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Intelli-Car with Auto-Pilot for Accident Prevention

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Abstract: ***Temporary auto pilot mode can help in saving lives, especially those of drivers. Using sensors, one can continuously monitor a driver's biological attributes, collect and process the obtained biological data with algorithm to get the physical status of the driver and decide whether he is fit to drive. In this work, we propose an intelli-car with auto-pilot mode. In intelli-car, if the driver found unfit to drive, the car takes the responsibility by switching to a temporary auto pilot mode with the support of various sensors and algorithms. In addition, it will find a safer way to stop while sending its location along with the data obtained using Global Positioning System and Global System for Mobile Communication modules to the concerned authorities. A hospital nearby to that incident will be notified when the driver's biological condition is found unstable.***

Keywords: ***Car Control System, Fuzzy Bayesian Network, Internet-of-Things, Self-localisation and Map Matching.***

I. INTRODUCTION

Road safety is one of the important health concerns. With increasing population, the number of road accidents is also increasing every year. Most of these accidents take place when the driver is not in a proper condition to drive. This happens when the driver is drunk or drowsy or his medical condition is worse. When the issue is his medical condition, his life is at risk. No one will even know what has happened, if the road is a highway or a road in a deserted area. This puts the driver's life at stake. In such situations, the car goes out of control and results in a terrible accident, leaving their family in endless trauma and creating havoc on the road. The model proposed in this paper solves this problem. The driver is continuously monitored and when any abnormal situation is detected, the car gets into temporary auto pilot mode and stops nearby without causing any trouble on the road.

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If the problem is just that the driver is drunk or is drowsy and doesn't have a serious medical issue, then a message, with the location along with biological data obtained, is sent to the concerned authority. If the problem is driver's medical condition, which is serious, the same message will also be sent to a nearby hospital.

Though there are many existing accident prevention methods, none of them has this temporary auto pilot mode that helps in solving the problem without disturbing its surroundings. In this paper, we have considered the five most important factors and their contribution to the probability of an accident rather than depending on a single factor. More importantly, these factors can be measured without disturbing the driver.

II. LITERATURE REVIEW

In [1], the authors propose to place a MQ-3 sensor in the car, on steering wheel, to continuously monitor BAC (Blood Alcohol Concentration) in the driver's exhalation and the controller locks the ignition, if the alcohol level detected crosses the threshold limit that was defined. And in [2], the seat belt system gets controlled by the alcohol content and that seat belt system controls the engine of the car. In that case, the reaction of turning off the ignition may lead the drunk driver to feel more anxious and can lead to immediate accident. This locking of ignition will prohibit the car from accelerating further, if alcohol is detected while driving, but what if the driver continues to drive without accelerating further or he isn't able to park properly as he is stuck in traffic? Moreover, the traffic can collide with the car and can cause many lives causalities. If this problem is not addressed, the car stops in the middle of the road and may result in an accident.

Pertaining to drowsiness detection, there are many proposed methods such as based on physiological features as in [3], where eye blinking and head movements are considered ; by Image Processing as in [4], where images are analysed using neural networks; based on the driving pattern of driver as in [5], where pattern of pedal controlling based on the outside view is observed; based on biological features as in [6], where variations in heart rate are monitored; based on Blood Alcohol Concentration (BAC) as in [7], where driver's perspiration is analysed for BAC, as in [1] and [2], where alcohol in breath is analysed using a MQ-3 sensor.

In [7], the authors propose to mount the infrared sensors and heaters on steering wheel. The purpose of heaters is to warm the palms of driver and collect sweat in order to measure the alcohol content and determine whether the driver is drunk.

This idea sounds less effective when it comes to determine that driver is drunk or not, because the amount of sweat needed is 2-3 ml to detect and it can take time because palms are not steady, or leather cover is on steering wheel or driver is wearing gloves.

Moreover, displaying message to driver who is drunk with a danger signal will only make the drunk driver uncomfortable and more anxious that can add up to odds of accident.

In [8] the authors propose to illuminate the driver's eyes with infrared sensor CNY 70, however, it is not effective as the eyes are not stable throughout and in the long journey exposing infrared rays directly on eyes may cause discomfort.

III. PROPOSED SYSTEM

The proposed system helps to park car in a safer location when any abnormality is sensed in the driver's biological condition while driving. First, we must collect the data related to biological status of the driver. To achieve this, we need different sensors collecting data related to different biological attributes of the driver's body. And then process this data with algorithm to detect trouble and do the needful. We must follow these steps:

- Biological data collection
- Data Procession and Detection

To enable a car to drive on its own, we should incorporate the following intelligent methods into it.

- Self-localisation and Map matching
- Navigation system
- Perception of Environment
- Realisation of Motion (Direction and Speed)
- Car Control System

When the car is in auto pilot mode, the car gradually decreases its speed using Car Control System and then chooses a destination to safely stop the car. This destination point is determined by the algorithm which uses the self-localisation and map matching techniques along with the data of the road coordinates obtained from the API of Google maps. This destination point is 200 meters away and is the left most end point of the road.

Once the point is set, the algorithm now verifies whether the point is a feasible destination to stop the car. This checking part makes sure by using the map's data that this point is not in or around the junction of lanes or a point where there is a turn. If the point is found not feasible, the distance is increased to 250 meters and again the process is repeated until a feasible point is found. If the road ends nearby and there is a turn, the car chooses the point accordingly after the turn on the road.

Once this destination is set, the navigation system helps to decide the path to travel. Based on the perception of the speed, the direction and the environment around the car the Car Control System decides the necessary control mechanism, the steps to be taken to reach the destination safely. This process continues till the destination is reached. If there is any obstacle detected on the destination point, the destination point gets changed to the point 5 meters away from the decided point.

Once the task gets completed, it checks the reason for the car to be in this mode. If it is just because the driver is drunk or drowsy and doesn't have a serious medical issue, then a message of the location along with the reason will be sent to the concerned authority. If it is a serious medical issue, a message with location and biological data along with location will be sent to a nearby hospital.

Biological Data Collection

The proposed system comprises of several different sensor modules to monitor the real time activity of driver. We extract facial features using facial features module, a camera module, placed facing the driver's face in the car. Then spectral analysis is done using the bio-signal spectral module which includes Photoplethysmography (PPG) and Electrocardiography (ECG) sensors attached to the steering wheel [9]. PPG gives the perfusion and changes occurring in the volume of blood in skin whereas ECG monitors the contractions of heart. Spectral analysis of these two signals gives the Heart Rate, the interval between two adjacent peaks of ECG signal, and the Blood Pressure (BP). The BP can be expressed as

$$BP = (a * PP) - b$$

where PP is the duration between the crest and its immediate trough of the PPG signal, and a and b are constants that are dependent on the method of calibration.

Temperature is obtained by temperature sensor that is put on steering of the car. Speed of the vehicle is obtained using Global Positioning System (GPS), further explanation is found in [10]. Raspberry Pi collects and monitors the data from these sensor modules and acts accordingly. Facial image obtained is transformed to a binary image based on the HSV index (Hue-Saturation-Value). Morphological operations are further performed on the image to obtain the exact region, these Image processing operations and algorithms applied checks the vertical line of eyes. Normally, eyes are in vertical line otherwise, indicating unstable eye position due to some unstable posture of driver [9]. This extracted feature observed over time further helps to determine the PERcentage of eye CLOSure (PERCLOS) [11], measure of eyelid closure as a percentage in a certain time, over pupil, which is a measure of drooping eyes. The longer the closure, the drowsier the person will be [9].

The fatigue level of the driver is determined by the extraction algorithm which is carried on the data collected form these sensor modules. Other modules which include MQ3 Alcohol sensor, GPS, and Global System for Mobile Communication (GSM), will help in detecting when the driver gets drunk and notifying their relatives and friends.

Data Procession and Detection

All the data obtained is fed to a network, Fuzzy Bayesian. In Fuzzy Bayesian, a type of Bayesian network, the nodes are variables in fuzzy states, and these nodes have probability functions assigned to each of them. These functions take few values as input for their respective assigned variables and calculate the probability. The conditional dependencies among these nodes are displayed as links of a directed acyclic graph in a Bayesian network. Conditional Probability Table is used to get these dependency values. To represent this network, we should mention the nodes and the features representing these nodes and arrange their initial states [9].

Our final aim is getting the probability of fatigue. And all the variables contributing to this are considered as nodes.

Here we have five factors, thus five nodes: Heart rate, PERCLOS, Blood pressure, Speed and Temperature.
Depending on the degree of their contribution to fatigue, their respective probability functions are assigned using product t-norm, denoted as t_p [12]. The fatigue can be obtained as follows,

$$fatigue = \left(\sum_{1}^{p=L} \bar{t}_p \times \overline{cpt}_p \, , \sum_{1}^{p=L} t_p \times cpt_p \right)$$

where L is number of total possible combinations, cpt_p is the conditional probability table, and $\overline{cpt}_p$ and $\bar{t}_p$ are their respective false values. Depending on the value of the probability, say if the value is above 0.5, then the car gets into temporary auto pilot mode. Here an assumption is made that the fuzzy state will either be true or false.

Self-localisation and Map matching

In general, GPS is popularly used in navigation systems to achieve self-localisation, i.e. enabling the car to know its own position by using GPS module. We use this data to decide in which link (route) the car is travelling and lay the vehicle on the network of the roads in our map, this is called map matching. But, the noise signals, inaccuracies in map and instruments used to obtain this data distorts the data and results in providing a deviated value which is highly undesirable. To avoid this Quddus algorithm is used to properly relate the positioning to the links on the map. The step-by-step procedure of an efficient method based on Quddus algorithm [13] is as follows:

Step I: Get the GPS point as ‘A’.
Step II: Locate the closest node to this point as ‘B’.
Step III: Select all the links passing through ‘B’ or repeat from I.
Step IV: Use Quddus algorithm to get the proper link ‘C’.
Step V: Match ‘A’ and ‘B’ to the link obtained ‘C’.
Step VI: Get the car’s position on the link ‘C’ for both ‘A’ and ‘B’ using Quddus formula.
Step VII: Get the next GPS point as ‘D’, if the difference between heading of ‘A’ and ‘D’ is more than 45° (this shows car has changed its direction), repeat from I; if not then get ‘E’.
Step VIII: ‘E’ is the length of the present link added to half the width of the previous link in which the car has travelled.
Step IX: Calculate the distance travelled between the nodes (junctions), the current and the previous as ‘F’.
Step X: If ‘E’ is greater than ‘F’, then car is in the same direction or else car has changed its direction. The new edges get selected accordingly.

Navigation system and perception of environment

As here the car is travelling only a shorter distance, it is enough if we go with basic navigation algorithms. Dijkstra algorithm is one of the most used algorithms [14]. This determines the shortest path to reach the destination by selecting the node closer to the present node continuously by calculating the distances between all the available next nodes and our present node. This sets the path for the vehicle. Now the map and path are clear. Now the car should drive on this path observing the surroundings that is with the perception of the environment. This perception includes, detecting lanes, roads, pedestrians and other vehicles. Externally placed Light Detection and Ranging (LiDAR), Vision and Radar sensors will help to monitor the surroundings.
Radar can detect object, its range, velocity or angle by using radio waves whereas LiDAR uses laser light and gives a wider view and accurate measurements. Vision sensor measures the intensity of light it provides with rich dataset and even wider view [15].

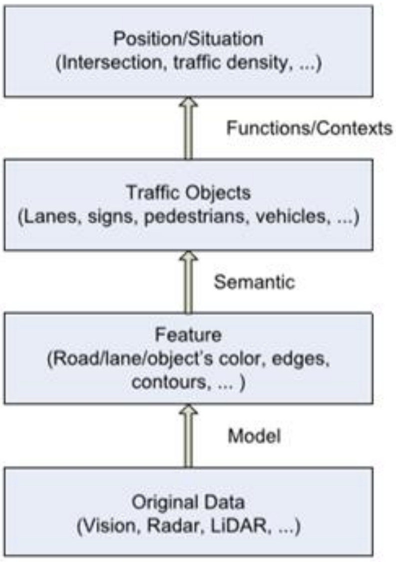

Fig. 1. Flowchart of Perception of Environment [15].

As shown in Fig. 1 and Fig. 2 this collected vehicle’s data gets processed and the features are extracted using computer vision algorithms, they are further processed to detect defined objects, when detected their respective function gets calculated and the data is sent to Car Control System.

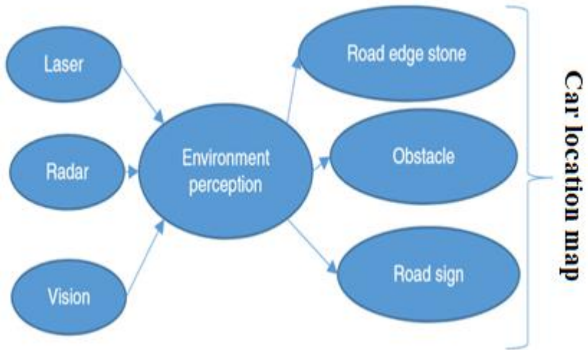

Fig. 2. Block diagram of Perception of Environment [16].

Realisation of Motion (Direction and Speed) and Car Control System

All the collected vehicle’s data and the analysed results are collectively fed to Car Control algorithms continuously as shown in Fig. 3, GPS is used to get the speed and direction of the vehicle [10]. In general, Proportional-Integral-Derivative (PID) algorithm is used in Car Control System.

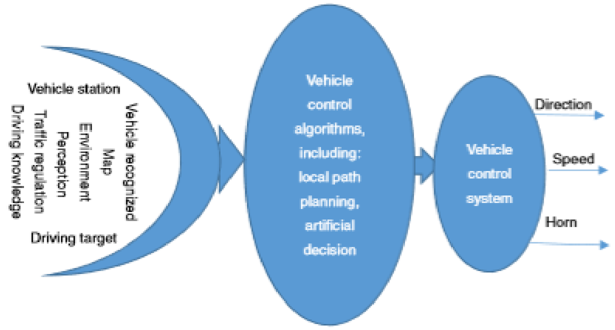

Fig. 3. Car Control Mechanism [16].

PID Algorithm

In PID Algorithm, as shown in Fig. 4, an expired input signal r(t) along with e(t) feedback signal (error signal), is subjected to proportion, differentiation and intergration separately and the results from all these operatoins is combined to get control signal u(t) and c(t) the current output actual signal. The difference between c(t) and u(t) gives e(t), this e(t) helps in adjusting the target [16].

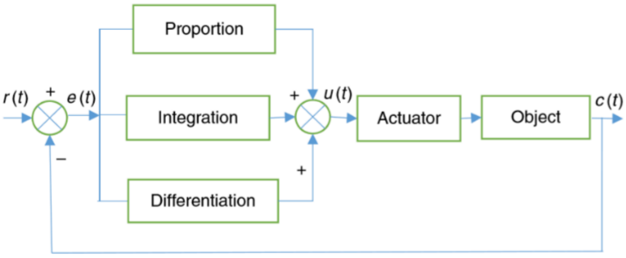

Fig. 4. PID Algorithm [16].

IV. CONCLUSION

The system proposed in this paper is capable of monitoring a driver, detecting abnormalities in driver's biological attributes that make him unfit to drive, finding a safer way to park without disturbing the environment around, and sending its location along with the biological data collected to required authorities. If the driver's health is found unstable, the proposed system sends this data along with location to a nearby hospital. This system using well established algorithms could be a life saver. The temporary auto pilot mode is used only under critical circumstances and for a shorter distance; and thus, is acceptable and reliable.

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