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Sensor based Vehicle Environment Perception Information System

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***Abstract*— A sensor based vehicle information system (SVIS) is proposed to study vehicle environment perception in this paper. The different types of sensors are installed on the road side environment and wireless communication technology is used to realize the sense information between sensor, base stations and servers. The system considered the high speed characteristics of vehicles, when vehicles will be passing a road ahead that is prone to accidents; the vehicles driving states should be predicted to ensure drivers have advance information about road and safe from accidents. To evaluate the performance and stability the traditional sensor mounted system compared with SVIS system. The simulation results show the accuracy and efficiency of proposed system.**

Keywords- Sensor, Information system, Base station, Error rate

I. INTRODUCTION

Recent years have witnesses a dramatic growth of information and communication technologies in intelligent transportation system applications for safety and entertainment purposes. The main purpose of intelligent transportation system applications are to providing safe and convenient services during travel to the passengers and drivers [1]. Various applications have been developed and reduce fatalities and protect travelers from accidents. The vehicular information systems have been a popular and hot area for researchers in intelligent transportation systems. The vehicles used sensor systems, control systems, information processing systems for perceive the surrounding environment and identification [2]. However, the vehicular environment is highly mobile and dense [3], and the limited range of environment acuity, interference are major challenges for these embedded systems. Therefore, Sensor based Vehicle Information System is proposed to handle these problems and improve environment perception. The previous environment perception system uses sensors and cannot produce comprehensive environment perception. The remainder of this paper is organized as follows: Section 2 presents the previous systems and related other work. Section 3 addresses the proposed system model and its part with details. Section 4 shows the experiment setup and last section is about comparative analysis of experiment and simulation results.

II. RELATED WORK

In previous systems the laser based sensors, vision based sensor and millimeter-wave radars, etc; are used for environment perception, which are installed in vehicles. The Toyota Company used vision based radar, millimeter-wave radar and CCD (charge-coupled device) sensors for detect the distance between vehicles. In Carnegie Mellon University project NAvlab used range finder and trinocular vision for vehicle safety and global positioning system (GPS) receiver used for vehicle position and laser sensor is used for detect the obstacles [4]. The federal university of Espirito Santo used stereo vision for detect obstacles in their commercially automated vehicle [5]. The intelligent vehicles are based on various functions and features like lane departure warning system, driver assistance, collision warning and automated platooned system, etc. These cars can use visual sensors for localization and detect other vehicles through ultrasonic and laser sensors. But these visual systems are not suitable and fail in low visibility and illumination and dense traffic environment [6]. The laser sensor also not working properly in bad weather conditions and radars fail in the presence of reflective objects. The ultrasonic sensors used for short distance and not well due to its measurement features. The previous proposed systems have various types of expansive hardware devices like high precision laser scanners, GPS/INS system, high performance computers and high density cameras. Therefore various infrastructure based sensor technologies have been studied to replace previous systems. Recently the sensors are placed in highways for information exchange and communication between vehicles and infrastructure. These systems are low in cost and efficient in performance. In these systems the information of the surrounding environment can be disseminate between vehicles in the range of base station or infrastructure. Fig. 1, shows the example of sensor based infrastructure system.

The author [7] proposed an infrastructure based path tracking control system based on sensors, actuator and vehicle controller modules. In this system the position, obstacle and heading angle information sent to vehicle via infrastructure sensors. The vehicle controller calculates input information such as throttle angel, steering wheel angel and break torque to track the customized reference path for avoid minimum clearance to obstacles. However this system is not working in high speed situations.

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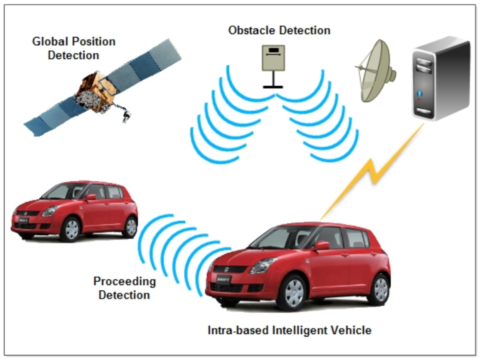

Figure 1. Infrastructure sensor based intelligent vehicle control system

In another framework author [8] proposed sensor based secure multimedia communication for VANET. In multimedia data the gaming, chatting, video/audio and television, etc. are included. The framework is based on secure multimedia communication and remove redundant messages and reduce the network delay and load. Author claimed that framework is better in malicious environment. However author neglect the error rate in this framework.

Our proposed vehicle information system is cost effective compare to previous proposed systems. The previous systems have different types of expensive devices such as GPS/INS system, high precision laser scanners, smart and expensive computers and high density cameras. In our proposed system we use different types of sensors. These sensors are tinny devices and less in price compare to previous devices and high in accuracy.

III. System Model

In this paper, we proposed sensor based vehicle information system (SVIS) based on sensors, base station, systems server and vehicle communication devices, etc. The distributed sensors are placed on road sides and sense the environment perception and send the information to sink sensor and then to the base station. After obtained the information sent to system servers and server evaluate the information and further disseminate the information to the vehicles. The system has four parts: the sensor nodes, base station, communication devices (laser, ultrasonic, radar, etc.) and wireless network and server systems. Servers are installed in traffic management centre (TMC) and collect the all data from sensors and further process the data and mathematical analysis. The first server (S1) system is responsible to collect and process data and second server (S2) collect the data and effective information disseminate to vehicles. We test out proposed system with previous traditional vehicle-mounted sensor systems. The distance and velocity we acquired from sensors placed on highways. The vehicle driving states collected from vehicle mounted sensor system. We compared both vehicle driving states and estimated errors between them and check our proposed system performance. When vehicles are passing from highway the effective information collected through sensors and send the data to sink nodes and then send to base station and to the servers and after processing the data will be broadcast to other vehicles through base stations.

From Fig. 2, we can show that SVIS mainly contains four parts: sensor (sensors, sink node), base station, communication and server. The different types of sensors are placed on highways like visual, laser and radar, etc. and connected with sink node. Through base station data further send to servers which are installed in traffic management center.

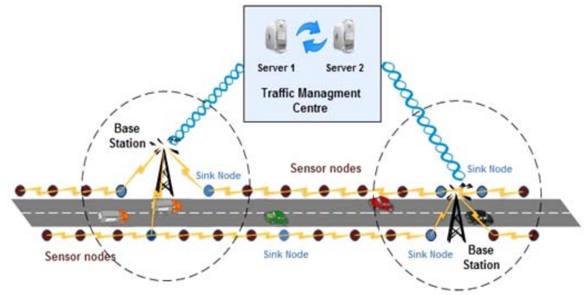

Figure 2. SVIS system

The data process module shows in Fig. 3, with the help of flow chart. The sensor module is responsible to sense the raw data and send via sink node to the communication module (base station). The base station further sends the data to processing module (servers in TMC). Where the data receive the raw data and analyzed and synthesized to process the desired information. After fusion prediction the final data will send to base station again for broadcasting to the vehicles. The system have many distributes sensors, which sense a large amount of driving state detection and sensor information data fusion. Through proposed system the road recognition ability will improved and provide more comprehensive information for safe and efficient vehicle driving.

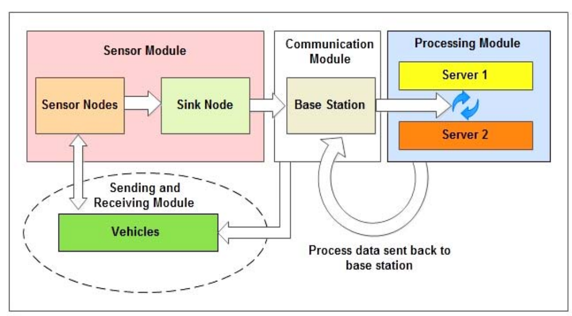

Figure 3. Data process model

IV. Experiment Setup

For our proposed system we built the sensor perception environment. We used some experimental devices like two vehicles, a test machine for intelligent vehicles, sensors, simulation platform, Wi-Fi and Video capture system. We select a safe highway environment in our campus UTM. The magnetic induction and machine vision cameras are used for acquiring vehicle driving states. The two CCD cameras are used in field and magnetic induction coil detectors are installed between cameras. The cameras are installed with the help of three-legged stand for supporting a camera. For information exchange the USB interface is used between computer and cameras. For distance measurement the pinhole model distance principal is used. We used veDYNA [9] simulation tool because it provides real time virtual vehicle ability. It is also use for development and testing of vehicle control systems in traffic environment. We set simulation environment with 3 vehicles cars and set two applications departure warning system driver assistance system. These applications pick the environmental information such as lidar, radar or ultrasonic sensors. The all parameters set with same criteria which we used in our proposed system such as speed, distance, etc. First we test traditional vehicle mounted sensor system and then proposed system in simulation environment and acquired the results such as vehicle speed, vehicle acceleration and distance error.

V. SIMULATION RESULTS

First we shows the simulation results of traditional system then our proposed system results and in last compare both results with each other. Further result shows the accuracy in both systems.

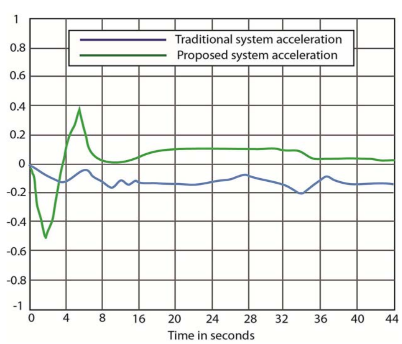

Figure 4. Vehicle acceleration

Fig. 4, shows the environment perception under SVIS and traditional system. The acceleration can effectively track and proved the accuracy of proposed system compared to traditional system. We set the error rate at 0, and ran simulation for several times to captured the proposed system accuracy and performance. The traditional system results shows that how vehicle accelearte and error rate is slightly down in 4 to 8 seconds and SVIS system results are totally different in error rate and suddenly declined and then go upward and shows better vehicle acceleration error rate compare with traditional system.

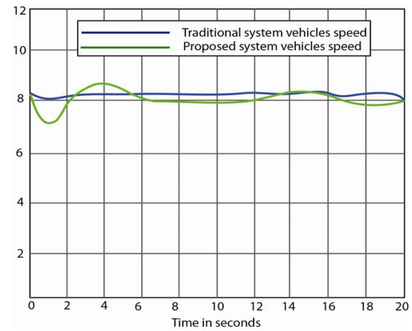

Figure 5. Vehicle speed

The Fig, 5, shows the results related with vehicle speed accuracy. The traditional system results shows that the speed of vehicle is stable but in actual situation the vehicle speed is go up and down and totally depends on road conditions and driver behavior. The previous systems are not so accurate to capture the accurate vehicle speed. The results clearly show the accuracy of proposed SVIS system, where the speed is goes down and then up and show variation.

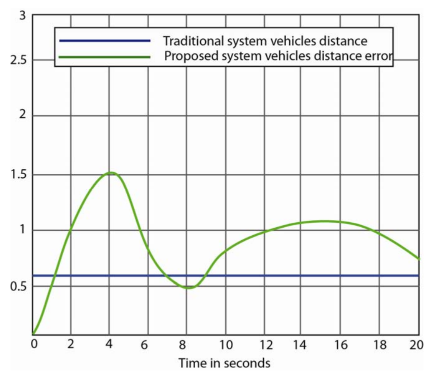

Figure 6. Vehicle distance error

The distance factor is very cruicial for safety applications and decision is based on data accuracy especially for emegency break system, curve movement application and accident detection applications. The Fig. 6, shows the accuracy of our peoposed system compare to traditional system, where the vehicle distance is change with the movement of vehcile and depends on different factors such as speed, etc. On the other hand traditional system show the distance is same which is totally because of error.

The Fig. 4, and 5 shows the vehicle acceleration and speed under the traditional system and proposed system environment. The Fig. 6, shows the vehicle distance errors and comparison with traditional system. From Fig. 4, and Fig. 5, we can reach the results and showed the proposed system accuracy. The two environments are used to track vehicle distance errors. The traditional vehicle mounted system vehicle distance errors are slightly smaller and SVIS can keep the vehicle distance error stable. The speed of vehicles showed the accuracy of proposed system compare to traditional system. The simulation results show that SVIS system to realize vehicle environment perception and ensure the system stability and accuracy.

VI. Conclusion

A sensor based vehicle information system (SVIS) is proposed in this paper for vehicle driving state in high speed environment. We tested the proposed system with previous traditional vehicle mounted system and compare the results of driving states. Finally the results showed that SVIS system can realize driving state and ensure system stability. Furthermore the system will provide accurate road information and efficient for warning applications.

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