Cloud Based Intelligent Transportation System for Collision Avoidance

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***Abstract*— The increasing need for mobility has brought about significant changes in transportation infrastructure. Inefficiencies cause enormous losses of time, decrease in the level of safety for both vehicles and pedestrians, high pollution, degradation of quality of life. Thus Intelligent Transportation Systems (ITS) might be the key to achieve solutions that help in reducing these problems significantly. In this project we will propose to serve the speed based lane changing, collision avoidance and Time of Arrival (ToA) based localization in Vehicular Ad-hoc Networks (VANETs). As GPS requires clear line-of-sight for accurate services of positioning and localization applications, we designed a Time of Arrival (ToA) based algorithm for areas where strong GPS signals are unavailable. Collision avoidance using automatic braking and camera-based surveillance are a few other applications that we addressed.**

Keywords—Raspberry pi zero, Pi camera, LCD, Ultrasonic sensor, L293D motor driven IC

I. INTRODUCTION

Vehicles nowadays come with highly intelligent and sophisticated systems to serve the real-time safety applications. The increase in requirement and finding in the Intelligent Transportation Systems (ITS) stream has led to a great demand for real-time applications to serve the public safety and reduce the potential hazards from these vehicles. Vehicular Ad-Hoc Network (VANET) has a key role to play in this. The connected vehicular network stream is a rapidly growing field for research and development of various real-time applications. Efficient traffic management is becoming of great interest today as traffic congestion becomes a more and more severe problem.

Throughout the world millions of hours and gallons of fuel are wasted everyday by vehicles stuck in traffic. Therefore, congested flow conditions have a negative impact on the economy, health, and environment. The improvement of traffic flow and congestion reduction can be achieved by means of Intelligent Transportation Systems (ITS). In general, the aim of ITS is to capture, evaluate and disseminate traffic-related information. Conventional technologies (e.g. Traffic Management Center (TMC) and Road Data Services (RDS)) in ITS offer very restricted bandwidth therefore, traffic information has to be limited in details. With emerging Vehicular Ad-Hoc Networks (VANETs), plenty of applications have been created for vehicles on the roads. Two main communication types are presented in ad-hoc domain of VANETs: communication among nearby vehicles called Vehicle-to-Vehicle (V2V) and communication between vehicles and roadside infrastructure that called Vehicle-to-Infrastructure (V2I).

The vehicles on highway will move at high speed. The speed of the vehicles which is in the range of 80 to 120 kmph should apply brakes to get in to complete stop. The deceleration of the vehicles more than 10 meter per sec. square will cause the hard brake whose impact is equal to accidents. Therefore the vehicle should apply brake with constant deceleration below 10 m/s2. The automatic braking system will automate the braking system, the vehicle automatically apply brake if driver did not react with in safe time. The automatic emergency braking system will reduce accidents due to sudden brake of leading vehicle by sending emergency braking messages to all vehicles which are being affected by particular hard brake.

Video surveillance is a rapidly growing field with various applications that include traffic monitoring and analysis, gesture recognization in human machine interface and tracking. In this application detection of moving object from the video sequence is a very challenging and critical task. Obtaining the traffic information like the vehicle volume count, traffic flow and traffic events are the significant task in traffic analysis and traffic management. Visual traffic surveillance which make use of computer vision models can be controlled, preset and cost effective. Formally video based traffic surveillance was only noticing the movement of vehicles and it is action to evade signals and speed violations.

A. Proposed System Architecture

The flow network of the system is as follows**:** The vehicles moving in a segment are connected to each other and exchange important information (viz., location, speed, etc.)

among themselves. This information is further passed on to the Road Side Units (RSU) that are installed at regular intervals of distance on the roads. The road side unit securely pass on the data to the central server supported by the cloud computing service. The central cloud server monitors and segregates this data so that it can be accessed by the smart traffic monitoring system and corresponding mobile devices that officers are equipped with for the further use.

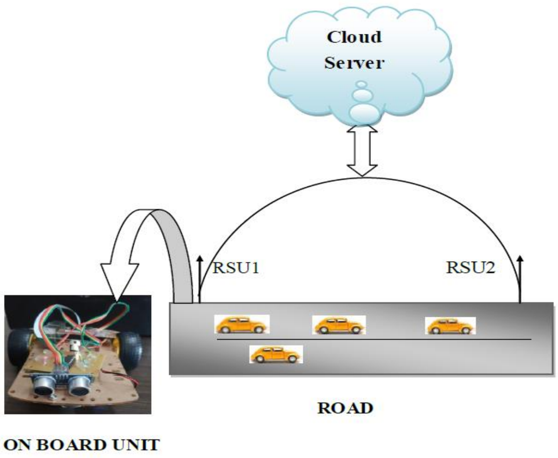

Fig. 1: Proposed system architecture

II. LITERATURE SURVEY

Ajaykumar N, et.al, implemented Vehicular Ad-hoc Networks (VANETs) for safe vehicular transportation based on communication between vehicles using ad-hoc networks. The vehicles with ad-hoc network will connect to the other vehicle with VANET technology when they fall in to range of ad-hoc networks each other. The information such as speed of the vehicle, GPS co-ordinates of vehicle, direction of vehicle, and lane in which vehicle is moving is shared with each other. This work proposes a simulation study of an Emergency Braking (EB) application accomplished by car dynamics and drivers' behaviour models using Network Simulator (NS3).

Rasheed Hussain, et.al, proposes a new VANET-cloud service called VWaaS (Vehicle Witnesses As A Service) in which vehicles moving on the road serve as anonymous witnesses of designated events such as a terrorist attack or a deadly accident. When confronted the events, a group of vehicles with mounted cameras collaborate with roadside stationary cameras to take pictures of the Site Of Interest (SoI) around them, and send the pictures to the cloud infrastructure anonymously. The pictures are sent to the cloud in a way that the privacy of the senders can be protected, and kept for forensic evidences to the law enforcement agencies for investigation.

Ravindra S, et.al, [10] explain the location information of a node deployed in Wireless Sensor Networks (WSN), using Time Of Arrival (TOA) measurements in Line Of Sight (LOS) environment. They estimate the position of an unknown source node using localization based on linear approach on a single simulation platform. The commonly used approaches for measuring position estimate in WSN are Time Of Arrival (TOA), Time Difference Of Arrival (TDOA), Received Signal Strength (RSS) and Angle Of Arrival (AOA), Direction Of Arrival (DOA). Where, the TOA, TDOA, and RSS measurement gives the distance calculation between the source sensor and the receiver sensors while DOA's provide the information of the angle and the distance measurements from the source and the receiver.

Arne Kesting, et.al, proposed to derive lane-changing rules for discretionary and mandatory lane changes for a wide class of car-following models using (Minimizing Overall Braking Induced By Lane Change) MOBIL. Both the utility of a given lane and the risk associated with lane changes are determined in terms of longitudinal accelerations calculated with microscopic traffic models. This determination allows for the formulation of compact and general safety and incentive criteria for both symmetric and asymmetric passing rules. The parameter allows one to vary the motivation for lane changing from purely egoistic to more cooperative driving behavior. The model is applied to traffic simulations of cars and trucks with the intelligent driver model as the underlying car following model.

Alberto Broggi, et.al, presents a robust method for close-range obstacle detection with arbitrarily aligned stereo cameras. System calibration is performed by means of a dense grid to remove perspective and lens distortion after a direct mapping between image pixels and world points. Obstacle detection is based on the differences between left and right images after transformation phase and with a polar histogram, it is possible to detect vertical structures and to reject noise and small objects. Found objects world coordinates are transmitted via CAN bus, the driver can also be warned through an audio interface.

A. Motivation

Road accidents are undoubtedly the most frequent and overall the cause of the most damage. The reasons for this are the extremely dense road traffic and the relatively great freedom of movement given to drivers. The prevention of road accident is also extremely important and will be ensued by strict laws by technical control. Due to the improper communication between the vehicles as well as the main control panel there increased a chances of rash driving the accident prone situations. So we came up with an idea where we would navigate all the vehicles in a particular area with the sufficient information where the disasters can be reduced to an extent.

Also the existing projects were having demerits regarding the information storing capacity of the nearby vehicles, we came up with the idea "why no cloud based server" where accessing and storing of the information would become much easier.

B. Scope of the project

Problems concerning traffic mobility, safety, and energy consumption have become more serious in most developed countries in recent years. The endeavors to solve these problems have triggered the interest towards new fields of research and applications, such as automatic vehicle driving. New techniques are investigated for the entire or partial automation of driving tasks. Intelligent Transportation Systems (ITSs), links the vehicle, the infrastructure, and the driver to make it possible to achieve more mobile and safer traffic conditions.

In this project, novel techniques have been proposed by using intelligent transportation system to serve the speed based lane changing, collision avoidance , Automatic breaking system and video/photo surveillance in Vehicular Ad Hoc Networks (VANETs).

III. PROPOSED WORK

Recently, cloud computing has witnessed significant attention in vehicular communication. It is because of the realization of smart Intelligent Transport System (ITS) applications, and architectural similarity between Mobile Cloud Computing (MCC) and Vehicular Ad Hoc Networks (VANETs). As a prospective Intelligent Transportation Systems (ITS) technology, Vehicular Ad-Hoc Networks (VANETs) have recently been attracting and increasing attention from both research and industry community. These networks have no fixed infrastructure and instead rely on vehicles themselves to provide network functionality.

A. Proposed System

In this section we will introduce in brief about all the elements involved in the model along with the proposed algorithms for the applications such as:

1) Obstacle Detection: To avoid collision with unexpected obstacle, the raspberry pi uses ultrasonic range finders for detection and accordingly the distance is calculated from the sensor. This manly depends on the performance and the detection level of the ultrasonic sensor. Some of the features of the ultrasonic sensor are the device is extremely robust, making it suitable for even the toughest conditions, the sensor surface cleans itself through vibration.

Ultrasonic sensors have proven their reliability and endurance in virtually all industrial sectors. The ultrasonic sensor transmits sound waves and receives sound reflected from an object. When ultrasonic waves are incident on an object, diffused reflection of the energy takes place over a wide solid angle which might be as high as 180 degrees. Thus some fraction of the incident energy is reflected back to the transducer in the form of echoes. If the object is very close to the sensor, the sound waves returns quickly, but if the object is far away from the sensor, the sound waves takes longer to return. But if objects are too far away from the sensor, the signal takes so long to come back (or is very weak when it comes back) that the receiver cannot detect it.

2) Collision Avoidance: In order to avoid the accident an specific algorithm is followed where there exists an predefined value, i.e. 15 cm (approx.) distance. Whenever raspberry pi gets less than the defined value from any object, then automatic brake comes into picture. The ultrasonic sensor is also interfaced with the raspberry pi board. The ultrasonic sensor transmits and receives the value from the object. The distance of the object is continuously noted by the sensor and displayed in the software. If the values meet the threshold value then it displays the output as object detected. The camera detects the object and calculates the area of the same. The sensor is used for distance measurement from the object and its reading is shown in the display combined with the readings of the camera. This shows that the object is detected and the distance is noted in order to alarm the system about the obstacle and to make the vehicle to steer away from the obstacle thus avoiding collision.

3) Photo Surveillance : Surveillance is the monitoring of behavior, activities, or other changing information for the purpose of influencing, managing, directing, or protecting people. This can include observation from a distance by means of electronic equipment such as cameras. The on-board unit is interfaced with a camera that can be remotely activated from the Raspberry pi. The camera high signal is detected, the camera is activated and then turned to the direction calculated by the cardinal points and the photo or the video of the designated event is taken.

4) Lane Changing: Once the vehicle is detected in front of the sensor activates and passes the message on to the LCD of the same vehicle as an alert message. Then the vehicles can change the lanes by increasing and decreasing the speed and also considering the minimum gap that is required between any two vehicles. An algorithm which measures the distance between the vehicle ahead and calculate the distance at which the vehicle can change lane is implemented in the unit, such that the vehicle can auto lane change with high accuracy. The automatic lane changing feature can reduce accidents caused due to driver negligence.

5) Time Of Arrival And Time Difference Of Arrival: The GPS receivers require a clear line of sight for accurate services. When a vehicle is in a tunnel or a shady area (areas that are not properly mapped) the GPS signals and information is not so reliable. Moreover, the GPS receiver can also fail sometimes, or there may be some malicious attacks that tamper with the data and at the end the data being received is not authentic and reliable. Therefore, some other technique for localization is required in order to keep a proper track on the vehicles. To address to this problem, we propose an algorithm based on the Time of Arrival (ToA) and the Time Difference of Arrival (TDoA) based localization technique.

a). **Time of Arrival (ToA):** Time of Arrival is the simplest and most common ranging technique, most notable used in the Global Positioning System (GPS).This method is based on knowing the exact time that a signal was sent from the target, the exact time the signal arrives at a reference point, and the speed at which the signal travels (usually the speed of light). Once these are known, the distance from the reference point can be calculated using the simple equation.

$$d = c \times (tarrival - tsent)$$

where c is the speed of light. Using this distance, the set of possible locations of the target can be determined.

b). **Time difference of Arrival:** Time Difference of Arrival is the second-most popular ranging technique, and it is somewhat more versatile than ToA. This method does not require the time that the signal was sent from the target, only the time the signal was received and the speed that the signal travels. Once the signal is received at two reference points, the difference in arrival time can be used to calculate the difference in distances between the target and the two reference points. This difference can be calculated using the equation.

$$\Delta d = c \times (\Delta t)$$

where c is the speed of light and Δt is the difference in arrival times at each reference point.

B. Automatic Braking System

Automatic braking technologies combine sensors and brake controls to help, prevent high speed collisions. Automatic braking is a safety technology that automatically activates the vehicle's brake system, to some degree, when necessary. Systems vary from pre-charging brakes, to slowing the vehicle to lessen damage. Some advanced systems completely take over and stop the vehicle before a collision occurs. It is critical that drivers understand the exact capabilities of their car's automatic braking system. Regardless of a vehicle's autonomous technologies, drivers should remain aware of their surroundings and maintain control at all times.

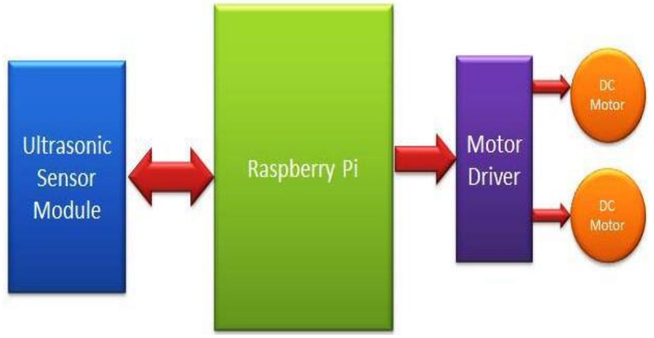

Fig. 2: Block diagram of automatic breaking system

We can calculate the distance of the object based on the time taken by ultrasonic wave to return back to the sensor. Since the time and speed of sound is known we can calculate the distance by the following formula.

Distance= (Time x Speed of Sound in Air (343 m/s))/2

The value is divided by two since the wave travels forward and backward covering the same distance. Thus the time to reach obstacle is just half the total time taken.

IV. VANET(Vehicular Adhoc Network)

Vehicular ad hoc networks (VANETs) are defined a as subset of mobile ad hoc networks (MANETs) with the distinguishing property that the nodes present in here are vehicles. So node i.e. vehicle movement is restricted by road course, encompassing traffic and traffic regulations. Because of these restrictions VANET is supported by some fixed infrastructure that assists with some services of the VANET and provides access to stationary networks. The fixed infrastructures are deployed at critical locations like road sides, service stations, dangerous intersections or places with hazardous weather conditions. VANET, is a technology that uses moves cars as nodes in a network to create a mobile network. VANET turns every participating car into a wireless router or node, allowing cars approximately 100 to 300 meters of each other to connect and, in turn, create a network with a wide range. As cars fall out of the signal range and drop out of the network, other cars can join in, connecting vehicles to one another so that a mobile Internet is created.

A. Simulation of Vehicular Adhoc Network

Normally, developing a realistic simulations is not a easy as the mobility of moving nodes needs to be extracted from the real-word measurements. Yet, the measurements obtained may only be performed well under a specific scenario and misbehave in other scenarios. However, full control over all the aspects of scenario can be achieved if movement traced are generated by traffic simulation tools. We used MATLAB and SUMO to develop the mobility model that will be used for VANETs.

MATLAB: VANET simulation in MATLAB is done by connecting a two Road side Unit(RSU) between the vehicle nodes. We exploit the infrastructure of roadside units (RSUs) to efficiently and reliably route packets in VANETs. The basic motivation behind using RSUs to route packets is that RSUs are a fixed infrastructure. It is much easier to send a packet to a fixed target than to a remote moving object.

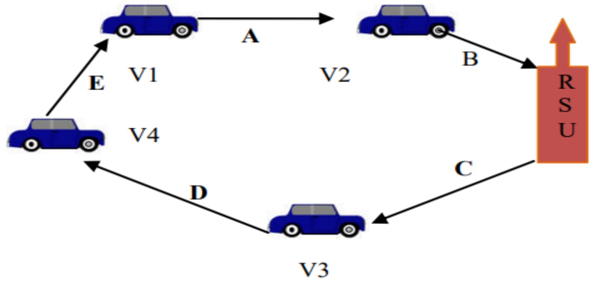

Fig. 3: Vehicle communication using RSU

SUMO: SUMO is an open source traffic simulation package including net import and demand modeling components. We describe the current state of the package as well as future developments and extensions. SUMO helps to investigate several research topics e.g. route choice and traffic light algorithm or simulating vehicular communication. Therefore the framework is used in different projects to simulate automatic driving or traffic management strategies.

Fig. 4: Map from open street org.

We can manually generate network file by writing route, but this networks are very primitive and it is very difficult to create complex networks. But for the realistic simulation we have to create network file which are present in the real world for that purpose SUMO incorporate by which we can download real world road map Form the openstreetmap.org. The map are downloaded are OSM file, after downloading map from the website the OSM file edited using JOSM Java OpenStreetMap Editor.

B. Cloud Generation

Rclone is a bit like the command-line tool rsync, a staple for developers and other advanced users. However, Rclone is designed to work with established cloud services, no need to set up rsync services on remote machines. Rclone can work with Google Drive, Amazon S3, Dropbox, Google Cloud Storage, Amazon Drive, Microsoft One Drive, Hubic, and Backblaze B2, just to name a few.

Fig . 5: rclone-rsync for cloud storage

V. RESULT ANALYSIS

A. Hardware Results

The chassis was designed using the acolyte wooden composite with the proper motor mounting along with components mounting. Motor operation was designed separately using the motor IC L293D, voltage regulator, resistor and an LED with an separate power supply to it using rechargeable battery, to avoid the back EMF from the motor, this design is basically for the circuit isolation.

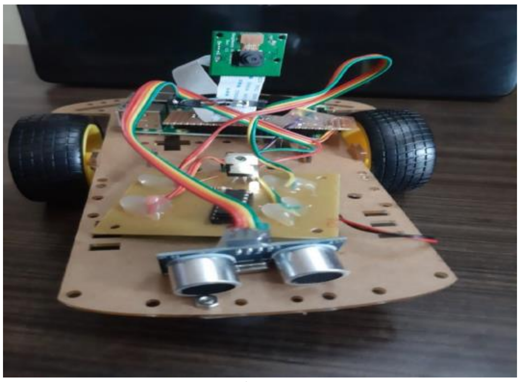

Fig. 6: Sample of the complete model

The method used is related to each other and works hand in hand. The flow is as once the obstacle is detection it activates the ultrasonic sensor, based on the delay the camera gets triggered and the command goes either to the cloud or to the motor driver and so as the LCD for broad casting.

B. Software Results

The vehicular ad-hoc network is been demonstrated using an simulation process in the MATLAB code. General concept of this VANET is, each and every vehicle in the particular domain are interconnected with the road side unit as well the vehicle to vehicle connections, which will be monitored using the internet connectivity and the behaviour will be captured and stored in the cloud server for the data to be transferred to the upcoming vehicles in that lane as well as for the future scope. The following results are graphically illustrated and below are the simulation of VANET using MATLAB.

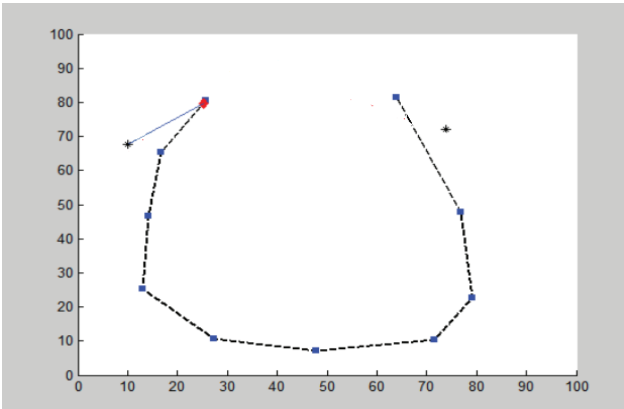

Fig. 7: VANET Simulation using MATLAB

VI. CONCLUSION

We proposed a model on the speed based lane change, collision avoidance on roads, accident detections, video/photo surveillance. Proof of theoretical concept of our system design has been demonstrated with the help of simulations performed in SUMO.

We developed the partial hardware for the system design and we intend to completely design the fully functional system integrated with the raspberry pi 3 to implement it in the real-time scenarios. As the raspberry pi uses the power battery, there may be some instances where the battery is down and then model doesn't function as desired. Therefore, we intend to get into optimizing the power of the raspberry pi and connect it with the external power in order to make the system more efficient and reliable.

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