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Vehicles to Vehicle Communication in Intersection using Li-Fi and RF Technology

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Abstract: -As a society, we should not accept that 2,222 die on our roads every day due to a road accident. This paper divulges the design of Wireless communication technology in vehicles where the vehicle will communicates among themselves for creating a safer and smarter driving experience. This system helps to control road accident and time waste due to traffic especially at the four-way intersection points. Light Fidelity (Li-Fi) technology, Radio Frequency communication and Global Navigation Satellite System (GNSS) are collaboratively used to develop a new algorithm Vehicle-to-Vehicle in intersection (VVI) to facilitates time-critical information to be disseminated to all the adjacent vehicles. The vehicles will share their parameters with nearby vehicle such as speed, the distance between each other, latitude and longitude of a vehicle from the centre point of the intersection, the direction of movement of the vehicle with nearby vehicles in intersection and the time duration to reach the intersection point. With these parameters, the driver can aware of the vehicles around him and helps him to control the vehicle to avoid accident. Basically, this involves a dedicated short-range communication for controlling the traffic without a traffic signal and accident avoidance to prevent the accident occurrence. At the 4-way intersection point, the vehicles will communicate among themselves and give way based on Master-Slave configuration to give way for the vehicle based on priority. Providing a way for emergency vehicles like ambulance, fire engine, etc., will be done with the highest priority. Consequently, the accident rate and time waste in traffic signals will get reduced. This idea primarily concentrates on controlling the traffic without a traffic signals, accident avoidance and time-saving in traffic.

Index Terms: Li-Fi; RF; GNSS; Dedicated short range communication; Vehicle to Vehicle communication in intersection; Traffic signals.

I. INTRODUCTION

Travelling is inseparable from humans life because everyone has to move from place to place. The public transport usage has reduced and everyone prefers to use own vehicle for comfort and faster travel. The vehicle usage by the entire population creates a huge need for technology to intervene and to solve the traffic congestion problems everywhere. While travelling it is important to follow the traffic rules for safer & efficient driving for us and the betterment for others. But, everyone rushes while travelling and fails to follow the rules which increase the rate of road accidents.

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Especially the control of traffic at the 4-way intersection is a tedious process and traffic police is made in charge of each such intersection roads. On an average, if we travel from one place to another regularly for our job, we would be wasting 1 to 2 hours per day due to traffic this accounts to nearly 30 hours a month and 365 hours a year by waiting at the signals. We need to reduce the unwanted wasting time on roads particularly at the intersection roads by regulating the traffic. This paper proposes an algorithmic model that would reduce the waiting time at the intersection roads and also regulates traffic congestion automatically with the process of initiating communication between vehicles using Li-Fi, GNSS, RF and with other supporting modules. By implementing this system in all vehicles it would completely eradicate the need of centralized traffic control system at the intersection roads.

II. MOTIVATIONAL BACKGROUND

A roadway being a critical infrastructure helps in the economic development of a nation. India has one of the largest road networks of over 4.885 million km. The inefficiency of the traffic control in India causes loss of life, which adds to a considerable number of people who lose their lives every year. "Accident is painful but safety is gainful". Traffic accidents in India are a major source of death, injuries and property damage every year. The Indian government has given out the official statistics for road accidents, injuries for the year 2017, and the news prolongs to be bad. As per the most recent data, in 2017, a total of 4,64,910 road accidents were testified in the country, suing 1,47,913 lives and causing injuries to 4,70,975 persons, which explicate into 405 deaths and 1,290 injuries each day from 1,274 accidents.[1] This also means that 16 people are dying and another 53 are being injured for every 1 hour on Indian roads. The National Highways records, which constitute approximately 2 per cent of India's total road network of over 56 lakh kilometre, accounted for 30.4 per cent of entire road accidents and 36 per cent of deaths in 2017, while accidents on State Highways and other roads created 25 per cent and 44.6 per cent, correspondingly. In the case of casualty, State Highways accounted for 26.9 per cent, while other roads accounted for 37.1 per cent. People in the working age group of 18 to 60 years of age accounted for 87.2 per cent of the total road accident fatalities. [2] The main reason behind road accidents, over speeding, is first in the list and contributes to 70.4 per cent of all the accidents, which accounts for 66.7 per cent lives lost and 72.8 per cent individuals being injured. [3]Another foremost concern on the road is giving way for emergency vehicles.

Lack of attentiveness among motorists and the public about the seriousness of ambulance movement is disheartening. The 108 services have assisted 29.4 lakh people in various health emergencies like pregnancies, respiratory and cardiac disorders, snake bites, suicides and traffic accidents, among many others. However, many of them are dying in ambulance due to the time delay in arriving at the hospital due to traffic. As a way forward to a safer India, we have designed this VVI algorithm for the vehicular communication which enable vehicles to communicate with each other and thus not only reduces our waiting time at the signals and controls the traffic congestion at peak hours but also enables us to smoothly pave way for emergency vehicles and to control the speed of vehicle in accident occur situation. By providing the nearby vehicle details the driver can experience better and safer driving.

III. MODULE DESCRIPTION

A. LORA SX1278 RF Module

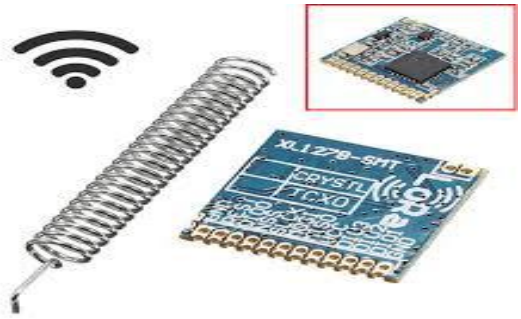

Fig.1 LORA RF Module

Fig.1 Shows the LORA SX1278 RF module using for long-range wireless communication. It can communicates up to 50km range with higher sensitivity of about -136 dBm. This module consists of RFIC SX1278, thin SMD crystal and antenna matching circuit for better performance and for signal acquisition. This module operates at 1.8~3.6V with extra low standby current which makes it suitable for battery powered-up applications to withstand longer operating conditions.

B. Arduino Nano Module

Fig.2 Arduino Nano

The fig.2 shows the Arduino Nano microcontroller board, which is compact in size, user friendly, easily programmable and based on Atmega328p / Atmega168. The board is equipped with set of analog and digital input/output (I/O) pins with serial communication that can be interfaced with external devices. It is also compact in size, easily programmable and low cost.

C. LI-FI Module

Light fidelity, which is commonly known as Li-Fi, which is similar to that of Wi-Fi; it uses visible light to transmit data at a higher speed. The data which has to be transmitted will be converted the processed data will be transmitted through light and it will be received by the nearby the receiver and will get processed.

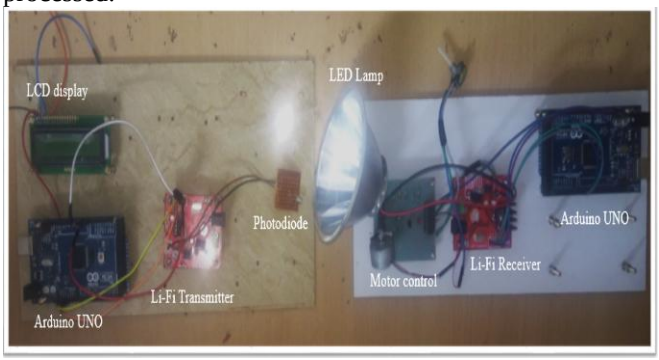

Fig.3 Li-Fi module interface

The Fig.3 shows the experimental setup of Li-Fi to transmit data using visible light. Li-Fi offers several advantages like working across higher bandwidth and offering higher transmission speeds.

D. Global Navigation Satellite System

It is a satellite navigation system with global coverage, termed as Global Navigation Satellite System (GNSS) used for Geo-spatial positioning. It allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) from satellites. It can be used for real-time tracking of vehicles. It operates independently on any telephonic or internet connectivity. It can enhance the accuracy of the positioning information generated. L96 GNSS module is used to implement our Vehicle to Vehicle in Intersection (VVI) algorithm. It operates in low power has high accuracy and also stores data when in rural areas with very high sensitivity.

IV. INITIAL SIMULATION

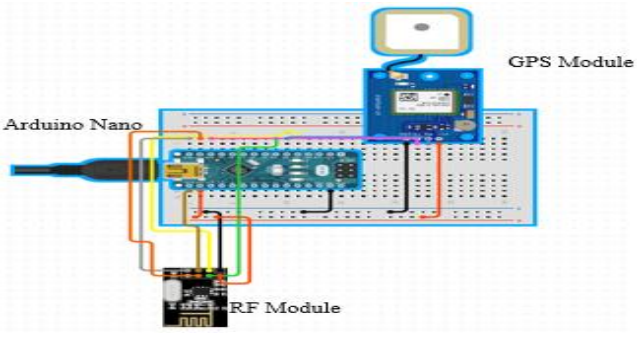

Fig.4 Initial simulation of various modules

The fig.4 shows the initial simulation setup of various modules involved in the execution of VVI algorithm. Arduino Nano, GPS, RF Modules were used for initial simulation to analyse the operation of various block and to know the efficiency on executing the VVI algorithm. In order to increase the efficiency and to have better performance certain block was changed later. The positioning accuracy given by GPS was not faster when it comes to real-time experience and hence to make the system to provide accurate quadrants GNSS is used. GNSS module has many advantages compared to GPS. It is mainly designed for navigation purpose. To execute the VVI algorithm in efficient way we decided to use GNSS L86 module for navigation, LORA RF SX1278 module for longer range communication, Li-Fi for data transmission and Nano for compact processing.

V. Vehicle to Vehicle in intersection Algorithm

A. BLOCK EXPLANATION

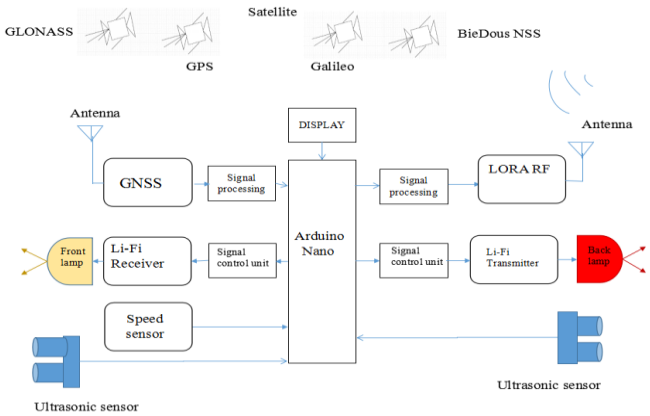

Fig.5 Block representation

The fig.5 shows various operating blocks involved in executing VVI Algorithm. Normally, if a vehicle is equipped with VVI algorithm it should be equipped with the above mentioned block with some supporting block added with. GNSS is used for the better real-time navigation experience to get accurate quadrants even when the vehicle is travelling in rural place. Then for the wireless communication between vehicles in long range SX1278 RF module is used. Ultrasonic sensor is used to measure the distance between vehicles to reduce the accident rate. If chance of accident between vehicles detected by sensor then the speed of vehicle will be gradually decreased with the help of speed sensor for this communication among vehicles Li-Fi communication technology is used.

B. Flowchart

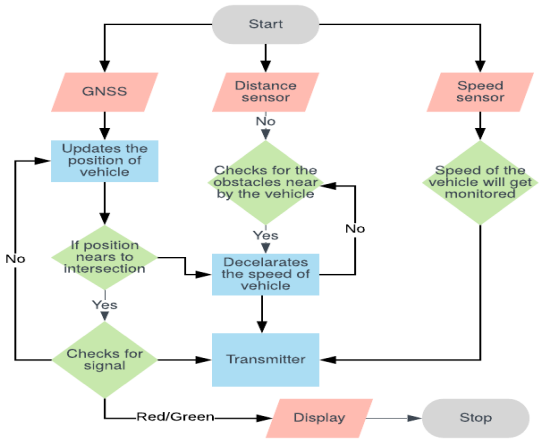

Fig.6 Flowchart for VVI algorithm

The fig.6 explains the various operational flow of the VVI algorithm execution and the flow of operation is clearly shown in the flowchart for the better and easier understanding.

VVI algorithm is a wireless vehicular communication algorithm, where the vehicle will communicate among themselves without any centralized unit. This algorithm is designed with a unique feature for controlling the traffic and intended in reducing the accident rates at intersection signals. This algorithm is economical in replacing the present traffic control system.

The flow of VVI algorithm execution is explained below for better understanding,

Step 1: When the system gets powered up then the system will reset all the modules connected with the system and checks the initial status.

Step 2: The microcontroller will start to track from the initial condition of all the modules connected with it for better and efficient operation.

Step 3: The microcontroller starts to receive data from various modules connected with it and will process the data by comparing the data with the set values assigned for the various modules which are arranged in the database.

Step 4: If the set values match with the received value then the required action will be performed by the controller. The respective detailed to be displayed will get displayed for the understanding of the user.

Step 5: After executing the required action the controller will start to repeat step3.

Step 6: If the power supply is not provided to the system then it turns to sleep mode.

In 4-way intersection point of the road, the vehicles are regulating by a centralized control system mainly with a traffic signal or by traffic police. If centralized control fails, the impact would be huge. With VVI algorithm vehicles will communicate among themselves. The vehicles are allowed to pass on priority, based on their time of arrival at the 4-way intersection road. Among them, one vehicle will be assigned as a master.

The master has to put himself in wait mode to serve the vehicles in the opposite lane know as slave lane. This is done by Master-slave configuration. With this approach, the work of regulating traffic melts invisibly into the wireless infrastructure.

The job of the master is to assign a red signal to its lane, the entire lane will be in waiting state and the perpendicular lane to the master lane will get a green signal. After 30 seconds, another vehicle from the perpendicular lane will be made to act as the master. The leadership will be circulated in a circular manner. If there is no cross traffic then the vehicle is allowed to cross without waiting. In addition, if there is an emergency vehicle in the master lane the algorithm will assign way for it by providing the highest priority to them.

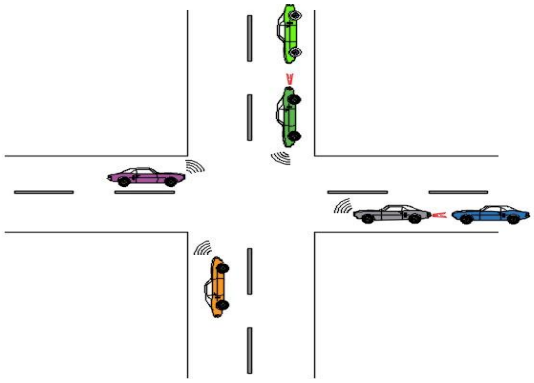

Fig.7 communicative vehicle in intersection point

As shown in Fig. 7 the communicative vehicle in an intersection point and communicating among themselves without the centralized control system sharing the parameters with the nearby vehicles. The selection of master-slave will be done by considering parameters such as speed, latitude and longitude, the direction of movement, estimated time to reach the intersection point etc, will get considered. Those information about a vehicle will be communicated to the nearby vehicle through RF wireless communication technology. This algorithm reduces the number of accidents at the intersection points and also reduces the unwanted waiting time at the signals. With this algorithm, the efficiency of traffic control will be improvised. This policy ensures that if a vehicle closer to the intersection point gets the right-of-way that is, the virtual green light then the vehicle far from the intersection will get wait signal. In addition, once the decision has been made, a head-up display in each car displays the light to the driver from a normal viewing position. Implementation of this VVI algorithm does not require any centralized unit, sensors on the roads, cameras, and radar or lidar technology. It gets all the required orientation with wireless system precisely the function we are using it for, intersection collision avoidance and dedicated short-range communication in an intersection. This algorithm gives way for better and safer driving experience, increases traffic efficiency and road safety.

VVI algorithm implemented with the help of LORA SX1278 RF module, GNSS L-86, Li-Fi module, Ultrasonic, and Arduino Nano.

The centre point of the 4-way intersection is measured and stored as a database. Likewise, for all the intersection the quadrants will get collected and stored for the better performance.

The speed limit of the vehicle closer to intersection point is controlled automatically through a signal which will be placed in the speed limit board. Thus, the vehicle reaches the intersection point at a low speed.

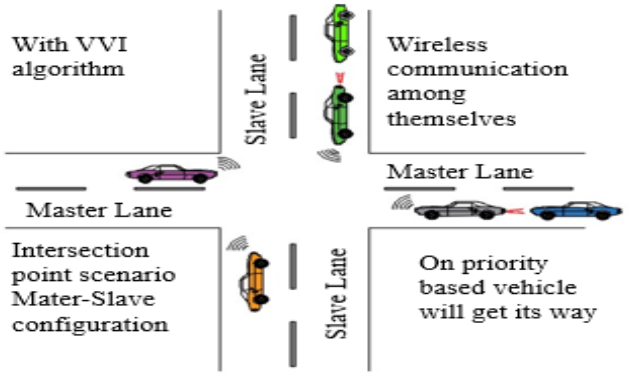

Fig. 8 master-slave configuration in intersection point

The fig.8 shows the diagrammatic representation of communicative vehicles in the intersection point and configures master and slave. Therefore, the parameters like estimated time for a vehicle to reach the intersection point will be calculated and the direction of movement of the vehicle towards or outwards from the intersection will also be calculated and communicated through LORA RF module earlier.

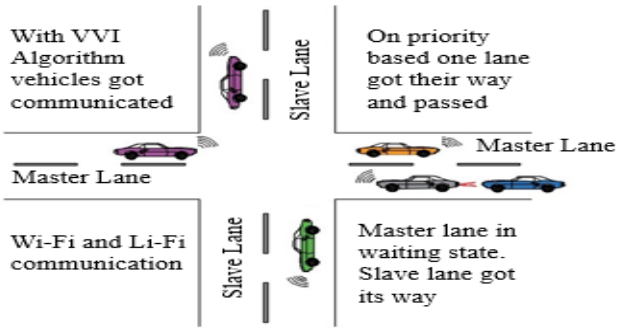

Fig.9 Master in wait mode& slave lane has moved

The Fig.9 shows the lane crossing by the slave vehicle, which is directed by the master vehicle. In addition, the perpendicular lane will be in the waiting state. After 30 seconds, the waiting lane will get its way and other lanes will be in the waiting state.

Fig.10 Prototype model

The fig. 10 shows the prototype model of “VEHICLE TO VEHICLE COMMUNICATION IN INTERSECTION”.

This helps in implementing the VVI algorithm for better understanding and to check the performance of various modules involved. This will helps to implement this idea in real-time as error free system. When the system gets implemented in the real-time a secondary system as like as primary system will will be installed along with the primary system for the safety and security purpose. The operation of secondary system is to monitor the primary system. If the primary system fails the secondary system has to do the required to avoid the problem.

VI. COMPARATIVE ANALYSIS

1. "Design and implementation of a vehicle to vehicle communication system using Li-Fi technology"[4]
In this paper, they tried to intimate driver about the surrounding vehicles and its position in a T junction. But in this idea, there will not be not intimation the communication done directly between vehicles. The deceleration and acceleration of the vehicle are controlled automatically. So, the driver will not get diverted while driving.

2. "Cooperative autonomous driving for traffic congestion avoidance through vehicle to vehicle communication technology"[5]
This paper explains about autonomous vehicles for traffic congestion avoidance. This technology for an autonomous vehicle is costlier but our algorithm can be implemented in all types of vehicles at a lower cost and with more efficiency.

3. "Vehicle to vehicle communication technology and platooning using EV with wireless sensor network"[6]
This paper uses a V2V communication technology for communicating between the vehicles and to share the details about the vehicle. But, in our idea, we are concentrating more on the intersection point in order to prevent traffic congestion and to reduce the waiting time at the signals.

VII. RESULT ANALYSIS

The distance between Karunya Institute of Technology and Sciences, Coimbatore-641114, Tamil Nadu and Gandhipuram -641012, Coimbatore, Tamil Nadu is 31km. The normal time taken to reach this distance is 1hrs 45 minutes. Moreover, in peak hours the time taken would be approximately 2 hrs or more. In between this route, there are 5 traffic signals to be crossed. If it takes 120 seconds in a signal then to cross all those signals it will take approximately 600 seconds which is 10 to 20 minutes wasted just by waiting at the signals. But vehicle implemented with this module roughly takes 1 hour to reach the destination.

VIII. CONCLUSION

Life is short, and it seems shorter when we are waiting at the traffic signals. By implementing this VVI algorithm in all the vehicles we can save the time wasted at the traffic signals and reduces unwanted traffic jams. This system can create road free from traffic signals and vehicles would easily communicate with each other to cross any intersection points with less time and more accuracy.

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AUTHORS PROFILE

Sundara Ganesh S Pursuing Under Graduate degree in Karunya institute of technology and sciences bachelors of technology under the stream of Electrical & Electronics Engineering. I am performing outstanding excellence in studies and research work. I am interested in doing things which is more innovative. Presented my various innovative ideas in various National and International conference. I have completed a research work under the topic biogas from fish wastes(Non-edible parts) and got published in IEEE Explorer. Innovative idea like new learning kit for the deaf people using smart phone was done by me in lower cost to educate the deaf people. I am holding membership in ITEEA - International Technology and Engineering Educators Associates, IAENG - International Association for Engineering. My domain is embedded system design which should be more innovative and should solve the society problem.

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