INTER-VEHICULAR COMMUNICATION USING PACKET NETWORK THEORY

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Abstract

As a component of the intelligent transportation system and one of the concrete applications of mobile ad hoc networks, inter-vehicle communication has attracted research attention from both the academia and industry of, notably, US, EU, and Japan. The most important feature of inter-vehicle communication is its ability to extend the horizon of drivers and on-board devices (e.g., radar or sensors) and, thus, to improve road traffic safety and efficiency. Such type of Driver assistance systems are meant to support drivers with driving process in order to avoid traffic accidents, speed up the traffic and have a higher control over the traffic in general. These systems use the capacity of the vehicles to communicate, not only between them but also with infrastructures. All the information is collected and processed to offer useful services.

Wireless adhoc network protocols are widely used in this area which provides communication among vehicles and road side equipment. The performance of communication depends on how better the routing takes place in the network and these routing protocols we have already been analyzed and compared in the past, simulations and comparisons have almost always been done considering random motions.

Since the application development is for Inter-Vehicular Communication and Decongestion of Vehicular Networks, it is necessary to initially locate the car position from GPS co-ordinates, Using filtering techniques and localization algorithms its accuracy is enhanced. The vehicular density in the lanes is then found out for all vehicles at a specific location based on location and then congestion algorithms are applied to congested lanes to decongest them.

Keywords: *Intelligent Transportation System, Localization, Inter Vehicular Communication, GPS, Wireless Adhoc Networks, Routing Protocols*

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1. INTRODUCTION

Recent studies show that about 60% of roadway accidents could be avoided if the driver was warned just one half second before the collision occurs. Actually, traffic accidents have become the main cause of mortality, quite above illnesses. Emerging technologies appears to provide faster, safer and more reliable communication techniques. Bring together, this communication can be used in order to reduce collisions, as well as to support and improve the quality of the traffic. There are different kinds of systems to assist drivers in the roads.

Inter-vehicle communication (IVC), on one hand, is an important component of the intelligent transportation system (ITS) architecture. It enables a driver (or its vehicle) to communicate with other drivers (or their vehicles) that locate out of the range of line of sight (LOS) (or even out of the radio range if a multihop network is built among several vehicles). As a result, information gathered through IVC can help improve the road traffic safety and efficiency. On the other hand, moving vehicles equipped with communication devices form exactly an instance of long envisioned mobile ad hoc networks. Benefiting from the large capacities (in terms of both space and power) of vehicles, the nodes of these networks can have long transmission ranges and virtually unlimited lifetimes. Also, many existing protocols designed for ad hoc networks and experiences learned from related researches can be applied, such that results staying so far in academia are put into practice.

This Inter-vehicle communication can also be categorized as follows. When the communication occurs between vehicles, it is called Vehicle-to Vehicle (V2V) communication. It takes place in cooperative driver assistance or in decentralized floating car data sharing (i. e. traffic monitoring). If the communication is between a vehicle and a infrastructure, that is, Vehicle-to-infrastructure (V2I) communication, then vehicles can communicate using a fix infrastructure along the road to give support some services like Internet access, inter vehicle chat, mobile advertising...etc.

The paper discusses how localization techniques combined with GPS will provide the car’s location. Using filtering techniques and localization algorithms its accuracy is enhanced. The vehicular density in the lanes is then found out for all vehicles at a specific location based on location and then congestion algorithms are applied to congested lanes to decongest them. Finally this application will be supported by pedestrian detection and lane detection algorithms.

2. RELATED WORK

Comparison among different MANET routing protocols based on different application is discussed in [1]. A review of location area routing mechanism is proposed in [2].The proposed scheme performs a review of different routing protocols which can be used for Vehicle to Vehicle (V2V) and Vehicle to Infrastructure (V2I) communication. It also discussed the need of location area routing mechanism to get the exact location of the cars through GPS and localization techniques to avoid collision and control congestion. Different methodologies for the design of tractable solutions for complex distributed systems that require safety and liveness guarantees are presented in [3]. Implementation of cooperative intersection collision warning system that is not limited by the requirement of line-of-sight and is also capable of collision warning for other scenarios such as frontal and rear-end is proposed in [4]. [5] Discussed possible cause and type of crashes and the available technology to avert or reduce crashes. The relevance and importance of the collision avoidance systems with respect to the existing conditions and advantages and disadvantages of the collision avoidance systems are also discussed. The fundamental technical challenges and business motivations behind wireless position location systems are described, and promising techniques for solving the practical position location problem are treated in [6]. Cascaded Haar method for upper body detection, front face detection and side posture detection is explained in [7]. Survey of recent advances in face detection is presented in [8]. [9] Presents a family of probabilistic localization algorithms known as Monte Carlo Localization (MCL). Hough transform to detect lane boundaries with a parabolic model under a variety of road pavement types, lane structures and weather conditions is proposed in [10]. Implementation, evaluation and comparison of selected optimal edge detectors and the HOUGH transform algorithm towards automated geologic feature mapping in a volcanic geotectonic environment is presented in [11].

3. PROPOSED WORK

Proposed work presents Inter vehicular communication-Application of wireless protocols where we will see Inter-Vehicular Communication and Decongestion of Vehicular Networks by using different algorithms.

3.1 Lane Contention Algorithm

Here we will be building our model based on optimization where our objective will be to continuously minimize the difference between our set point and the output actually obtained i.e. by employing Least Minimum Mean Square Error estimation. The approach was first modelled for static traffic and then for dynamic traffic and its results are shown below:

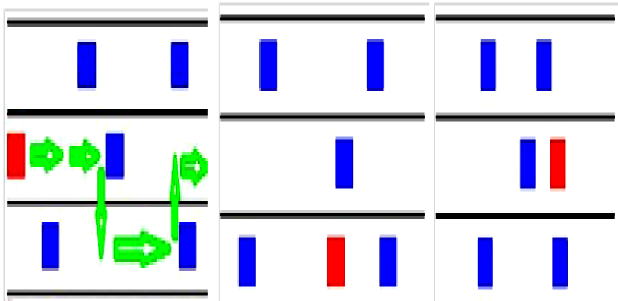

Fig.1 Vehicle Maneuvering in Static Traffic Conditions

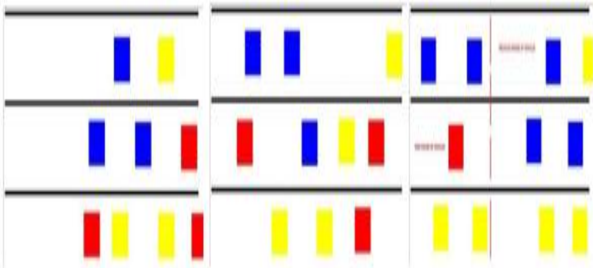

Fig.2 Vehicle Maneuvering in Dynamic Traffic Conditions

Referring to fig.1 above we modelled this as a static obstacle avoidance system where the red car has a-priori information of all the blue cars in the current frame. Its maneuver will be as shown in fig.1. This same algorithm is then modified and extended for dynamic traffic where each car treats this as an obstacle avoidance problem and updates its current position at every sampling instant and multicasts this information to its neighbouring peer set so that every peer car will carry out the same process flow in a loop. It will then use this information and based on its own safety & control calculations make a decision whether to continue in the same lane or undertake an overtaking maneuver as shown in fig. 2 above.

The problem of congestion is also taken care by traffic policing algorithms such as Leaky Bucket algorithm where it maintains the rule that if the output flow rate is higher than or equal to input flow rate the lane is decongested however if the input flow rate becomes higher than output flow rate that is there is presence of burst traffic the lane will be congested as shown in fig.3 (a-c) below.

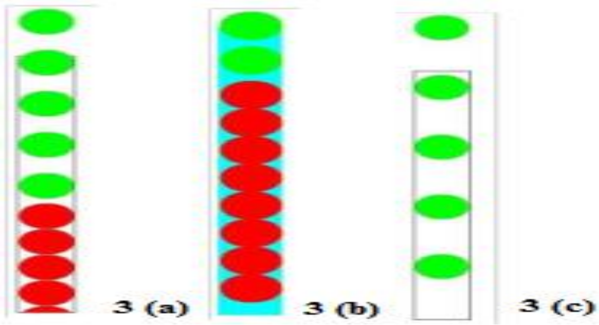

Fig 3 a) Traffic - steady state flow rate b) lane congestion (c) traffic policing -new flow rate

3.2 Vehicular Localization & Tracking

The next part deals with vehicles trying to localize their positions with respect to peers. Whenever a car is travelling on the road, it requires both longitudinal and lateral control to avoid collision with the other vehicles.

The data obtained from GPS and cameras is sometimes uncertain and or even momentarily unavailable; hence it is imperative that localization using Bayesian filtering [12] be carried out so that the range of error reduces from 3-10 meters to 2-8 cm of error. Extended Kalman and Particle Filtering [12-15] have been used for tracking of vehicles. This is shown in our simulation screenshot in fig 4 (a-d) below

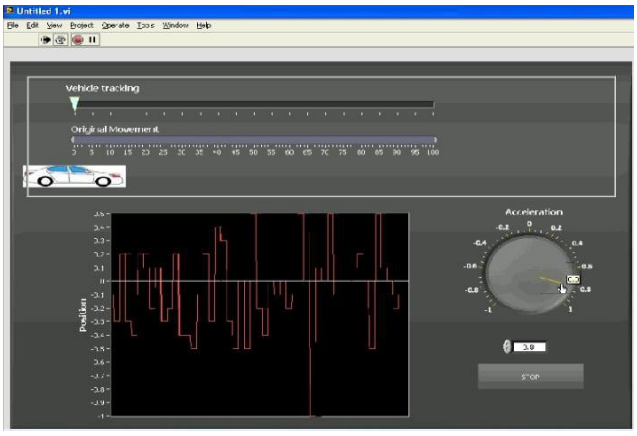

Fig.4a Error Overshoot & Undershoot at start of tracking

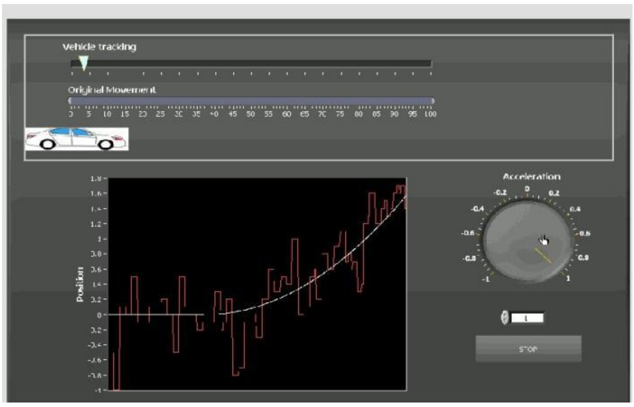

Fig.4b Change in movement of car leading to reduction in error

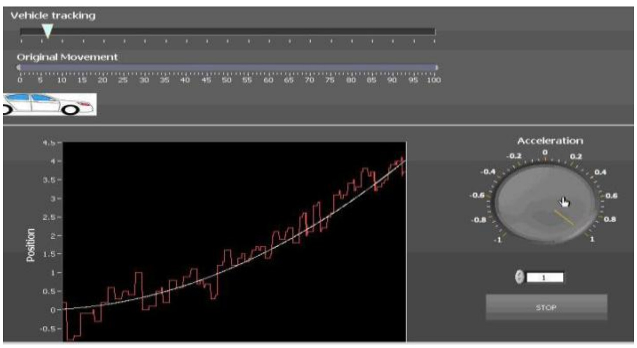

Fig.4c Reduction in Error with advance of the car

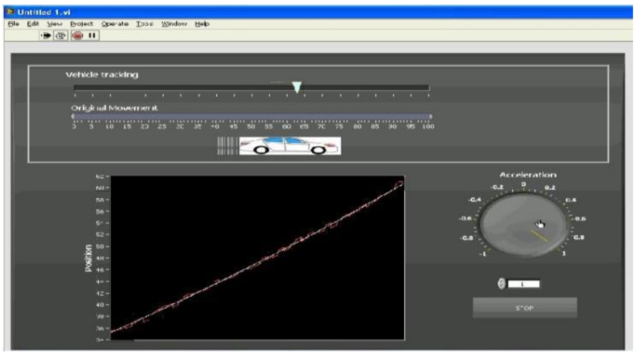

Fig.4d Kalman filtering now tracking the error perfectly

3.3 Modified Dijkstra's Algorithm

The modified Dijkstra's algorithm is explained as follows: The source and destination will be sent to the centralized controller using the vehicle's Xbee module. The centralized controller performs the Modified Dijkstra's Algorithm and finds the shortest path from source to destination. The direction for the navigation of the vehicle to the next node is sent. It is checked if all the nodes are passed. Once all nodes are crossed it will display that the destination is reached on the LCD display in the vehicle. Initially a dynamic configuration of nodes is defined in Matlab in fig.5.

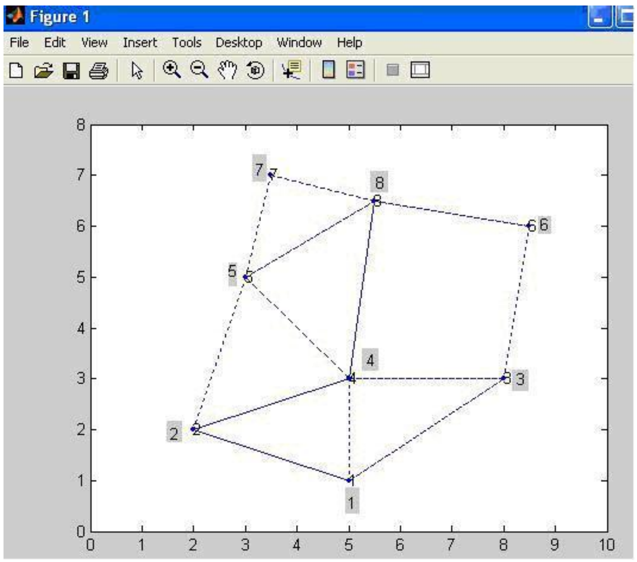

Fig. 5 – Matlab Node Assignment Dynamic Configuration

A dynamic link cost will be assigned to each node at run time which in real time accounts for the changing traffic density on roads due to peak hour traffic or accident. So the shortest path will not be the only criteria for travel. It will take into account all such constraints of load balancing and then select the optimized path as shown in figures 6(a-d) below.

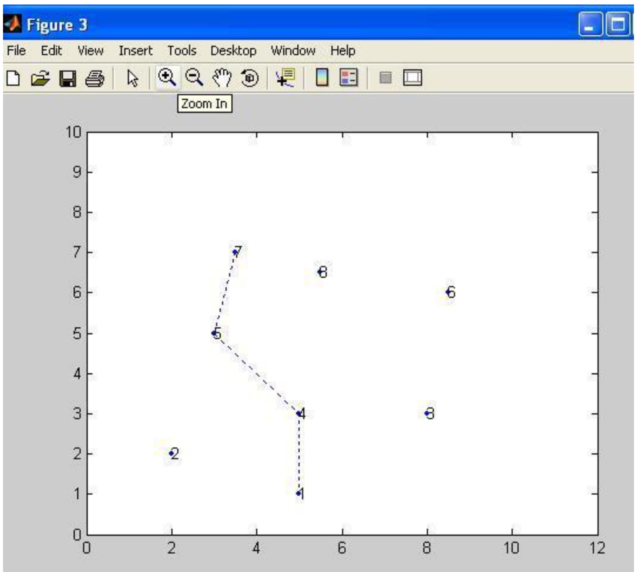

Fig. 6a Best path from Node 1-7

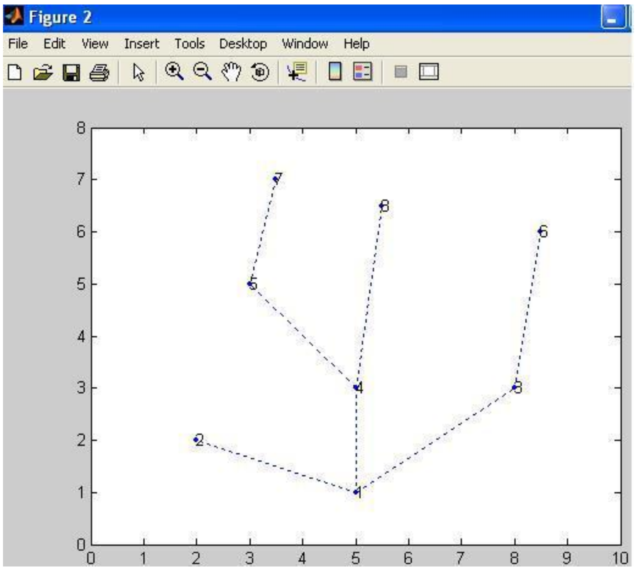

Fig. 6b Best path from Node 1 to all nodes

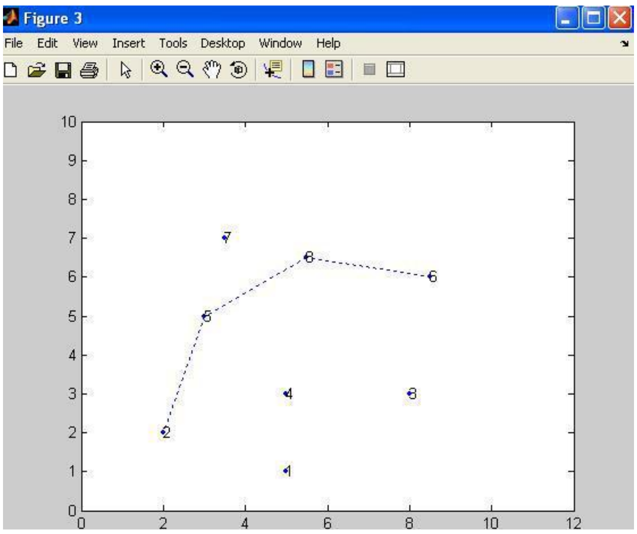

Fig. 6c Best path from Node 2-6

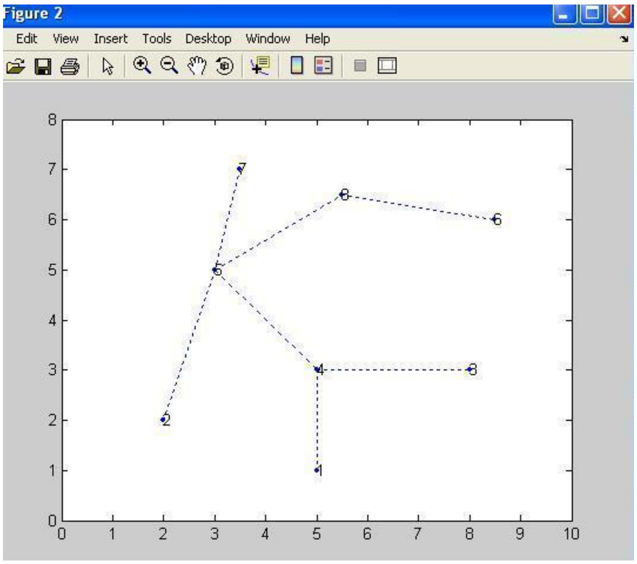

Fig. 6d Best path from Node 2 to all

3.4 Pedestrian Detection

A simple pedestrian detection system is being implemented by us using OPENCV v2.4.3. Initially the Cascaded Haar method [7] was utilized for upper body detection, front face detection and later the method was further enhanced by incorporating side posture detection as seen in fig. 7.

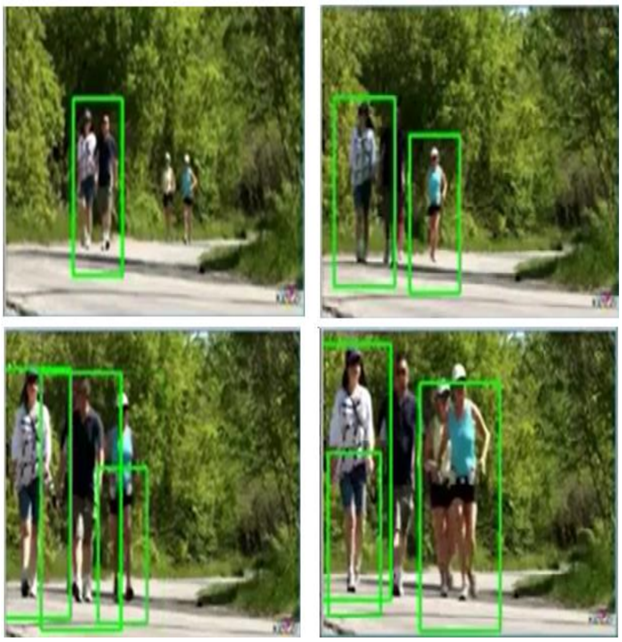

Fig.7 Validation of Pedestrian Detection and Tracking using HOG Transform

3.5 GPS Localization & Client Server Architecture

The Google API is used in LabVIEW to read the frames which are imported from the module shown below in fig. 8. The module comprises of a GPS transceiver & antenna connected to the Raspberry Pi Controller or with direct interfacing to the computer. The system is powered up from either the car battery or from USB supply of the computer. The client-server architecture is designed where the host vehicle acts as a client and the Apache Tomcat Server is configured on a home desktop. The communication is established using mobile internet to report real-time values of ground vehicle location. The setup can be seen in fig. 8 below

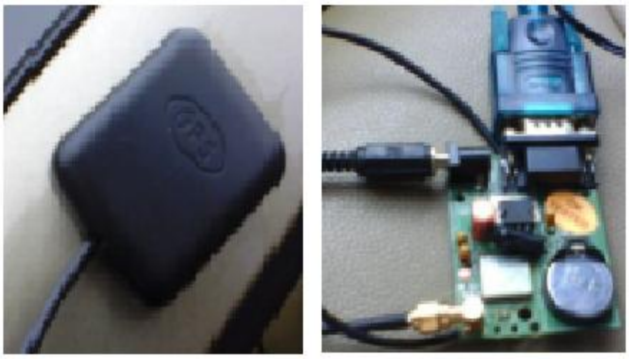

Fig.8 GPS Module with Antenna with interfacing to Google API and LabVIEW installed Computer

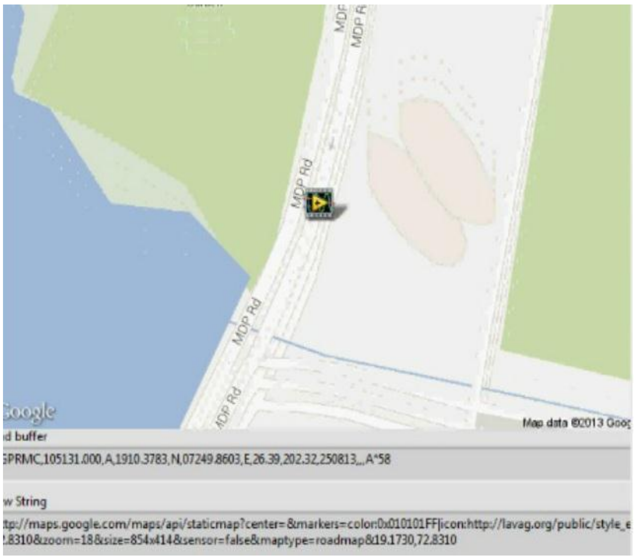

Fig.9 GPRMC frame with Google API- Location Marker on Maps using LabVIEW

The vehicle tracking requires from the GPS the GPRMC frame amongst the other 8 frames that are received. On receiving the valid GPS frame, the value is parsed to obtain the latitude & longitude of the vehicle. This is seen in fig. 9 with vehicle being located on the maps and then localized using Monte-Carlo Localization & Extended Kalman Filtering as discussed in [9].

The real-time location of the vehicle also needs to be conveyed to a supervisory control system hence needs the client server configuration. This configuration has been shown in the fig.10 where the client server communication establishment is shown. This can be replaced by a web domain collecting all real time data for centralised control over the system.

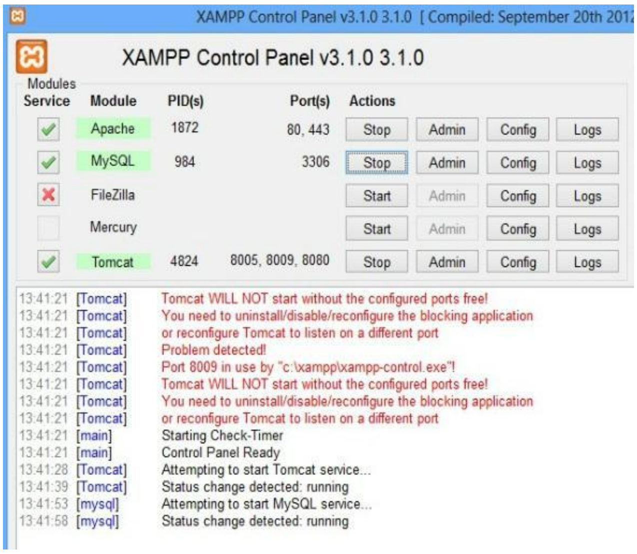

Fig. 10a Tomcat Server Service ready for client servicing

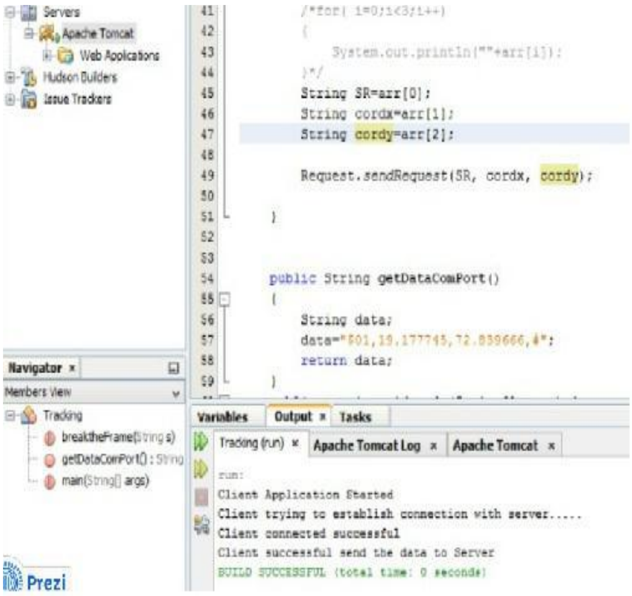

Fig.10b Client to Server Communication Initiated and ready for data reception

3.6 Lane Detection

It is important to understand the lane we are currently in, if the lane contention algorithm is to be run or if we are to avoid obstacles in course of vehicle movement. The work done here briefly shows the steps in which we follow to detect the lane markers and then take the next course of action. The image used for the same can be seen in fig. 11a. On the original image the two main filters are applied. The first is the Hough Transform [10] which uses a binary map as its inputs which can be generated using the Canny Algorithm [11]. Canny Algorithm runs a gradient on the image to find sharp changes in the pixel intensities, these being the contours in the image which are again shown in the output by a binary map as seen in fig. 11b.

Fig.11a Original Image

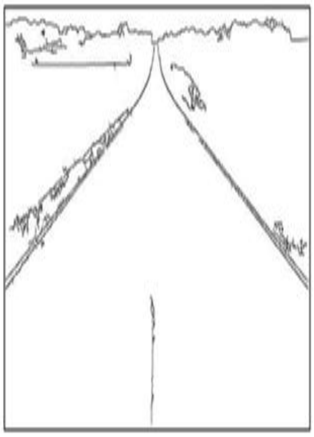

Fig.11b Contour Image

We then apply Hough Transform to the image, the results of which can be seen in fig. 12a and over this the Probabilistic Hough Transform is run to find the end of the lines. The results can also be seen in fig. 12b.

Fig. 12a- Image after Hough Transform

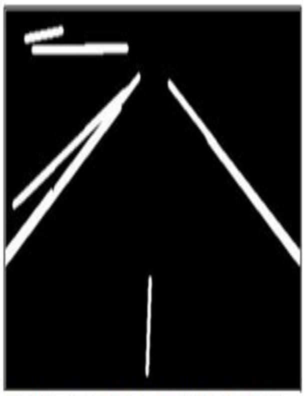

Fig.12b – Image after Probabilistic Hough Transform

Fig.12 Images after hough and probabilistic hough transform

The final image can now be obtained by doing a bitwise addition of both the images. The final processed image can be seen in fig. 13 which shows the lane detection

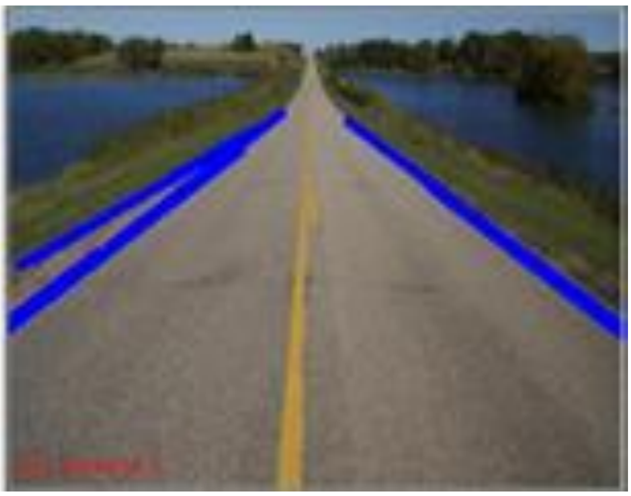

Fig.13 Bitwise addition

5. CONCLUSIONS AND FUTURE WORK

Inter vehicle communication is an emerging area and important source of research thanks to the improvements of in-vehicle computing and processing capabilities and also the advancements in mobile and wireless communication.

In addition, since vehicles will get more "smart", partially due to the installation of Inter vehicle communication systems, security and privacy are becoming new concerns that both academia and industry should pay attention to. Finally, mathematical models for road traffic are important tools in developing Inter vehicle communication systems, because simulations are still necessary in testing large scale communication systems.

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