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ACCIDENT PREVENTION USING LOW COST SENSORS AND USB CAMERA

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Abstract— A cloud based approach is proposed as a solution for preventing accidents. The system provides face detection and eye detection from the image captured using a low cost USB camera. Then driver's head pose is estimated using the region of interest computed by Viola-Jones algorithm. The system also contains a heart rate sensor for detecting the biological problems of the driver and an alcohol sensor to detect whether the driver has consumed alcohol or not. This combined system is used to prevent drink and drive accident, accident due to inattention of driver and accident due to driver's biomedical problems.

Keywords— Cloud based approach, face detection, eye detection, Viola-Jones algorithm.

I. INTRODUCTION

Accidents are major problem in our day-to-day life, so it is important to monitor the driver to understand his needs, behavior and errors. There are already many techniques to provide automatic driver monitoring. But these techniques had more disadvantages and invasive systems.

The existing system used high cost camera and sensors. It used time of flight and stereo cameras which is not yet implemented in Indian cars. Also, the sensors used (Kinect Sensor) is costly and it is designed for indoor applications. Its usability for outdoor applications is limited as it is sensitive to strong illumination.

The proposed system uses only a low expensive USB camera for face and eye detection. This makes the system easier to be implemented in all vehicles at affordable cost. The camera image provides trustable features such as face and eyes for head pose estimation. By using Viola-Jones algorithm Region of Interest is calculated which is helpful in behavior analysis of driver.

The heart rate sensor uses IR transmitter and photo receiver. The IR ray is interrupted by the blood flow which determines the heart rate. This heart rate value is determined before starting and while driving.

The alcohol sensor (MQ4) is a semiconductor sensor in which the change of conductivity is converted to gas concentration. This gas concentration represents the amount of alcohol consumed. This value is also checked before starting and while driving.

II. STATE OF THE ART

As intended in [1], it monitors the driver based on the data from the Kinect sensor. It fuses 2D and 3D information which provides reliable face detection and accurate pose estimation. It uses a cloud based approach in which more enhanced vision detection is provided. In this system only relevant features of face is sensed which enhances the accuracy. A cloud is formed from the captured image and it is used as a reference for further images. By comparing with reference image, transformation matrix which consists of rotation matrix and translation vector is obtained. From this, Region of Interest is determined by cropping the irrelevant information like neck, hair, etc. It is processed using a Voxel filter for reducing the cloud points which reduces the search space, reduces processing cost and provides easier analysis. After this, Iterative Closest Point algorithm (ICP) is used. This reduces fitness error. Based on the matrix developed using ICP, Euler's angle is calculated for the three dimensions namely pitch, yaw and roll. The disadvantage of this system is that Kinect sensor loses its information depth under strong illumination condition. There is no detailed analysis of eye performed here.

As proposed in [2], it is an invasive system. The vehicle is controlled based on distance between two vehicles, current driver's velocity and in front vehicles driver's velocity. In Gaussian Mixture Model (GMM) both static and dynamic properties are detected and the identification rate is 78%. Hence it is better than Helley and optimal velocity model. Here both single and multiple features are detected, but in single feature the better one is accelerator pedal. While comparing with multiple feature both accelerator and brake pedal is better. Here a disadvantage is both pedals cannot be controlled at same time. In order to overcome this drawback, we use the sum of log-likelihood of the force on accelerator and brake pedal and the rate obtained is 73%. In future physical and statistical model has been combined to develop more precise identification.

As suggested in [3], [4] it is used to detect the sleepiness of the driver. Among all physiological parameters EEG signal is better. Previously, normal working of driver is detected. Here two sets of condition were considered-Control session (normal) and Sleepy session (driver did not sleep before 24 hours). For eye blinking monitoring, EOG signals are captured using CCIR camera and in this electrodes are placed below the left eye. While checking the condition, it is observed that both the number and mean (duration) of eye blinks were increased during Sleepy session. Eye blinking level is measured by this technique. In EEG, the bands available are α, β, γ, θ and Δ. By conducting this method, the observed values are changed in α, β, θ, Δ but no changes in γ value. In this α and β values are more important. From this driver's sleepiness level and ability to drive safely were detected. EEG signals have both technological and practical problems so in upcoming work, by using specialized camera eye blinking may be detected.

As contemplated in [5], Head pose estimation using low cost device with DRRF algorithm is detected. In Previous system, only high quality camera has been used for processing, but in this we can use low quality device. Head pose estimation works on frame-by-frame basis and it needs initialization and runs in real time. The DRRF algorithm consists of two steps- Classification and Regression. In Classification, we take a patch and check whether it is head or not. In Regression, after the head is detected, we consider a patch and based on this patch, decision tree is developed. In this tree, for each node, we check criteria. If node satisfies these criteria, it will move along child node or else discard it. This test conducted at node and leads a sample to leaf node and classify it. If classification is positive (above set threshold level) this sample is stored at leaf. Leaves store- ratio of positive patches that reached the node and multi-variate Gaussian distribution computed from the pose parameters of those positive patches. The proposed system does not improve accuracy. In destiny, to improve accuracy, reduce complexity and allow large variations in head rotations.

As advanced in [6], it deals with how orientation selective Gabor filters enhance differences in pose and how different filter orientations are optimal at different poses. It uses PCA (Principal Component Analysis) that provides an identity invariant representation in which similarities can be calculated more robustly. The angular resolution for resolving pose changes was also specified using this method. Recovering facial features from the image captured is a difficult task as the appearance of face changes with variations in head pose, spatial scale, identity and facial expression and illumination conditions. It proposes a system for real time identity independent head pose estimation from a single 2D view. It uses a sensor which is placed at the user's head and it is sensitive to change in the head pose of the user. This sensor also provides pose labels for the face images of the user captured by the camera. The camera is calibrated relative to the transmitter and it provides 3D coordinates and 3D orientation (tilt, yaw, roll) of the sensor. The 3D coordinates of facial features were used to determine the coordinates of 3D points inside the head relative to the sensor's 3D coordinates. Then, the image was cropped by scale factor and re-sampled to a fixed number of pixels.

Gabor filters are particularly appropriate because they incorporate smoothing which is used to reduce sensitivity to spatial misalignment. PCA is used to eliminate identity information even though it maintains pose information. It also has an advantage that similarity measures in low dimensional space are easier to compute than in a high dimensional space. This urges a method for analysis of face similarity distributions under varying head pose. The angular separation was found to be between 10° and 20° approximately. In millennium, the drawback in combining pose-selective filters and PCA may be overwhelmed. Instead of static learning, linear discriminant analysis can be used to find the projection that maximises discrimination between faces at different poses.

III. SYSTEM DESCRIPTION

The system proposed in this model can be implemented in any commercial type of vehicle at a low cost. Two sensors namely heart rate sensor and alcohol sensor and a USB camera should be attached to the vehicle.

The location of USB camera plays a vital role in determining the resolution and accuracy of the image. So, several factors are needed to be considered.

- Minimal Distance between camera and driver's face.
- Not to obstruct driver's field of view.
- To avoid driver's hand movements blocking the line of sight.

The only location which satisfies all these constraints is the car's dashboard. Other locations were neglected because they did not satisfy these criteria.

The alcohol sensor is also placed in the dashboard so that the change of conductivity with respect to driver's alcohol consumption level is effective.

The heart rate sensor used here is a clip type sensor which needs to be held on the driver's fingers.

Fig. 1 shows the overall architecture of the system.

The proposed system detects the head pose of the driver from which driver's inattention (face detection) and drowsiness (eye detection) is determined. Before starting the engine, the heart rate and alcohol values are checked using the values determined by the sensor. If those values are in the specified range, the engine starts. While driving also, these two sensors continuously check these values. If it exceeds the range, the engine will be switched off automatically. The USB camera captures the image. A reference cloud is formed from this image which is processed using a cloud based approach. By using Viola-Jones algorithm, a rectangle is drawn for a specified frame size. An ellipse is drawn on the face after determining the point center using this algorithm. Also, a circle is drawn on the face after determining the radius. From these images, the region of interest is determined. This region of interest is the search space for further images. While comparing with the reference image, if face and eyes are found within that search space, it displays face and eyes are detected. Otherwise it gives a warning alarm for the driver because he may be inattentive (turned left or right) or feeling drowsy (closed the eyes or fell asleep).

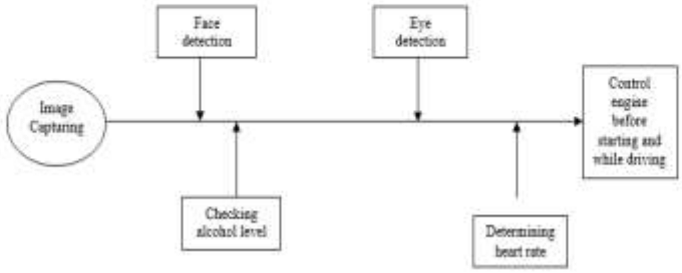

Fig. 1. Overall system view

A. *Heart rate sensor*

The heart rate sensor used here consists of a transmitter and a receiver. The transmitter continuously emits IR rays which are detected by a photo receiver. The driver's finger whose heart rate is needed to be determined is inserted between the transmitter and the receiver. The blood flow in the finger obstructs the IR rays. The amount of IR rays obstructed by the blood flow is directly proportional to the heart rate of the driver. The amount of IR rays obstructed is converted into voltage by the photo receiver. It is then amplified using an op-amp circuit. As this value is negative, a NOT gate can be used.

Before starting the engine, the heart rate value is determined to check whether the driver has any biological problems. The engine starts only if the heart rate value is within the specified range.

We need to check this value continuously, so it is given as an interrupt to the microcontroller.

B. *Alcohol sensor*

The alcohol sensor we use is a semiconductor sensor. It is made up of a sensitive material called SnO_2. It is sensitive to the alcohol concentration. The conductivity of SnO_2 in pure air is zero (acts as an insulator). When the alcohol level varies, there is a change in its conductivity value. The conductivity is directly proportional to the alcohol level. An electromagnetic coil is used to convert this change of conductivity into the gas concentration. From this, we can determine the amount of alcohol consumed.

This is an analog value which needs to be converted into digital for the microcontroller to process it. So we have to give this value to the Analog to digital converter (ADC) of the microcontroller.

Before starting the engine, it is checked whether the driver has consumed alcohol or not. If the alcohol level is lesser than the specified value, then the engine is turned ON. During driving also, this value is checked. The engine is turned OFF automatically, if the alcohol level exceeds the range at any point of time.

C. Face detection and eye detection

The USB camera captures the image of the driver's face before starting the engine. This image is processed and used as a reference image. Here we deploy a cloud based approach for processing the image.

A cloud is formed from the captured image, it is then filtered using a distance filter to remove the background. The obtained image is a RGB image which needs to be converted to Grayscale for easy processing. The face is detected from the image by forming a rectangle of specified dimensions. The rectangle is then cropped to remove the irrelevant features like hair, neck, etc.

To find the region of interest, an ellipse is drawn whose point center is determined using Viola-Jones algorithm[7]. This ellipse represents the face. Next, eyes are found using this algorithm. For this, first we determine the radius and then draw the circle.

This image is used as a reference image. While driving, the USB camera continuously captures the image and compares it with this reference image. The rectangle drawn in both the images should be of same dimensions. Also its center and broader should be matched. Filtering is applied to both these images. These two images are compared.

From this comparison, accurate head pose of the driver is estimated. If the region of interest of both the image matches, it displays face and eyes are detected. This means the driver is attentive, active and facing the road straight. If the region of interest of both the image does not matches, face and eyes will not be detected which means the driver is feeling sleepy (Closing his eyes) or inattentive (turning left or right). If so, an alarm sounds to make the driver attentive. It continues to alarm till he becomes attentive (till the region of interest of both the image matches). As the search space (region of interest) is reduced, processing time is less.

For image processing, a microcontroller with specialized features can be used.

IV. RESULTS

With a view to check the accuracy of the system, we implemented the system using a model. In the model we used two microcontrollers, USB camera, Heart rate sensor, Heart rate circuit, Alcohol sensor, Power supply, Motor, Relay, an IC for relay control and a Buzzer.

Of the two microcontrollers, one is for image processing and the other for controlling motor using heart rate and alcohol sensor values. For image processing, we used ARM 11 Raspberry pi (BCM2835) for its enhanced image processing features. The USB camera is connected to the USB port of the Raspberry pi controller. The output from this controller (from GPIO pin) is given to the second controller.

We used an Arduino UNO (ATMEGA 328) as a second controller. The car key is given as an input to its IO port. The output of the heart rate circuit should be given as an interrupt so it is given to the IO port. The alcohol sensor value is an analog value. For the microcontroller to process this value, it should be converted into digital. So, the output of alcohol sensor is given to the analog to digital converter of the Arduino UNO controller.

The buzzer is the output which is connected to its IO port. A motor is used here instead of the car engine. A relay is used in this motor. To control this relay an IC called ULN2003A is used. This IC is also connected to the IO port of the Arduino UNO controller.

We used an alcohol sensor of type MQ4. It has a built-in circuit with sensitive material SnO_2 in which the conductivity changes. It also has an electro-circuit used to convert change of conductivity to corresponding output signal of gas concentration. This sensor is an advanced sensor with long life, low cost, simple drive circuit especially good sensitivity to combustible gas and natural gas in wide range.

For determining heart rate, we used a clip type sensor which is inserted in the driver's finger. This sensor determines the heart rate value in a digital form. It is connected to a heart rate circuit. The heart rate circuit consists of two operational amplifiers to boost up this value. It also contains resistors and capacitors biasing. Each of operational amplifiers consists of a trimmer circuit which has a capacitor connected in parallel with a resistor. This trimmer circuit is given as a feedback. A NOT gate is used to provide positive value. Two zener diodes and a resistor are used to avoid loading problems. An LED is used for indication purpose (optional).

In this system, we used two values of power supply namely 5V and 12V. For ULN2003A, we used 12V supply. In all the other places, 5V supply is used. The power supply circuit consists of a step down transformer to reduce the 230V AC to 12V AC. The primary of the step down transformer is connected to the AC main and the secondary is connected to a bridge rectifier. The bridge rectifier converts the AC to DC. Ripples present, if any, is removed using two capacitors connected in parallel.

The output is given to a voltage regulator to get a regulated DC output. A voltage regulator IC 7812 is used to get a steady 12V DC supply. Another voltage regulator IC 7805 is used to get a regulated DC supply of 5V.

V. CONCLUSION AND FUTURE WORK

With the proposed system, the head pose of the driver is estimated accurately by using cloud based approach. It also provides enhanced face detection and eye detection. The system provides information about the driver's biological conditions and alcohol consumption level. The test results provided the proof for performance and accuracy improvement.

All these advanced features were implemented in a extremely low cost of around Rs.10000/- , considerably lower than other systems available, which involves high expenses in thousands of dollars. Also the previously designed systems were not implemented yet. This projected system is very easy to implement in any type of vehicle especially Indian cars.

It is important to note that this system showed high performance at a limited cost, but it has some demerits that should be stated. No sensors are used for image processing which may have an effect on the resolution of the image. It could be overcome by using a high definition (HD) camera.

Forthcoming work may concentrate on a more specific and detailed analysis of eye. The expectation is to concentrate on determining the amount of time the eyes are closed. This helps in providing accurate eye gaze estimation.

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