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A Distinctive Approach on Safe Driving through Interactive and Behavioral Analysis

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Abstract— As the automobile industry is growing rapidly, every individual has an urge to own the luxurious cars either for comfort or the number of safety features it may provide say the Advanced Driver Assistance System. However, due to the devices, sensors and monitoring systems, it includes such safety features limited to the higher classes of the society. But, safe driving is a requirement for the society as a whole in a holistic understanding. With the growing need for transportation, the life style of human race has transformed a lot. People focus on reaching their destination in minimal time ignoring the safety measures in many instances. This paper elucidates about a mobile application which helps the user in safe driving on different parameters by using smartphone sensors like the Accelerometer and its related technology.

Keywords— Safe Driving, Accelerometer, SmartPhone, Mobile Applications

I. INTRODUCTION

This paper majorly focuses on detecting safe lane change, acceleration/deceleration, studying road anomalies and detecting accidents followed by notifying the relatives of the driver. Considering the cost as a major factor, phone's accelerometer and GPS (Global Positioning System) sensor has been used instead of external sensors. The accelerometer consists of three axes namely the X-axis, Y-axis and Z-axis. The Y-Axis is used to study the acceleration and deceleration. The graph generated by the accelerometer helps to know if it is safe/unsafe. The time duration and graph pattern are taken into consideration. In case of unsafe behaviour the driver is notified immediately. The X-axis is used to analyse the lane change. The most difficult module is detection of potholes/speed bumps. The variation in graph varies from vehicle to vehicle as each automobile is designed in different ways. The accelerometers when used in cars show drastic change in graph whenever speed bump/pothole occurs. On the other hand manufacturers have designed better cars which eliminate the jerk and it feels as if the car is on a smooth road. This makes it difficult for the accelerometer to detect road anomalies. The accelerometer's Z-axis helps to detect road anomalies. At high speeds the bump can be easily detected using the sudden spike formed on the Z-axis. At lower speeds the X-axis is used in combination with the Z-axis. When threshold value is crossed in both axes a bump can be assumed. Once the bump is detected, the location is obtained from the GPS sensors and the accelerometer's reading is considered as a segment and marked onto the maps. At the time of accident the accelerometer detects the accident and a message is sent to the relatives which includes the location obtained from the GPS sensors [11]. Building an application for mobile phones which help to ensure driver's safety by analysing their behaviour and notifying them during unsafe scenarios [10]. Figure 1. describes about technology perspective of user/ driver using a smart phone and the data being collected into a data analytical machine [21] for management and improvement.

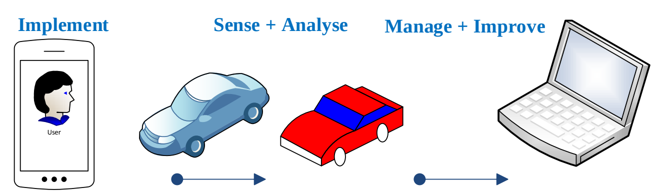

Figure 1. The Concept of Velocity with Collision Free Maps

This can be used not only to detect the left and right shifts but also the number of shifts within a given time can be recorded. The time duration involved in the shifts helps to differentiate between safe and unsafe lane changes. In case of unsafe change the driver is notifies immediately. The below is ordered as follows. Section II elicits the literature part on the related work. This is followed by design of the proposed application in Section III. The results and discussion is described in Section IV.

II. Related Work

The below content elicits about the related literature study on safe driving. The systems of automation used earlier in the Automated Cruise Control - ACC was a primitive one where the inter-vehicle distance was very large. But in today's environment the same is unknown and keeps changing which is not normal, also to add, to achieve a better fuel economy and a higher road capacity it is desired to have reduced the inter-vehicle distance to a safe limit. So, to achieve this vehicle manufacturers are now having more complex functions and communication between vehicles have increased opportunities. This has now been mainly seen in German Manufacturer Mercedes-Benz where the use of connected cars has been used to a very big extent.

The use of adaptive cruise control to find control the inter-vehicle distance has to be made to the best, so it is required to evaluate and verify the system performance that is making a system that meets documented requirements or specifications. To verify and test such systems requires high amount of experimental work, both numerical simulations and real world tests. Although, extensive simulations and practical experiments can be used to verify system reliability and performance in different situations, any analysis based on simulation or practical experiments may not capture all the situations the system is exposed to [1]. In order to improve the efficiency of system verification, mathematical tools can be used like Background and Preliminaries on Reachability Analysis and Invariant Set Theory. There is a concept which deals on controlling an autonomous vehicle based on the velocity input provided by the driver. The major constraints include avoiding of static and dynamic obstacles and real-time computation.

The system works by exchange of information among vehicles. Once the location, acceleration and direction of vehicle is obtained the data is used to evaluate the collision condition. If this is satisfied the red signal is generated. Also, it is necessary to determine the data well in advance to avoid collision [3]. Therefore, the problem of collisions at intersections can be avoided using this approach. The rate of road accidents has always been an increasing number owing to many reasons which include rash driving, bad road conditions, carelessness and the like. A technique was proposed [4] that reduces the road accidents by giving the driver prior details about the routes he is about to traverse. This proposed application 'RoadEye', is aimed at portable devices which could be easily placed on the dashboard. RoadEye is capable of giving information such as presence of potholes, speed bumps and dynamic events which include accidents, road block and the like. Not every user requires minute details about his route. Therefore, this application is made personalized so that users can retrieve only the preferred data. The system first collects the data and categorizes based on the region and the type of event. It also ranks them based on importance. The list of events are maintained in the ascending order of their rankings using linked lists for each region. The coarse grain information such as number of speed bumps could be obtained from the linked lists. On the other hand retrieving detailed information involves accessing of database and hence consumes more time.

Information representation is as follows. The application can be made personalized using the login feature. Thereby result of every user is distinguished. The users are also given the freedom to input data whenever they come across any unusual road conditions. This data collected is represented in the form of a tree. Root node represents a city/village/town. The first level stands for each region in the city. These nodes are sub divided to represent the streets covered by a particular region. Basically, every node is divided to represent the road conditions. The nodes contain description of the problem, the frequency and pointer to next nodes. The leaf nodes point to the database which contains detailed information about the events. Insertion takes place only after top down traversal of the tree from the specific node. In case of the events being resolved by the concerned person, the corresponding node needs to be deleted and its frequency gets updated. This is achieved in a simple manner as the data structure used is not very complicated.

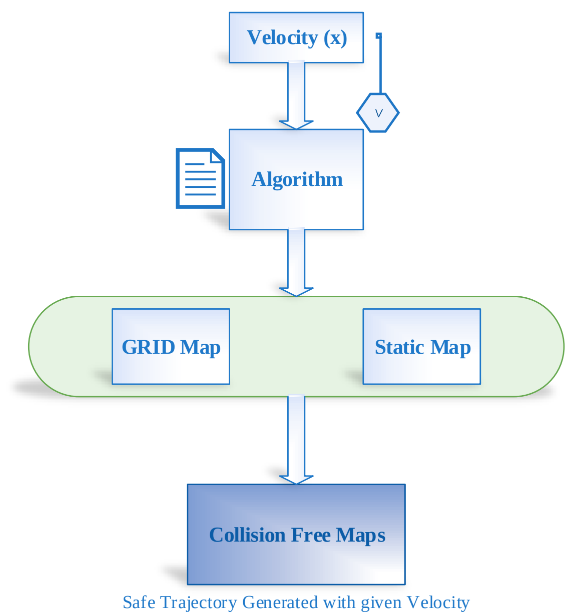

Figure 2. The Concept of Velocity with Collision Free Maps

The above Figure 2. description involves two steps:

1. Taking velocity input and

2. Generating a collision-free map for the given velocity.

The velocity input for a given time is taken and it is converted into a grid map onto the static map. Based on the velocity, the system studies the neighbouring obstacles and plots points on the map which are collision free for a given time instance. This points are generated dynamically and acts as a guidance for the moving vehicle. Considering the velocity of other objects the grid map changes in order to avoid colliding into them. This grid map ensures safe driving by providing a trajectory path for the vehicle to move safely. Therefore, with the idea of shared control collision free motion of the vehicle can be achieved. As the system makes use of centralized and distributed algorithm, computational complexity is reduced [2]. This further optimizes the system providing efficient outputs in a short time. In urban cities, road congestions on a busy road are controlled by the traffic signals. Traffic signals at every intersection helps to have a systematic flow and avoid accidents. These signals are usually installed at major junctions and not across every intersection. The proposed idea here is to develop an application for mobile devices which guides the driver at times of cross overs. The application is more like a virtual signal on the device. It studies the surrounding environment and signals the driver red or green at intersections. These signals are determined based on the location of the vehicle and the neighbouring vehicles. This application studies the position of the vehicle at intersections and if other vehicles are approaching in the direction of motion then the driver is warned. This virtual signal works on demand. It also studies the acceleration of the vehicle and signals accordingly.

Curb detection is important when it comes to achieving safe driving through urban places. The 2D LIDAR made use of the depth factor in order to prevent accidents but this paper proposes the usage of 3D LIDAR which provides a dense point that helps to detect curbs at a larger extent [5].

Most of the curd detection algorithms uses stereo cameras. A few make use of images to calculate depth. But major drawback is the computational overhead. By using LIDAR sensors this can be avoided as the depth can be directly determined from the dense points. Sometimes the depth is confused with the depth of other obstacles like a moving vehicle. This leads to misinterpretation of data. This can be avoided by performing a convolution on the data obtained. Thus with the use of multi layered sensors we can successfully detect curbs and filters are used to differentiate other obstacles. Monte Carlo localization algorithm is used to localize the vehicle even when the GPS range is weak. This makes the system efficient and convenient for the users. The automobile industry is in the midst of making a transformation from the fuel driven vehicles to E-vehicles or solar vehicles, owing to the shortage of fossil based fuels. Earlier systems were developed to warn the driver's whenever they reach a threshold level of battery. Later a feature was added to indicate the distance that could be travelled considering the present charge state of the battery. This information does not resolve the problem of critical situations wherein the driver runs out of battery completely.

This paper published which has the details provided about the charging stations nearby so that the driver never runs out of battery [6]. The working of the system is similar to previous system. The driver sets his destination and the software determines whether it is reachable or not considering the battery level. In case of low battery, it guides the driver to the nearest charging station. Advantages of the proposed existing system:

- Traditional systems restricted the journey to one particular destination. On the contrary this proposed system gives the freedom to the driver to drive anywhere within the chargeable region without running out of battery. Thereby giving a broader perspective to the drivers.
- This system also takes into consideration the battery level of the vehicle on reaching the end point. This ensures that the vehicle is never out of battery and the driver is always safe to drive back.
- The driver's path is not restricted by the available stations. Instead he gets to choose his path within a given range. This flexibility was not provided by traditional systems.

In today's world, technology has made everything so much easier for common man. May it be industrial, household or governmental, technology rules the world in every aspect. Taking into account these massive changes in mankind, it is always a boon for the disabled if technology could make their lives independent [7]. A concept was published taking into consideration the inabilities of the disabled and focuses on building a vehicle based on the Brain Computer Interface which uses the concept of controlling devices with the cognitive thought. CyberCars are vehicles which are capable of navigating on their own. They are built with an intention to travel safely in the dynamic environment of the urban city. The challenging part here is to build a CyberCar capable of planning the routes and also permit communication with other automobiles to prevent collision at intersections majorly.

Considering the dynamic environment, the real time constraint forms a major role in decision making. Secondly, the concept of inter communication has to be implemented for safe motion of the cars. There are two basic approaches to overcome the real time constraint. First, the reactive approach consists of studying the local environment and choosing of appropriate speed velocity to ensure safety. The second approach is called the deliberative approach. In this the route towards the goal is determined before the navigation begins. But these are restricted to smaller dimensions. Both approaches do not focus on time constraint. The "Partial Motion Planner" on the other hand provides a bounded time interval at the cost of completeness of the solution. In PMP, the trajectory of a vehicle based on the safe states we acquire after studying the future trajectories. A continuous safe track is generated by combining the individual safe states [8].

Communication among vehicles is established using network communication. In this each vehicle gets to choose their immediate neighbours and exchange of messages takes place among this circle only. In this manner every vehicle is connected to one another in 1 hop or more. Thereby forming a chain of communication. The problem arises when a vehicle disappears from the network. At this point a message is broadcast to connect with the next immediate neighbour.

In today's world transportation and its safety has become a priority for every individual. Implementing smart tools to assist the driver is not exactly the area to be focused. The cost of these intelligent tools is a major concern for most manufacturers. This technique [9] focuses on assistance of a RoboCar based on compact cameras mounted on the car which provides following features.

- It helps to detect the white line on roads for safe driving.
- It helps to read the sign boards with the help of previously recorded images.
- It is set to choose the best route based on the data provided by maps.
- It also avoids obstacles on its way towards the goal.

III. DESIGN OF THE APPLICATION

Figure 2. represents the sequence diagram for the proposed idea in Unified Modelling Language UML [15]. It consists of five objects – Driver, mobile device, google maps interface, accelerometer and the database. The sequence of actions are as follows:

a. The driver opens the Safe Driving Application.
b. The mobile device establishes a connection with Google maps retrieving the current location.
c. Google maps interface demands for a destination.
d. The user receives the request via the interface.
e. The user is allowed to enter the destination as textbox input provided on Google maps interface.
f. The destination is located on the map using a marker.
g. The route from current location to the destination provided is generated.
h. The map is displayed on the mobile device.
i. Whenever the vehicle goes on a speed bump/ pothole an event is triggered.
j. The accelerometer detects the change in motion generating values corresponding to the changes.
k. The X-axis and Z-axis co-ordinates are retrieved.
l. Distinguish between speed bump and potholes.
m. Once the anomaly is detected the co-ordinate points corresponding to the location are fed into the database.
n. If the driver goes on the same road anytime in future, then the database content is used to retrieve the co-ordinates depending on a radial parameter and warn the driver.

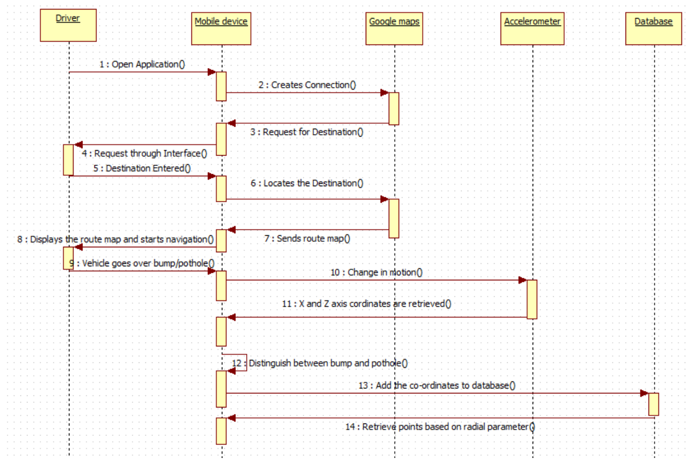

Figure 3. The UML Sequence diagram for the proposed design

IV. RESULTS AND DISCUSSION

The below Figure 3. shows the screen shots of the speed bumps and potholes where data retrieved from the database are displayed in the form of yellow markers to the user. The green arrow indicates the "current" location of the user.

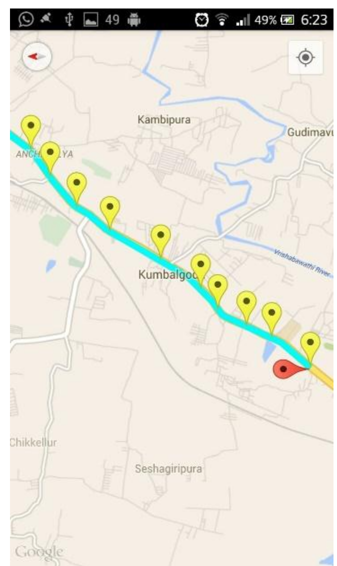

Figure 4. User's interface in the mobile application.

When the pothole/bump is detected by the accelerometer, the location (latitude and longitude) is obtained from GPS and saved to database. The database is implemented with the help of Django [12] and Heroku [13]. Django is a high-level Python Web framework. Django consist the tables for storing data. The language Python is used to query database. Python [14] is a widely used general purpose programming language. Its syntax helps the programmer to express the concept in fewer lines of code. Python supports multiple programming paradigms also. It supports object oriented, imperative and procedure oriented paradigms [18, 19].

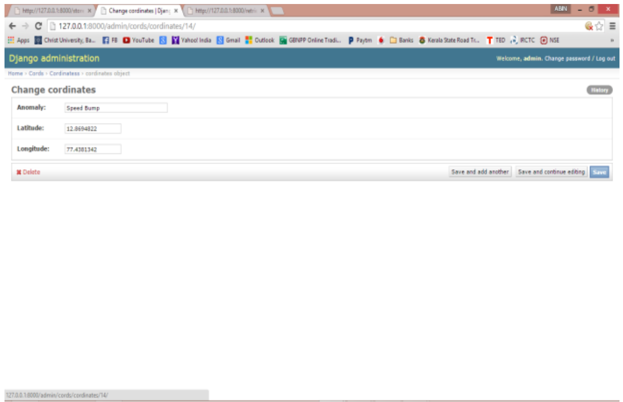

Figure 5. Coordinates specification with longitude and latitude

Heroku is the cloud platform used. It is a cloud platform as a service. The programmer does not have to worry about infrastructure and how it is been implemented. So he can focus more on the application. Server management is a difficult task which require hard work and prior experience. Heroku will help to get free of establishing and maintaining a server. It will reduce cost and workload.

V. CONCLUSION AND FUTURE SCOPE

The accelerometer and GPS [16,17] sensors of the smartphone are used effectively. Using X, Y, Z – axis of accelerometer the motion of the car is detected and speech warning messages are given to the driver in unsafe scenarios with respect to their behaviour [20]. Road anomalies are identified and distinguished to potholes and bumps. Identified bumps and potholes are pinned to Google maps using markers. A database is designed to store the values of latitude, longitude, bump/pothole which is implemented by Django web framework and it resides in Heroku Server. This concept can be further developed and improvised in a broader aspect as well like supporting Governments with the road anomalies data which can be used for maintenance of roads and Taxi operators can find driver behaviour on road with respect to driving standards. The scope of this concept can fit into specific scenarios as this can be implemented and used almost free of cost.

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