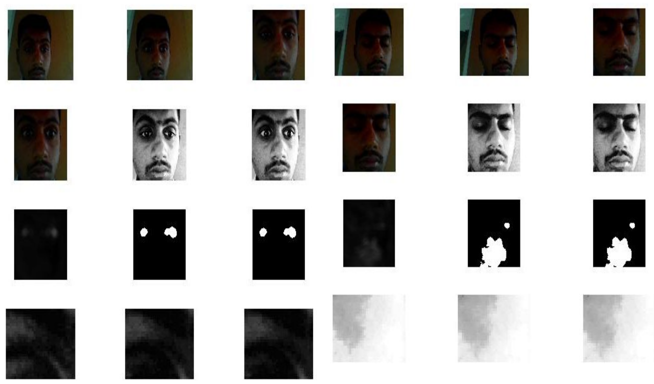


Fig.2 Face detection

The vision Cascade Object Detector is used to round off and detect the eye portionthrough initialize an object EyeDetect. The total no of frames for prestage is fixed as first 50 frames. Frame conversion from the obtained video is realized using the getsnapshot function that returns a matrix for an RGB image. The factors like rect positons, height and width is given as input rectangular function to process the obtained image for detecting the eye region. The position, width and height are obtained by using the Vision class function and eyes are detected using the built in object detector function CascadeObjectDetector The Eye Detect object is given as input beside the image and the values revertedrelate to the X Coordinate, Y Coordinate, Width and Height of the eye region.
Next imcropfunction is utilized to crop the image as per the desired using n*4 matrix followed by grayscale conversion using the rgb2grayfunction. The im2bwfunction is used where the image again flipped from gray scale image to its black and white form using. Dilation is performed over the black and white image to get the eyes. The purpose of performing the dilation function is to enhance the foreground features.
The actual frame is extracted from webcam through the command getshanshot. Face finder checks whether the frame contains a face or not. If so, then there are also eyes which have to be captured. Face finder gives an array back with four coordinates per face. Check if the array contains some coordinates. If not then the images contains no faces. The difference image of each frame and the previous frame is thresholded. This output results in delivering a binary image showing the regions of movement that is used to locate the eyes of the user. To save computational time, the algorithm only considers area which contains the face. So we need some boundary coordinates.
To find the occurrence of eye blink the next step is to recover the number of connected components in the resultant binary image and check if there are two connected components left. If so then an eye blink has been occurred. Now let's have a look at the correlation coefficient r. If correlation coefficient factor is below 0.2, there is no correlation among the template and the matching image area. So the algorithm has to go back to his initial phase. If the correlation coefficient r is bigger than the value of Threshold, then we are assuming that the eyes are still open. The commands tic and toc are responsible for measuring the time, how long the user keeps his eye closed.



3 (a) **3 (b)**
Fig. 3 (a) Normal – Eyes Open (b) Fatigue detection – eyes closed

3.2. Mathematical Analysis Using OpenCV

Nevertheless Matlab toll is having a diverse limitations. The processing capacities required by Matlab were very high. Likewise there were other problems in real time video signal processing. Matlab tool can process only few frames per second. To detect the fatigue from facial features we all know an eye blink is of few milliseconds. So the Matlab source code for detecting drowsiness performance was found not suitable for quick analysis

.Computer vision is the converting of data from animage, or video camera into either a representation or a new decision.

3.2.1. Fatigue Detection

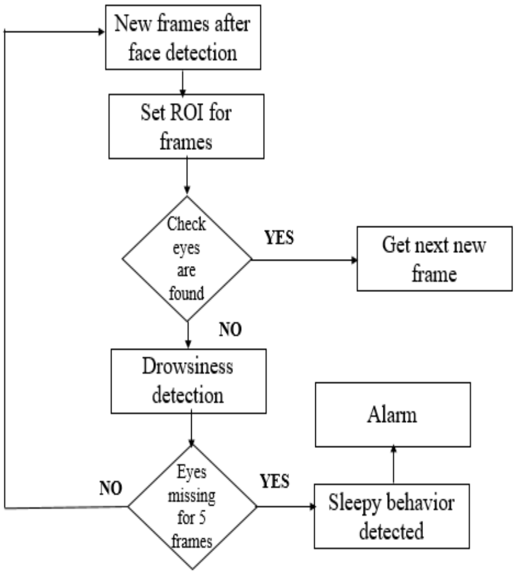


Fig. 4 Fatigue detection using OpenCV

The first step is to grab a frame from the camera or a video file and here meanwhile the video is not stored, the frame is grabbed from the camera and once this is realized, the next step is to recover the grabbed frame. This is done by using a single function that performs dual role i.e grabs a frame and returns it by decompressing.For face detection, initially we process the cascade file loading. Then permit the acquired frame for an edge detection function that discovers all the likely objects of dissimilar sizes in the frame. At that point the yield the edge finder is put away in a cluster and contrasted with the course document with recognize the face in the edge. Since the course contains similarly positive and negative examples, it is required to express the quantity of disappointments on which an article identified ought to be ordered as a negative sample. When the features are matched the face is detected and a circle is drawn around the face.

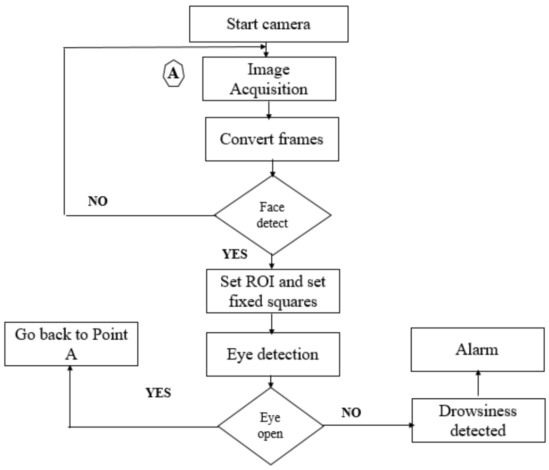


Fig. 5 Simple procedure for eye closure detection

The equivalent of Haar course Xml record is utilized for eyes identification. Out of the distinguished items, the article which has the most noteworthy surface region is gotten. This is estimated as the got positive example of first class. Out of the rest of the articles, the item with the most elevated surface zone is resolved. This is considered as the positive example of second classification. Presently, we check if the two positive examples have at least 30 pixels from both of the edges. Next, we check if the two positive examples have at least 20 pixels separated from one another. In the wake of breezing through the above tests, we infer that positive example 1 and positive example 2 are the eyes of the vehicle driver. Concentrate the pixel esteems from the eye area and check the accompanying: If these pixel esteems are white, at that point it derives that the eyes are in the open state, If the pixel esteems are not white then it induces that the eyes are in the shut state. This is improved the situation every single casing separated. In the event that the eyes are identified to be shut for two seconds or for five edges then the car driver is distinguished to be tired.

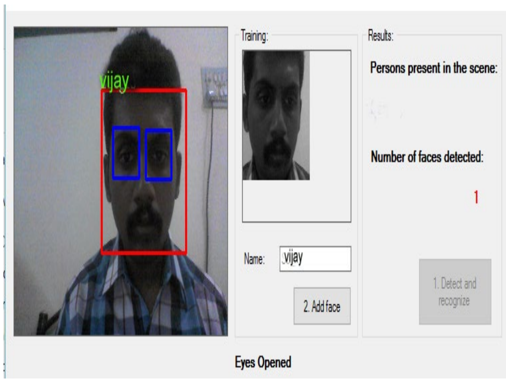


Fig .6 Normal conditions

Table 1 Test results for Drowsiness detection

Number of participants	Face detected	Open Eye Detection	Closed eye detection	False count	Accuracy
1	25	21	3	1	96.1%
2	30	26	2	2	93.3%
3	33	14	16	3	90.9%
4	26	16	6	3	88.4%
5	33	26	5	2	93.9%
6	45	37	4	4	91.1%
7	28	15	13	1	96.4%
8	40	19	18	3	92.5%
9	19	8	9	2	89.4%
10	57	26	28	3	94.73%
1	25	21	3	1	96.1%

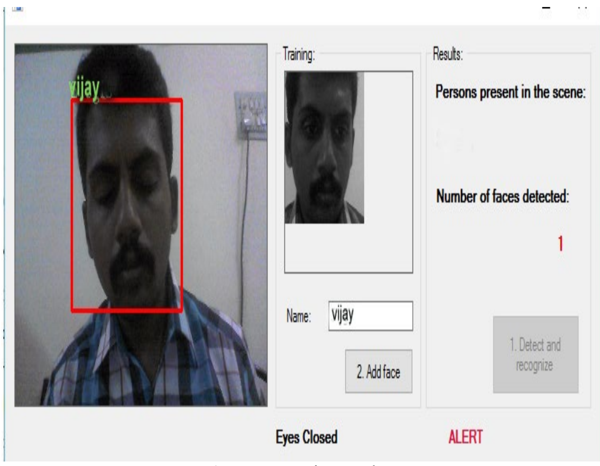


Fig. 7 Drowsiness alert

3.3. ECG Based Heart Rate Variability Analysis

The second method of analysing fatigue is determined from HRV obtained from ECG. Our system uses a non-invasive method of picking up an ECG where each half of steering wheel is wrapped with electrically conductive fabric (ECF) as two ECG electrodes.

3.3.1. Signal Conditioning

ECG signals acquired are very small electrical signals in the incidence of higher noise components.

3.3.2. ECG Noise Filtering

Once after getting the ECG signal the next step is to remove the noise associated with the signal and extract the noise free signal. Changes in respiration and body movements caused the low-frequency high-bandwidth components that leads to baseline noise. It can cause problems to analysis, exclusively when inspecting the low-frequency ST-T segment. Different types of filters for obtaining a noise free ECG signal are shown in Table.2.

Table 2 Methods used for noise free ECG signal extraction

Different methods of filtering	Types of noise removal
Low pass filter and High pass filter	Drift due to respiration
8 point moving average filter &Notch filter	Power line interference removal
Recursive least square adaptive notch filter FIR high pass filter	Baseline drift removal Baseline wandering
Adaptive filter	Muscle noise removal
Band pass filter	Low amplitude noise at output
Wiener filter	High frequency noises of ECG
FIR equiripple band pass and FIR butter worth filter	Composite noises

3.3.3. R Peak Detection

This is the primary reason that motivated us to concentrate on on QRS complex wave and RR interval since QRS complex wave is the most central, visual part and less affected by noise.

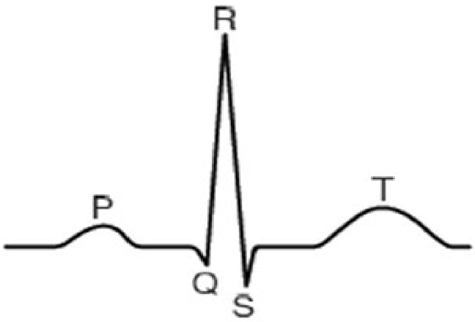


Fig.8 Typical ECG waveform

Our proposed work is concentrating only on RR intervals where RR interval is the time between QRS complexes. By processing this R-R interval, the decrease in LF/HF frequency ratio while drowsy state is analysed and fatigue behaviour is detected. The reason for choosing the RR intervals is less affected by noise for HRV analysis. From the LF/HF ratio, we can easily find the heart rate of the driver. If the LF/HF ratio decreases, the driver will be in drowsy state. Normally, when a person becomes sleepy (LF/HF ratio) decreases. Thus, LF/HF ratio is a best reflector of drowsiness detection. Subsequent to deciding the normal pulse, choice is taken dependent on our limit whether the pulse of the individual is not exactly the most reduced edge esteem (Heart rate <80) at that point the driving individual is exposed to tiredness or in the event that it is more than the most astounding edge esteem (Heart rate > 100)

If drowsiness is not detected from the images then it checks heart rate of the person from the ECG sensors attached to the steering wheel. We have performed an analysis using LabVIEW by taking a noisy ECG signal and determined R peaks from it. The ECG simulator endows us to scrutinize normal and abnormal ECG waveforms without essentially using the ECG sensors and DAQ board. The insinuation is to apply direct fast Fourier transform (FFT), remove low frequencies and restore ECG as shown in figure 7. Band pass filter was applied to the input ECG and noise free ECG was obtained.

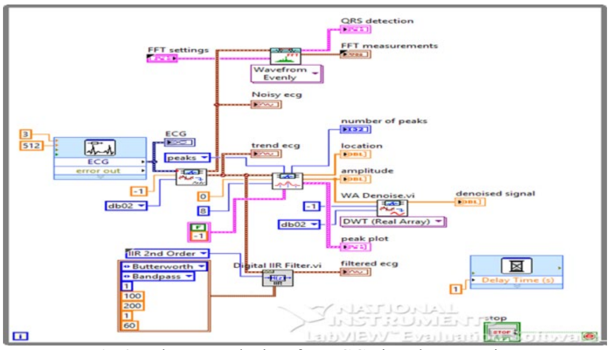


Fig.9 LabVIEW design for ECG signal processing

3.3.4. Simulation Results

LabVIEW Biomedical Toolkit affords a Bio signal filtering file which we can design a Kaiser Window FIR high pass filter to remove the baseline wandering. Besides to digital filters, the wavelet transform is also an effective way to remove signals within precise sub bands.

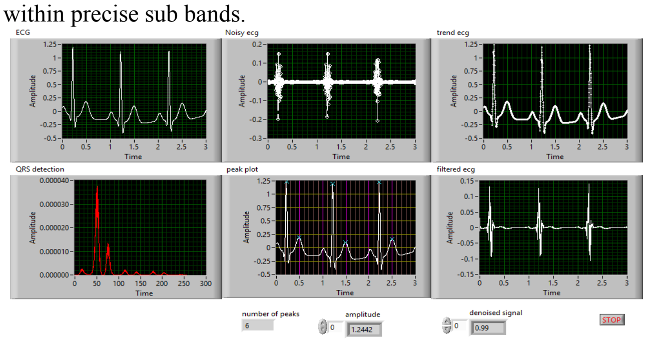


Fig.10 Output results with QRS complex detection

Here as appeared in figure 9 we have utilized the Daubechies2 (db02) wavelet since this wavelet is similar to the genuine ECG flag. Here, contingent on the examining span and inspecting purposes of ECG flag, the pattern level is set. It is determined as appeared as follows

Trend level = {log2 2t / log2 N} (3.1)

Where t is the sampling duration and N is the number of sampling points. After baseline wandering is removed, the resultant ECG signal is more immobile than the original signal. However, some other types of noise discussed in table 1 might still affect feature extraction of the ECG signal.

The noise may be complex stochastic processes within a wideband, so it is not possible to remove those by digital filters. To remove the wideband noises, we have used the Wavelet Denoise Express VI and the results are shown in figure 11. The next step is to predict QRS and RR intervals since heart rate is calculated from successive RR intervals. The results are shown in of figure 12

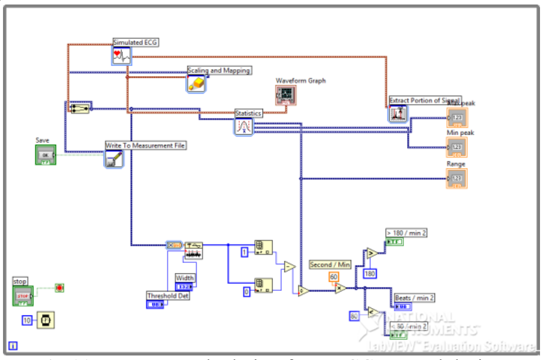


Fig.11 Heart rate calculation from ECG – Panel design

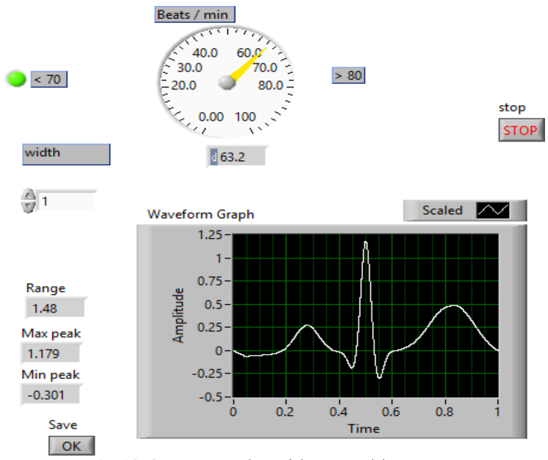


Fig.12 Output results with normal heart rate

4. Conclusion

This research work provides a collective analysis for determining the perilous activity of person in driving state. We have analysed the behavioural changes of a person in driving state by combining the two major parameters eye state and heart rate variability. In this first part of research work we have examined the driver's state of drowsiness on-line, which requires low computational and time complexity. We tried to face this constraint by using unfussy image processing techniques by means of a simple detection algorithm via Matlab as a tool. Use of normal web camera, fast computation obtained from scaling factor compromise the systems performance for the sake of simplicity which is a major criterion for real time scenario. This proposed model is very cost effective i.e it can be implemented with mobile cameras which now-a-days have high pixel quality. This algorithm even works for candidates wearing spectacles and in lighting environment up to an extent.
Our second part of the research work was accomplished by analyzing the fluctuations in ECG of a patient through LabVIEW as a simulation tool. When there is variation in QRS complex then the corresponding heart rate is displayedand buzzer provides an alarm. We are also developing a model in which the data for the analysis is taken from the wearable ECG Sensorswrapped on to the steering wheel. We are trying to enhance this work by combining two more non-intrusive metrics namely, head rotation monitoring and yawning count. If the driver is found to be drowsy, a first level warning will be delivered to the driver.

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