Sensor and Network Technology for Intelligent Transportation Systems

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Abstract: The innovations in the automobile industry over the last hundred years have made our vehicles more powerful, easier to drive and control, safer, more energy efficient, and more environmentally friendly. Future technological advancements will be expected to address these challenges and build vehicles with efficient electric drive systems, wireless communication capability with other vehicles on the road and the roadway infrastructure, and information technology to provide improved navigation, fuel efficiency, safety, and traffic management functions. The national highway traffic safety administration reported that the most vehicle accidents are reported which are caused due to driver error. Thus, technology that can help automate vehicle operation and take a person out of the control loop is expected to tremendously help in improving safety on the roadways. The long shot goal is to build autonomous vehicles that can operate without human supervision.

I. Introduction

In the civilian arena a number of research universities and companies are also investing in technology for deployment in autonomous vehicles. Google, with the help of robotics researchers from Stanford and Carnegie Mellon university’s has managed to deploy vehicles outfitted with sophisticated sensors and powerful computing resources for autonomous navigation. The sensor suite includes laser scanners, radar, video camera, inertial navigation systems, wheel encoder, and GPS. The artificial intelligence algorithms integrate the raw data generated by all the sensors to create a 3D map of the environment, including the surrounding vehicles on the road, traffic signals, pedestrians trying to cross streets, etc. The control software is responsible to make real time decisions for a safe navigation of the vehicle among the surrounding traffic. It knows the speed limit on road ways, decides when it is safe to change lanes, and follows a route given by the GPS navigation system [5]. There are also a few other similar success stories of projects such as the autonomous vehicle developed at the University of Parma that drove from Italy to China [6], an autonomous vehicle navigating the streets of Berlin [7], and the self driving car in China.

II. Design of proposed hardware system

Intelligent transportation system (ITS) refers to integrated application of communication, control and information processing technologies to the transportation infrastructure and vehicles. The resulting benefits save lives, time, money, energy, and the environment. This intelligent transportation system is used to solve four major issues of transportation. It has four sections.

Vehicle section

![Fig.1. Vehicle section](image)

In vehicle section we develop an autonomous vehicle which operates without human supervision. This system can be used to avoid accidents which caused by driver errors. In this robot section we have...
ultrasonic sensors which are used to calculate and maintain distance between the neighboring vehicles in adverse weather situations, such as a foggy or rainy weather and prevent collision from neighboring vehicles. So, even if the driver has low visibility of other vehicles or if he loses concentration, then the system can issue a warning to alert the driver of possible unsafe driving conditions. If an accident occurs, in this section we have an accident alert circuit to alert and give information to the controller. GPS is used to locate the place where the accident has occurred using latitude and longitude values. We can intiate this information using GSM. A message is sent to the person whose number is stored in the GSM module. The temperature sensor in the unit is used to sense the temperature of the vehicle. If it crosses the threshold limit buzzer will buzz indicating it. Autonomous vehicle uses a particular radio frequency to send and receive information. In this section we use a camera to continuously monitor the vehicle’s position.

Traffic signal section

The traffic signal section in the project is used to control the traffic based on density. This section is used to solve the problem of traffic congestion, which has been increasing worldwide as a result of population growth, urbanization, increased motorization, and changes in population density. Congestion reduces efficiency of transportation infrastructure and increases travel time, fuel consumption and air pollution. The main drawback of normal automatic traffic light controller is it gives green signals to different directions with some constant time delay. If we consider a junction, the traffic from all directions may not be same and density will change as per time. If controller is not considered this traffic density then what happened, traffic will become more and more in one side and another side even though there is no vehicles controller shows green light. Through our project we can avoid this problem. In this project we are going to use IR communication to analyze traffic density. IR signals from IR receiver are given to microcontroller and microcontroller gives appropriate result according to traffic. For better result we are going to use some bunch of IR transmitters and IR receivers in all directions. When there is a more traffic in one side more no. of IR receivers will not get the signals and result will compare with all other directions and microcontroller gives green signals at one side where more no of IR receivers will not get the signals. For IR communication we are using an IR transmitter and IR receiver. Here IR LED will acts as a transmitter. As we know microcontroller having inbuilt I/O ports and we are interfacing IR receivers to those I/O ports. For controlling of traffic we are using red, green and yellow color LED’s. These LED’s are connected to different I/O ports of microcontroller. When there is a more traffic microcontroller gives signal to green LED and it will glow. So by using this project we can control the traffic automatically like a human being.

Fig.2. Traffic signal section

Toll gate section

The toll gate section in this project is used to provide an accurate and safe environment for toll collection and to automatically control the vehicle movements.
at the toll stations by providing individual identities to each user with the help of smartcard technology.

Here in this project we will be giving the smart card to the drivers so that whenever the vehicle comes the driver will access his cards and only the authorized person can enter and pass out if the card is valid and also if enough amount is present in the card. The card will be placed in front of the reader and the card is checked for validation then the concerned amount will be reduced from the card and then the gate will be opened and the vehicle will be allowed. This project access the vehicle with the help of smart card there amount data will be reduced from the card where the account details will be maintained.

Parking slot section

The parking slot section in the project consists of parking space monitoring nodes, routing nodes, sink node, parking guidance display and an information and management center. The nodes transmit the information through wireless sensor network by tree-like topological structure with non-standard protocol we developed. There are three kinds of nodes, which are monitoring nodes, routing nodes and sink node. Those nodes communicate with wireless channel, and self-organize into an ad-hoc network. The monitoring nodes would detect the status of every parking space, and transmit the information through routing nodes hop by hop to the sink node. The sink node connects to the information and management center through RS-232 interface. After processing the data, the information and management center will send the message to all the nodes and update the information in LED screen at the entrance, and the LED displays at the main turnoffs of the road inside the parking lot which will notice the driver at the same time. So that the drivers can enter the parking lots and spends less time on looking for the parking space.

III. The Hardware System

**Ignition switch:** The term *ignition switch* is often used interchangeably to refer to two very different parts: the lock cylinder into which the key is inserted, and the electronic switch that sits just behind the lock cylinder. In some cars, these two parts are combined into one unit, but in other cars they remain separate.

**Accelerometer:** Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of micro fabrication.

**GSM Modem:** GSM/GPRS RS232 Modem from rhydo LABZ is built with sim com Make SIM900 Quad-band GSM/GPRS engine, works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz It is very compact in size and easy to use as plug in GSM Modem.

**GPS:** The Global Positioning System (GPS) is a satellite-based navigation system that sends and receives radio signals. A GPS receiver acquires these signals and provides you with information. Using GPS technology, you can determine location, velocity, and time, 24 hours a day, in any weather conditions anywhere in the world—for free.

**ZIGBEE:** ZIGBEE is a new wireless technology guided by the IEEE 802.15.4 Personal Area Networks standard. It is primarily designed for the wide ranging automation applications and to replace the existing non-standard technologies. It currently operates in the 868MHz band at a data rate of 20Kbps in Europe, 914MHz band at 40Kbps in the USA, and the 2.4GHz ISM bands Worldwide at a maximum data-rate of 250Kbps.

**Temperature sensor:** Temperature sensors are devices used to measure the temperature of a medium. Examples of this include maintaining the temperature of a chemical reactor at the ideal set-point, monitoring the temperature of a possible runaway reaction to ensure the safety of employees, and maintaining the temperature of streams released to the environment to minimize harmful environmental impact.
Stepping motors can be used in simple open-loop control systems; these are generally adequate for systems that operate at low accelerations with static loads, but closed loop control may be essential for high accelerations, particularly if they involve variable loads. If a stepper in an open-loop control system is over torqued, all knowledge of rotor position is lost and the system must be reinitialized; servomotors are not subject to this problem.

Reflection sensors: This sensor consists of IR transmitter and receivers on a single plain. Infrared (IR) radiation is part of the electromagnetic spectrum, which includes radio waves, microwaves, visible light, and ultraviolet light, as well as gamma rays and X-rays. The IR range falls between the visible portion of the spectrum and radio waves. IR wavelengths are usually expressed in microns, with the IR spectrum extending from 0.7 to 1000microns.

IV. Wireless sensor Network

Due to cost of deployment of roadside units to support VANETs, low-cost complementary technologies are being considered by various research groups. One such complementary solution is based on wireless sensor networks (WSNs) [23]. Nodes forming ad-hoc wireless sensor networks are typically based on low-cost, low power, battery operated sensing, processing and communication technology. These low-power nodes can typically operate for years on a pair of AA battery, thus reducing maintenance overhead. Due to their low cost and low power requirements large numbers of roadside WSNs could be deployed economically to support the vehicular communication system. Wiring makes up one of the major cost components of installing the in-roadway and over-roadway traffic monitoring infrastructure. With the use of wireless networking solution, installation and maintenance cost can be drastically reduced. Furthermore, the system will have greater flexibility as it allows easy replacement and upgrade of sensor nodes, and easy reconfiguration of the network setup. Below are a few examples of wireless nodes already available from different vendors for various sensing and monitoring applications in its.

a) Groundhog® G-8 magnetometer and road-weather sensor from Nu-Metrics [18]. Shown in Figure 1a, this is a self-contained battery-powered, wireless sensor. It is installed in-pavement but does not require the installation of any external loops, or tubes, or power and communication wires running to a base station. The sensor transmits data wirelessly at 2.45 GHz spread spectrum band to a base station up to 300 ft away. The base station can be powered from batteries charged by solar energy. The sensor provides data on vehicle count, speed, length, lane occupancy, daily and annual average daily traffic, environmental monitoring of road surfaces temperature, road surface dry or wet condition, and chemical index. Polling intervals range from 5 to 120 minutes. The G-8 operates from 4 lithium thionyl chloride batteries for up to 5 years, depending on the polling interval.

b) SensysTM Networks’ VDS240 wireless sensor [24], shown in Figure 1b, is a three-axis magnetometer that measures the x-, y-, and z-components of the Earth’s magnetic field. It is used to detect vehicle presence and movement. The sensor is installed flush-mount in-pavement with no wires needed for power or communication. It can communicate with an access point device over a range of 75 to 150 ft. The manufacturer claims that the sensor uses ultra-low power communication protocol that allows it to have a battery life of up to 10 years.

c) Dust Networks SmartMesh wireless mesh network solution [25], shown in Figure 1c, enables reliable gathering of real-time status (occupied, empty or expired) of parking spots. Municipalities can use this information to monitor parking spaces on city streets and parking complexes, provide real time parking information to drivers, minimize congestion due to traffic caused by motorists searching for parking. Streetline [26], a provider of smart parking solutions, uses Dust Networks SmartMesh wireless sensor network solution with ultra-low power IEEE 802.15.4 nodes that can run for years on two AA batteries. It utilizes a time synchronized mesh protocol to deliver networking resilience, reliability, and scalability. Streetline’s solution collects street-level data from the SmartMesh network to deliver real time web based parking management applications. These applications guide motorists to available parking spots, text them when their parking-meter is running out, and even direct parking enforcement directly to occupied expired meters.

V. Conclusion

This paper presented a review of the technology advancements that are leading the way in the realization of intelligent transportation systems. ITS is shown to offer great opportunities in maximizing utilization of roadways, while minimizing fuel consumption, congestions, and the environmental impact of vehicle traffic. Traditional sensing systems for in-vehicle and roadway infrastructure
deployments, as well as the wireless sensor networking technologies have been explored. The WSN solution offers ultra-low power sensing and communication technology, reduced installation and maintenance cost, greater flexibility, better adaptable and scalable mesh networking, and years of operation on battery power. We anticipate further improvements of the ITS technology and vehicular communication systems, and expect adoptions at greater scales in the coming years.

REFERENCES


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