VEHICLE PLATOONING

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Abstract— **This paper gives an insight on the implementation of the concept of vehicle platooning for vehicles moving in linear motion on highways. The implementation uses two autonomous prototypes. Our proposed approach involves V2V (vehicle to vehicle) communication and V2I (vehicle to infrastructure) communication which has been successfully established. This implementation serves as an affordable realization and a proof of concept of vehicle platooning.**

Keywords- **Platooning, Vehicle to vehicle communication, Vehicle to infrastructure communication, Socket APIs.**

I INTRODUCTION

Vehicle platooning is an important innovation in the automotive industry that aims at improving the safety, mileage, efficiency and the time needed to travel. Platooning vehicles in tightly spaced highways, which are computer controlled will lead to savings in fuel, increased highway capacity and increased passenger comfort. The introduction of automation into road traffic can provide essential solutions to the mainstream issues of accidents, traffic congestion, pollution and fuel consumption.

Under cooperative driving in Highways, automated vehicles drive like the migration of birds or a group of dolphins; the formation of birds in the migration is aerodynamically efficient, and dolphins swim without collision while communicating with each other. The co-operative driving, simulating the formation of birds or dolphins, will contribute to the increase in the road capacity as well as in the road traffic safety.

In 1995, a research report by National Automated Highway System Consortium (NAHSC) in San Diego presented a detailed description on the aerodynamic performance of platoons revealing that the air drag coefficient which accounts for both the vehicle size and velocity, experienced about 55 % reduction on average in 2, 3 and 4-vehicle platoons [1].

The platoon demonstrated the ability to start, stop, accelerate and decelerate as a single unit. Also demonstrated was the ability to split the platoon to allow for the entry of vehicles and then to rejoin as one platoon. A Heads-Up-Display unit was used to communicate to the driver information such as speed, distance to destination and whatever maneuver the vehicle is currently executing. Following the concept presented earlier, we can say that Vehicle Platooning is an approach to improve the current transportation system both economically and technologically.

The vehicles follow one another with a very small headway-vehicle spacing, as little as a couple of meters-and be “linked” through headway control mechanism, such as radar-based or magnetic-based systems. The first vehicle in every platoon (the leader) continuously provides the other vehicles, the followers, with information on the AHS (automated highway system) conditions, and what maneuvers, if any, the platoon is going to execute.

In Vehicle Platooning, a group of vehicles travel in close co-ordination under fully automated longitudinal and lateral control. The vehicles maintain a constant fixed spacing between themselves at all speeds. This short spacing results in increased highway capacity. Safety is increased by automation and close co-ordination between vehicles. Because of small relative speed between the vehicles, even extreme accelerations and decelerations cannot cause serious impacts on the vehicles, thus increasing passenger comfort.

II THE BASIC PRINCIPLE

The algorithms used for the implementation of vehicle platooning are obstacle detection, automatic braking, vehicle to vehicle and vehicle to infrastructure communication. The implementation involves a master car as well as a fleet of following cars communicating with each other, wherein the master car detects obstacles and commands the platoon cars to follow instructions like stop, move and brake. V2V and V2I algorithms the fleet of vehicles to maintain a safe distance between each other and travel at high speeds in a platoon.

Our proposed system to implement vehicle platooning consists of a smart computer namely raspberry pi 2 model B+. An ultrasonic sensor (HC-SR04), a servo controller (SG90), DC motor driver L298N, Wi-Fi modules, DC-DC step down converter based on XL1509.

III SYSTEM DESIGN

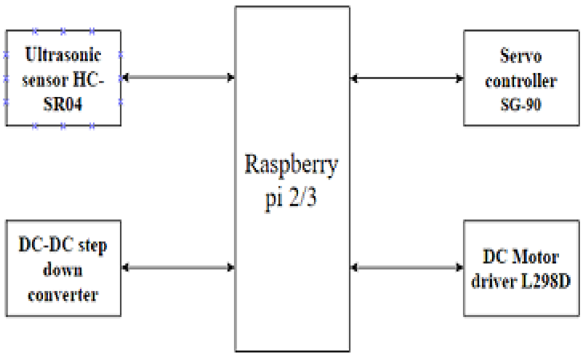

Fig 1. Block diagram

The ultrasonic sensor helps to detect whether an obstacle is in the path of the vehicle. This data from the ultrasonic sensor is sent to the microcomputer in the smart car, in this case it is the raspberry Pi as shown in Fig 1. The servo helps to steer the vehicle in the desired path. The dc motor driver helps to accelerate or decelerate the vehicle based on the path, course and other sensor data. The constant working voltage is provided by a step-down dc-dc converter.

IV HARDWARE

A. ULTRASONIC SENSOR

Ultrasonic sensors operating at frequency of 40Khz is much reliable than the IR sensor, they provide distance measurement efficiently regardless of color and lighting of obstacles. They measure lower minimum distances and wider angles of detection to ensure that obstacles are not missed by a narrow sensor beam. It measures distance by sending out a sound wave at a specific frequency(trigger) and waiting for that sound wave(echo) to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, the distance is calculated between the sonar sensor and the object.

B. DC-DC STEP DOWN CONVERTER

Built based on the chip XL1509, the module converts the battery output of 7.5V to 5V, so as to supply power to Raspberry Pi and the servomotor. This component is inexpensive and also provides efficient voltage conversion. As a DC to DC converter IC, the chip has an input voltage ranging from 4V to 40V and generates an output voltage of 5V with a current of as high as 2A. Please note: only when the input voltage is up to 6.5V, a 5V output can be supported.

C. DC MOTOR DRIVER L298N

The motor driver module is used to drive DC motors. The driver is built based on L298N. It is used as a high-voltage and large-current chip for motor driving, encapsulated with 15 pins, the chip has a maximum operating voltage of 45V and an instant peak current of as high as 3.0A, with an operating current of 2.0A and rated power of 25W. Thus, it is completely capable of driving two low-power DC motors.

D. SERVO CONTROLLER SG90

Servo control is achieved by transmitting a PWM signal, a series of repeating pulses with different width where either the width of the pulse (most common servos) or the duty cycle of a normal pulse train (less common) determines the position to be achieved by the servo. Small and lightweight with high output power. Servo can rotate approximately 180 degrees (90 in each direction). Small size and less complexity makes the servo controller an efficient manoeuvring hardware in our platoon.

E. RASPBERRY PI

The Raspberry Pi is a credit-card-sized computer having its own dedicated operating system that plugs into your TV and keyboard. It is a capable little computer which can be used in electronics projects, and for many of the things that your desktop PC does, like spreadsheets, word processing, browsing the internet, and playing games. It is one of the most widely used open source microprocessor to implement small-scale projects based on python code. Our hardware prototype involves communication between multiple micro-pc's which has to be fast and error free with minimal delay. Hence, Raspberry pi is considered because of its high-speed processor.

V SOFTWARE

A. PYTHON IDE

Python is a high-level, interactive and object-oriented scripting language which is highly readable. It uses English keywords frequently where as other languages use punctuation, and it has fewer syntactical constructions than other languages like Java and C++. Python has a design philosophy which emphasizes code readability.It supports functional and structured programming methods as well as OOP. The language provides constructs intended to enable writing clear programs on both a small and large scale. Raspberry pi boards can be programmed easily with python language.

Socket APIs – A network socket is an internal end-point for transmission and reception of data at a single node in a computer network. The application programming interface (API) that programs use to communicate with the protocol stack, using network sockets, is called socket API. Internet socket APIs are usually based on Berkeley sockets standard.

B. SYSTEM INTEGRATION

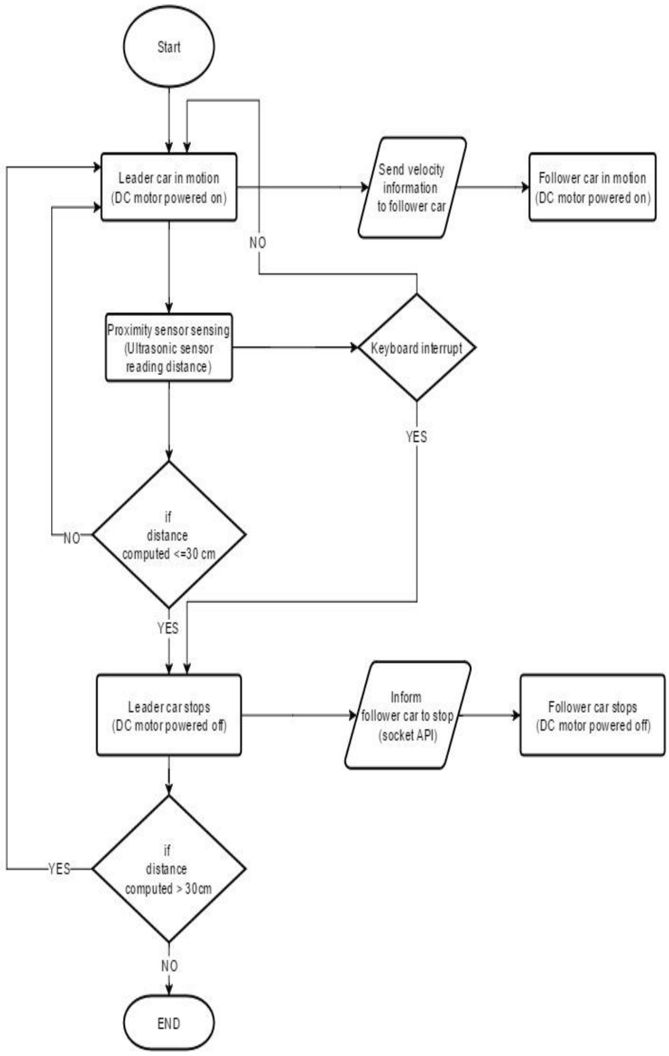

Fig 2. V2V communication

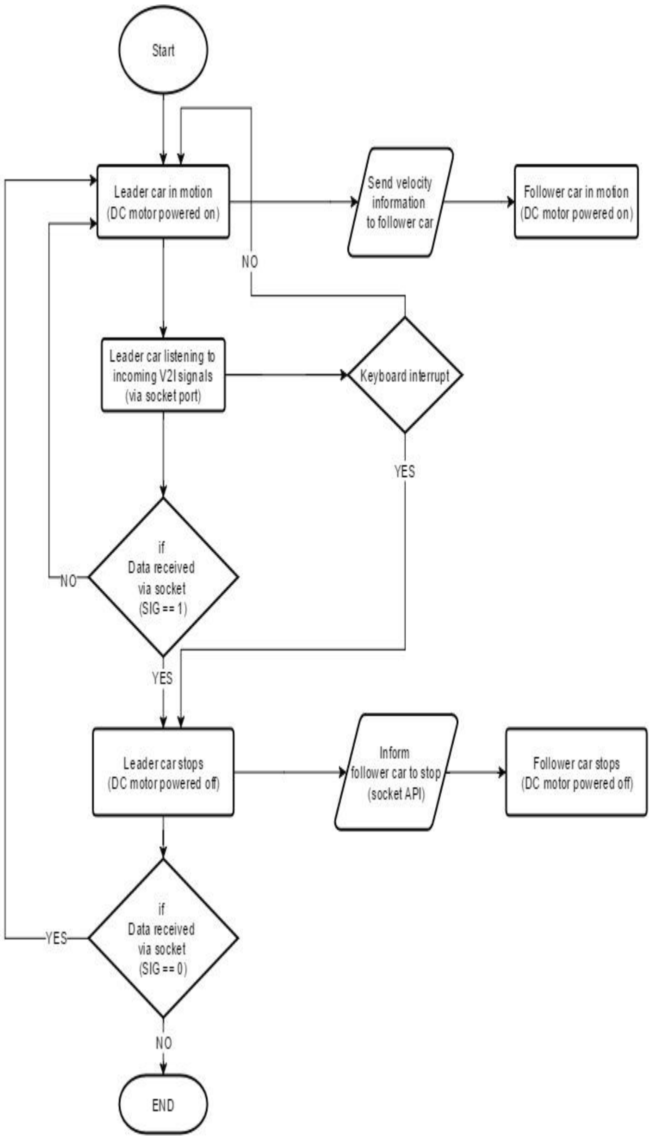

Fig 3. V2I communication

This algorithm is designed to implement the vehicle platoon consisting of a master and a slave. The master car detects the obstacles and communicates with the platoon car either to stop or continue its motion as shown in Fig 2. The object detection is made using the ultrasonic sensor and the minimum distance assigned to the object detection algorithm is about 30cm. If any object is detected within this 30cm then the master car stops and also instructs the platoon cars to stop accordingly.

This is an algorithm used to establish communication between the infrastructure and any vehicle in a platoon. From Fig 3 it can be inferred that if the socket sig==1, the master car stops and instructs the platoon cars to stop. If the socket signal received is 0 then the platoon continues its motion without any interruption.

VI RESULT ANALYSIS

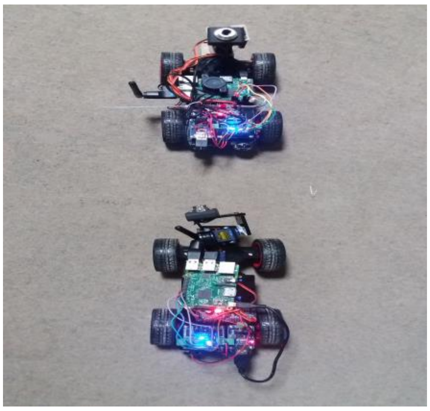

Fig 4. Master car and slave car moving in a platoon

The obstacle detection, V2V, V2I and automatic braking algorithms have been successfully implemented and tested as shown in fig 4. The master car is able to detect obstacles, brake automatically and communicate with the platoon cars to follow its instructions. Our implementation serve as a low-cost prototype demonstration of the concept of vehicle platooning for linear motion on highways. Since this implementation involves less number of sensors and has cost constraints, it will not be suitable for real time implementation. For accurate and precise implementation radar, lasers and expensive computing equipment are required.

VII CONCLUSION

The hardware prototype for implementation of vehicle platooning for V2V and V2I were successfully implemented. Here the RC cars were programmed to perform "stop and go" operations synchronously. The leader car holds the control over the follower car in the platoon and since they are constantly communication there will be less room for error in individual cars.

VIII FUTURE SCOPE

As of now the implementation of the concept of vehicle platooning is done with highways and heavy duty vehicles like trucks as the main consideration. Our implementation is on a smart car prototype. In future, it can be done on actual autonomous vehicles and considering city traffic and road conditions.

IX REFERENCES

[1]. Michele Segata, Falko Dressler, Renato Lo Cigno and Mario Gerla, "A simulation tool for Automated Platooning in Mixed Highway Scenarios", ACM on Mobile computing and communications review, vol. 16, no. 4, October 2012, pp. 46-49.

[2]. Kuo- Yun Liang, Jonas Martensson, and Karl H. Johansson, "Heavy Duty Vehicle Platoon Formation for Fuel Efficiency", IEEE Transactions on Intelligent Transportation Systems, vol. 17, no. 4, April 2016, pp. 1051-1060.

[3].Soodeh Dadras, Ryan M. Gerdes and Rajnikant Sharma, "Vehicular Platooning in an Adversarial Environment", ACM Symposium on Information, Computer and Communications Security, April 2015, pp. 167-178.

[4]. Imran Sajjid, Daniel D. Dunn, Rajnikant Sharma and Ryan Gerdes, "Attack Mitigation in Adversarial Platooning Using Detection-Based Sliding Mode Control", ACM Workshop on Cyber-Physical Systems-Security and/or PrivaCy, October 2015, pp. 43-53.

[5].Michele Segata, Renato Lo Cigno and Falko Dressler, "Towards Communication Strategies for Platooning", IEEE Transactions on Vehicular Technology, vol. 64, no. 12, 2014, pp. 5411-5423.

[6]. Pedro Fernandes and Urbano Nunes, "Platooning of Autonomous Vehicles with Intervehicle Communications in SUMO Traffic Simulator", IEEE Annual Conference on Intelligent Transportation Systems, September 2010, pp. 1313-1318.

[7]. CONTET Jean-Michel, GECHTER Franck, GRUER Pablo and KOUKAM Abder, "Physics Inspired Multiagent System for Vehicle Platooning", ACM conference on Autonomous agents and multiagent systems, May 2007, pp. 361-363.

[8]. J. Bom, B. Thuilot, F. Marmoiton and P. Martinet, "Nonlinear Control for Urban Vehicles Platooning, Relying upon a Unique Kinematics GPS", IEEE International Conference on Robotics and Automation, April 2005, pp. 4138-4143.

[9].Tushar Tank and Jean Paul M. G. Linnartz, "Vehicle-to-Vehicle Communications for AVCS Platooning", IEEE Transactions on Vehicular Technology, vol. 46, no. 2, May 1997, pp. 528-536.

[10]. U. Franke, F. Bottiger, Z. Zomotor and D. Seeberger, "Truck Platooning in Mixed Traffic", IEEE Symposium on Intelligent Vehicles, September 1995, pp. 1-6.