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End to end latency in vehicular platooning using tactile internet

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Abstract : Today's wireless communication is designed for transporting content. The breakthrough lying before us is to enable wireless steering of our environment by enabling the Tactile Internet. The Tactile Internet allows one to transmit data in real-time. The Tactile Internet will need to be ultra-reliable and have sufficient capacity to allow large numbers of devices to communicate with each other. It will also need to support very low end-to-end latencies. The fifth generation (5G) mobile communication systems will underpin Tactile Internet at the wireless edge. Fully automated driving and platooning of vehicles is a new step in mobility within the context of 5G. The time needed for collision avoidance in today's applications for vehicle safety below 10ms. The Vehicle-to-Vehicle communication is the wireless exchange of data among neighbour vehicles that offers the opportunity for significant safety improvements, vehicle-based data regarding position, speed, and location. The system is composed of two vehicles capable of moving in forward, reverse, left, and right directions. The vehicles are wirelessly networked using ZigBee which allows them to communicate information such as direction of travel.

Index Terms : Tactile Internet, Internet of Things, Arduino, LCD display, Latency.

Introduction

Road accidents account for a severe threat to human lives from both an injury as well as a financial perspective. Given that vehicles are designed to facilitate a smooth means of transportation, manufactures have long been in the process of designing vehicles based on principles of reliability and safety. However, due to reasons such as human error, circumstantial error and negligence, accidents occur. Today, special attention is focused on the technologies that can reduce traffic accidents. V2V technologies are simple to implement primarily because of their reliance on wireless communication.

The communication will takes place between two vehicles by using tactile internet. Vehicle-to-Vehicle(V2V) is an automobile technology designed to allow automobiles to "talk" to each other. V2V is also known as VANET. Availability, reliability, safety, integrity and security are among the main requirements. The main motivation for vehicular communication systems is safety and eliminating the excessive cost of traffic collisions. Vehicle-to-Vehicle(V2V) communications comprises a wireless network where automobiles send messages to each other with information. The data would include speed, location, direction of travel, braking, and loss of stability.

Vehicle communication [1]propose the key technical requirements and architectural approaches for the Tactile Internet, pertaining to wireless access protocols, radio resource management aspects, next generation core networking capabilities. The Tactile Internet will add a new dimension to human-machine interaction by delivering a low latency enough to build real-time interactive systems.Tactile internet is a technology which allows to transmit communication by touch or feel. It will enable haptic communication. Haptic was one of the devices which allow the users to touch and feel [2,3]. The Internet of Things (IoT) is the network of physical objects – devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity- that enables these objects to collect and exchange data. Internet of Things allows objects to be sensed and or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer-based systems, and resulting in improved efficiency, accuracy and economic benefit [4].

Further, the Tactile Internet has been described as a communication infrastructure combining low latency, very short transit time, high availability and high reliability with a high level of security[5]. The smart technology to improve the Intelligent Transportation Systems (ITS) with the help of Visible Light Communication (VLC) using LED based brake or headlights as transmitter and camera as receiver. By using Raspberry Pi as a processor this gives data to the LED. The camera on the receiver side selects a high intensity part of an image and extracting the actual data by using Image Processing techniques[6].

Vehicle communication require the high accuracy, such as safety warning. In this the improvement of time remaining before getting in the dangerous area is proposed by using the GPS detection of moving direction. GPS technology has been already registered in 5G technology in which all devices have to include it inside the hardware platform[7]. The vehicles are already equipped with devices able to connect to cellular networks, and to transmit and receive in real time traffic information through Vehicle-to-Infrastructure (V2I) communication[8]. The opportunity to take advantage of Vehicle-to-Vehicle in addition to V2I communications to reduce the amount of data to be transmitted from vehicles to a remote control center, and thus also to reduce the resulting costs for transmissions over the cellular networks[9].The design and performance trade-offs of two waveform families frequently discussed in the literature targeting 5G: filter bank multi-carrier with offset quadrature amplitude modulation (FBMC/OQAM) and filtered OFDM (FOFDM) with specific focus on V2V communications by utilizing a realistic geometry-based stochastic V2V channel model[10].

Experimental

Unlike the conventional Internet which provides the medium for audio and visual transport, the Tactile Internet will provide the medium for transporting touch and actuation in real time.Technical systems have a so-called ‘end-to-end latency’, which comprises all delays experienced by a communication from origin to destination. It includes the time spent in the transmission of the information from a human via the communication infrastructure to a control server; the processing of the information and generation of a reaction; and the eventual transmission of the reaction via the communication infrastructure back to a human.

The control objective in platooning is to maintain tight vehicle following within the platoon and platoon stability under the constraint of comfortable ride. Since the desired intervehicle spacing is very small, the allowable position error is also small, which implies very accurate tracking of the desired spacing and speed trajectories. This accuracy puts constraints on the performance of the sensors.If the intelligent car automatically avoids barrier and navigates, it needs to establish the distance measurement system of the moving vehicles. The ultrasonic distance measurement system can avoid obstacles and maintain the distance of 60cm between two vehicles.

As shown in (Figure 1), the end-to-end architecture for the Tactile Internet can be split into three distinct domains: a master domain, a network domain, and a controlled domain.

The master domain usually consists of a human (operator) and a human system interface (HSI). The HSI is actually a haptic device (master robot), which converts the human input to haptic input through various coding techniques. The haptic device allows a user to touch, feel, and manipulate objects in real and virtual environments, and primarily controls the operation of the slave domain.

Microcontroller is the core of the Vehicle-to-Vehicle communication. It controls all the other modules, and acquires path, speed, and wireless signals and other data.Motor driver is basically a current amplifier which takes a low-current signal from the microcontroller and gives out a proportionally higher current signal which can control and drive a motor. The circuit not only drives the motor, but also controls its direction.

The network domain provides the medium for bilateral communication between master and slave domains. The base station is connected to the antenna that receives and transmits signals in the cellular network to customer phones. The Tactile Internet requires ultrareliable and ultra-responsive network connectivity that would enable typical reliabilities and latencies for real-time haptic interaction. The Vehicle-to-Vehicle communications system includes a satellite-based network of ZigBee communications, which consists of a network coordinator and a number of network terminal nodes. Network coordinator is responsible for the management of the network, while terminal nodes acquire simulated data on the one hand; on the other hand, these simulated data are transmitted through a wireless network to the coordinator. By this way it not only reduces the complexity of the ZigBee network, but also facilitates the centralized management of data.ZigBee network can have up to 653356 devices, the distance between ZigBee devices can be up to 50 meters and each node can relay data to other nodes.

The slave domain consists of a teleoperator (slave robot) and is directly controlled by the master domain through various command signals.

Figure 1 Block Diagram of Vehicle to Vehicle Communication

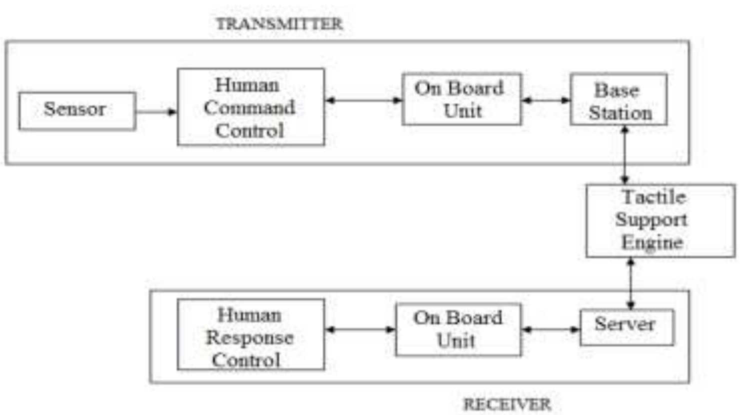

Figure 2 Hardware Setup for Transmitter Vehicle and Receiver Vehicle

Results and Discussion

The hardware setup for transmitter vehicle and receiver vehicle is shown in the (Figure 2). The circuit is built around an Arduino board, ATmega8 controller, motor driver L293D, DC motors M1 and M2, ZigBee and a few common components.

Transmitter circuit can be powered using 12v battery. IC 7805 regulates the 12v supply to 5v. The receiver circuit needs to be powered using 6v supply. The command is given through mobile phone by creating webpage as shown in (Figure 3). The Arduino Ethernet shield allows an Arduino board to connect to the internet using the Ethernet library and to read and write an SD card using the SD library. The shield is mount it on top of an Arduino board. Connect the shield to a Wi-Fi module using a standard Ethernet cable. The shield must be assigned a MAC address and a fixed IP address using the Ethernet. The code was uploaded and connected to the internet it creates a webserver in LAN and use the IP to access that webserver through browser.

Arduino (Atmega328) is fed with a set of code. The sending information from mobile phone reached arduino using Wi-Fi module. The arduino reads the data as binary zeros and ones. The vehicle moves according to the instruction given by the mobile phone. DC motor control in vehicle to vehicle communication is achieved using two dual h-bridge chips per vehicle. The speed of vehicle is 45 rotations per minute.

The direction of vehicles are followed by giving commands through mobile that was mentioned behind the IP address.

- $1 - Forward
- $2 - Stop
- $3 - Left
- $4 - Right
- $5 - Divert

The command given through mobile phone was read by arduino and send to ZigBee. ZigBee act as a transmitter and receiver. ZigBeeis a mesh network specification for low-power wireless local area networks that cover a large area.

ZigBee effectively supports the wireless communication between many vehicles, routers and receivers. It provides a key protocol for wireless sensor network applications. It allows vehicles to communicate information such as direction of travel. Ultrasonic sensor was placed to detect the distance between two vehicles. The distance between vehicles was displayed on LCD as shown in (Figure 4) in transmitter side.

The ZigBee in the receiver side send information to the ATmega8 microcontroller. The ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. The receiver vehicle act as same as the transmitter vehicle. LCD as shown in (Figure 5) in the receiver side displays the latency.

Figure 3 Control Transmitter Vehicle Through Mobile Phone

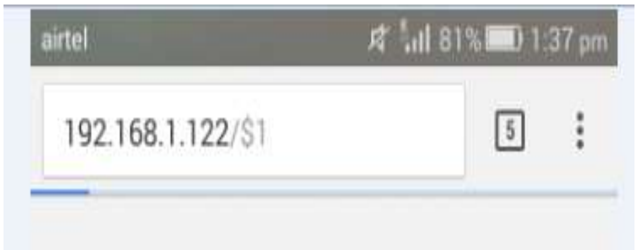

Figure 4 Distance Value

Figure 5 Latency Values and the Direction of Vehicles

Conclusion

The highways of the world are growing more congested. People are inherently bad drivers from a safety and system reliability perspective. Self-driving cars are one solution to the problem, as automation can remove human error and react consistently to unexpected events. Automated vehicles have been touted as a potential solution to improving highway utilization and increasing the safety of people on the roads. The development of the automated vehicle platoon provided a vehicle platform and software package that enables future research on the reliability of automated vehicles. V2V communication requires high accuracy of GPS, high bit rate, wide range of communication. It works together with 5G technology, the high utilization of network for safety approach in the future can be obtained. The presence of human drivers stabilized the velocity of the platoon, but the humans also reduced the highway throughput. The V2V communications provide safety for drivers and it is widely used for transporting and it reduce traffic collisions.

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