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Proposed Framework for V2V Communication using Li-Fi Technology

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***Abstract*— Vehicle to Vehicle (V2V) Communication is a developing technology which helps make our transportation system intelligent. The system can also avoid accidents and traffic congestion. In this paper, we employ Light Fidelity (Li-Fi) for data communication among vehicles. Li-Fi falls under the category of Visible Light Communication (VLC). Li-Fi involves the use of visible light spectrum as a medium of communication. The technology provides high speed and is an eco-friendly method. The use of Li-Fi in V2V Communication is considered promising. In this paper, we propose a framework for V2V Communication using Li-Fi Technology.**

Keywords—V2V, Li-Fi, VLC, Visible Light Spectrum

I. INTRODUCTION

Due to the increase in the number of vehicles on road, traffic control has become a great challenge for the present day. As of 2010, there were more than 1 billion vehicles in use. The rate of vehicles on road is increasing exponentially day by day. It also reflects the number of accidents occurring in the world. Road accidents caused a death of around 1.25 million people globally in 2010. In order to prevent heavy traffic and accidents we need to make our transportation system intelligent. One feature of Intelligent Transportation System (ITS) would be Connected Vehicles.

Autonomous vehicle is another domain in which most of them are working. In order to make a vehicle autonomous, we need to keep track of vehicles present nearby. In order to do this we need to exchange data with our nearby vehicles. So, keeping vehicles connected is an important part of making vehicles autonomous. V2V (Vehicle to Vehicle) communication comes into picture to have vehicles connected. V2V communication can be simply thought of vehicles connected to each other to exchange data which also has the potential to avoid a crash and prevent traffics. In order to achieve data communication, we use Li-Fi (Light Fidelity) technology. Li-Fi makes use of the unused visible light spectrum. This efficient data communication technology has a data rate in terms of Gbps.

Li-Fi not only is efficient in this application but also provides an electromagnetic free environment which is healthy. Because of its high speed there would be no risks of data loss or hacking.

II. FRAMEWORK

The framework includes vehicles which uses light as a medium for data communication. This data is helpful in many ways.

A. Li-Fi

Li-Fi stands for Light Fidelity. It is a technology which uses light as medium of communication. It makes use of the unused visible spectrum and has a high speed in terms of Gbps.

B. Implementation

Fig. 1. shows how communication can occur among vehicles on road.

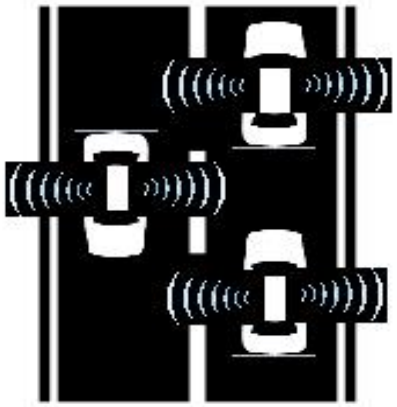

Fig. 1. Communication of Vehicles

A Light source is equipped in the vehicle. The data is transmitted through this source. Data can be any information related to that vehicle like velocity, load etc which would be important for other vehicles to know to avoid an accident. Variation in the intensity of light is made based on the data to be transmitted. The vehicles present in the vicinity of this vehicle are equipped with light detectors. These detectors capture the light variations and obtain the data. This is how communication can be done with light as a medium.

In this way we can connect vehicles using Li-Fi technology. It is a safe, efficient and fast way of connecting vehicles.

Fig. 2. shows the block diagram of transmitter.

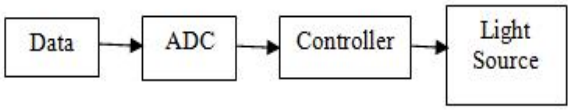

Fig. 2. Data at Transmission End

Information of a vehicle needs to be transmitted. This analog data is converted into digital using an Analog to Digital Converter (ADC). This digital data is passed on to a controller. This controller then varies the intensity of the light source through which data transmission takes place.

Fig. 3. shows the block diagram of receiver end.

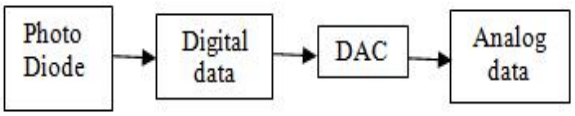

Fig. 3. Data at Receiver End

The light from source is received by the photo diode. This data is digital and is converted into analog using a Digital to Analog Converter (DAC). The output of DAC is analog data and thus data transfer occurs through light.

C. Data Capturing and Processing

V2V could capture and transmit the following inputs which can be considered important.

- Vehicle speed
- Vehicle position and its direction of travel
- Vehicle on-off throttle
- Lane changes
- Gear position
- Information regarding stability control, traction control
- Information related to brakes and Anti-Lock Braking.

Once these data is received by the surrounding cars, based on that data various actions can be taken in the surrounding cars. Data may be information related to speed of the car. If the speed is decreasing, we can even decrease the speed of our car. This can avoid accidents. Data can even contain in which lane the car is moving. Once this data related to lanes is received, we can overtake the vehicle easily and without any risk.

In this manner, data communication through light waves help in making vehicles autonomous with high efficiency and less delay. This also helps in making transportation system intelligent.

III. LIGHT SOURCE AND SENSOR

In order to have wide range coverage we need to use efficient and long distance light sources. Normal LED's would serve the purpose of creating a light medium but its range would be less. So LED lights would serve the purpose efficiently as this not only has a wide range but better features than normal LED.

A. Light Source

Choosing a light source for V2V communication is an important part. The Light source should have features of long range, low power consumption etc. So, LED lights would be an efficient source in this context. The following are its features:

- It provides more intense light beam than the other traditional lights.
- It has a wide range of visibility which is especially useful during night.
- It is highly energy efficient as its power consumption is low.
- LED Lights have a long lifespan.
- Maintenance is low and they are safer to use.

They are environmental friendly and not harmful to human eyes.

B. Photo Diode

The photo diode must possess certain important features in vehicular communication. The following are a certain features that the light sensor must possess in order to have an efficient data communication using Li-Fi.

- It should be highly sensitive and accurate.
- The response time should be less.
- It should have the capacity to sustain high intense light beams.
- Low Power Consumption.

These are the features that the source and sensor should have so that the entire system would be efficient and quick. Apart from these features both source and sensor should of low cost.

IV. COMPARISON WITH WIFI

In this section, a comparison of Li-Fi and WIFI is made. This also deals with how Li-Fi is also a strong technique for data communication when compared to the use Radio waves in applications like V2V communication

A. Li-Fi and WiFi

The following are a few major differences between WiFi and Li-Fi.

- Speed of Li-Fi is higher than WiFi .
- Wi-Fi which uses RF spectrum is limited by congestion but Light Spectrum is unused and provides reuse.
- Since the speed of Li-Fi is high, risk of data hacking is less. So, data is more secure in Li-Fi than in Wi-Fi.
- The data density of Li-Fi is greater than that of WiFi.
- It is difficult to control the transmission range in WiFi whereas the intensity is controllable and directional in case of Li-Fi.

Light waves cannot penetrate through walls whereas RF waves can.

B. Efficiency of Li-Fi in V2V Communication

The present era is making use of radio waves for V2V communication. Li-Fi, even, doesn't lack in this aspect and is a good contestant for Wi-Fi. It has its own strength and is more beneficial than radio waves in V2V application. This section deals with strengths and efficiency of Li-Fi.

Consider the following image Fig. 4. Imagine a scenario where cars are moving in 3 different lanes C1, C2 and C3. Assume there are 3 different rows R1, R2 and R3 for understanding.

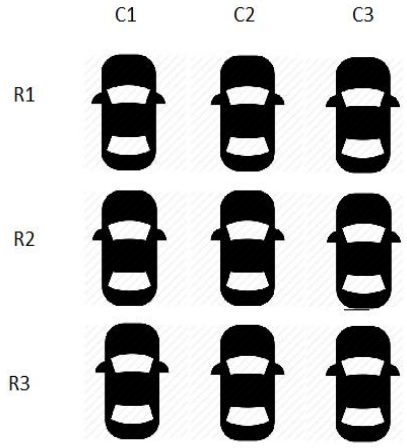

Fig. 4. Movement of Vehicles on a road

If communication is being done through Wi-Fi then its data would be transmitted to surrounding vehicles. Since RF waves penetrate through obstacles, the area covered is more. It is a point to multipoint communication. Information of car in lane C3 and row R3 would be available to all the cars. The data would be available to car in lane C1 and row R1 also. But this data would be of no use to that vehicle as its actions are would be based on behavior of its immediate adjacent cars. So, in this application it would be efficient if communication is point to point rather than point to multipoint. In case of WiFi the communication is point to multipoint. Car in lane C1 and row R1 would be receiving information from its immediate neighbours. This data would be of much importance than the data from car in lane C3 and row R3. In case of critical situations like high congestion, the system must work efficiently as data exchanged will be huge. During these situations, when data from car at lane C3 and row R3 is sent to car at lane C1 and row R1, which is of no use, will not only make the system delayed but also less efficient. The receiver system may get crashed also due to huge amount of data transmission which includes unnecessary data also. Priority mechanisms can be thought of, but system would get complicated and slowed down.

In case of Li-Fi, communication is point to point which is very efficient in this application. Information about a car is transmitted only to its immediate neighbours as light cannot penetrate through obstacles. So, data which is necessary only gets transmitted. So, data of car at lane C3 and row R3 would be available to car at lane C3 and row R3, car at lane C2 and row R2 and to car at lane C2 and row R3. This makes system efficient and faster.

One can think of implementing one point to multipoint communication instead of a number of point to point communications. We can't rely on a single data, as actions of a vehicle would not be based on behavior of a single vehicle but all its adjacent vehicles. And transmission of data to vehicles at a distance would be slow.

So, Li-Fi is an efficient mechanism of communicating information as far as V2V application is concerned.

C. Advantages of Li-Fi in real time situations

There is a prohibition on use of mobiles in petrol pumps as RF waves can ignite the flammable vapors of petrol leading to a disaster. Use of mobile phones is prohibited in airplanes also. This is because the radio waves in the electronic device of the passenger may interfere with the ones being used in the communication system in the aircraft. Due to this electromagnetic interference with avionics data may be lost which may turn dangerous.

Hospitals also prohibit the use of mobile phones in their vicinity as they may communicate with hospital equipments thus disturbing them.

Li-Fi can replace Wi-Fi in critical situations like petrol pumps and airplanes since it makes use of eco-friendly light waves.

V. FUTURE SCOPE

V2V is a trending domain in automotive industry and its implementation using Li-Fi can be extended. The field has

wide scope in real time as this application helps in making vehicle movement autonomous and thus transportation system smart.

Apart from V2V connected vehicles environment includes V2I and V2P communication as well. As a part of future scope, Li-Fi can be enhanced to V2I and V2P communication as well. V2I stands for Vehicle to Infrastructure and V2P stand for Vehicle to Pedestrian communication. This offers a wide range of safety, mobility and environmental benefits.

V2I communication involves exchange of data related to safety and operations between vehicles and infrastructure. V2I signs and signals could transmit traffic and weather indicators. V2P communication includes pedestrians and bicyclists. These communications can be implemented using Li-Fi Technology.

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