AUTO-LEADING ROBOTIC CONVOY

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Abstract - **Over recent years researches have been conducted that revolutionize mobility, these researches lead to the development autonomous ground vehicles. Numerous companies and agencies around the world are working towards developing automated solutions for a variety of applications that seek to benefit military and civilian interests. These include robotic convoy, a convoy is basically a group of vehicles that travel together that mutually support and protect each other.**

The focus of the project is to develop controllers to make each robot capable of following a leading robot in an auto-leading manner, so that if the current leader fails then the robot immediately following it takes up the leadership and so the collective of robots will be able to drive in a stable convoy. A hardware and sensor setup will be developed. This enables each robot to measure the distance ahead. The user interacts with the system using a central control.

Keywords- **Convoy, Arduino, nRF24L01, IRProximity Sensor, DC Motor, Arduino IDE.**

I. INTRODUCTION

Convoy driving is a relevant area of research, since it is applicable to both mobile robotic formation control and to traffic optimization. In many applications a single operating mobile robot is not feasible, and to have more mobile robots working on the same task requires coordination and to some extent formation control. Instead of having a large complex single robot a convoy system has multiple robots working on a task, all of them having a simple design. The system thus becomes more economical, it better is scaled and when more robots work together on a common task, the overall failure rate might be smaller [1].

Because roadside bombs have claimed the lives of thousands of troops, both the Army and Marine Corps are pursuing efforts to reduce the number of injuries and deaths by developing robotic trucks that can drive long distances at highway speeds. As part of its modernization plan, the Army is funding several ground robotics programs ranging from small, remotely controlled explosive ordnance disposal units to large autonomous wheeled vehicles. One of the more mature initiatives is a kit that promises to turn any of the Defense Department's trucks into an autonomous system. Funded by the Army Tank Automotive Research, Development and Engineering Center, the convoy active safety technology program aims to improve convoy operations. The kit is small enough to be installed in the cab of a transport vehicle while allowing ample room for soldiers to ride along. It connects to the steering wheel and pulls in feeds from the various sensors that are installed on the vehicle. The sensors include millimeter wave radar, LIDAR (light detection and ranging) and electro-optical and infrared cameras. The system is configured to operate either in an optionally piloted mode where the soldier sits behind the wheel but the vehicle drives itself, or in a fully autonomous mode without any humans in the cab. If an insurgent tries to disrupt the convoy by cutting into the line of vehicles, troops can simply hit a red button to disengage the autonomy in order to take control of the situation [2].

II. OBJECTIVES OF THE PROPOSED PROJECT

The objective of the project is to develop an auto-leading robotic convoy system. A hardware and sensor setup is developed. This enables each robot to measure the distance of the robot ahead of it. The central control takes care of the entire convoy system consists of robots and the user interacts with the system using this.

The aim of the project is to develop controllers to make each robot capable of following its immediate leader, that is, the robot just ahead of it in the convoy setup. This is also done in an auto-leading manner, so that if the current leader fails then the robot immediately following it takes up the leadership. In this way the collective of robots will be able to drive in a stable convoy. The leader is found out based on priority. The central control system broadcast the priority and commands to all the robots in the convoy and that robot that has the same priority as the broadcast priority is selected as the leader. The distance between the robots will be maintained so as to avoid collision. The distance is maintained using IR proximity sensors. These sensors emit

Manuscript received March, 2014.
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ISSN: 2278 – 7798

infra red rays and these rays go and hit the object in front of it and gets reflected. Depending on the range of the intensity value returned, the distance is determined. This idea can be extended in military and this is extremely useful as human lives can be saved.

III. ARCHITECTURE OF THE SYSTEM

A.CENTRAL CONTROL

The user interacts with the convoy system using the central control. Initially, the priority values are set for each robot. The commands and the current priority are sent by the central control to all the robots. The initial priority value sent is 00(highest). If the robot with the same priority is present, it broadcast an acknowledgement back to the central control and that particular robot is set as the master. If within a timeframe the acknowledgement doesn't come back to the central control, the priority value is incremented by one and this is again sent along with the corresponding command.

B.ROBOT

The present master and the slaves buffer the command sent in by the central control. After the present master is set by checking the priority value, the present master send an acknowledgement back to the central control. The command is acknowledged by the master and the corresponding command is executed. The robots maintain a constant distance with its immediate master. The slave calculates the distance to its immediate master using IR Proximity Sensors. The intensity value is thus got and the range of the intensity value is considered to calculate the distance.

The amplitude response of infrared (IR) sensors depends on the reflectance properties of the target. Therefore, in order to use IR sensor for measuring distances accurately, prior knowledge of the surface must be known. (IR) sensors are extensively used for measuring distances. Therefore, they can be used in robotics for obstacle avoidance.

IV. SOFTWARE DESCRIPTION

The open-source Arduino environment makes it easy to write code and upload it to the I/O board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing, avr-gcc, and other open source software. The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and is derived from the IDE for the Processing programming language and the Wiring projects .

It is designed to introduce programming to artists and other newcomers unfamiliar with software development. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. A program or code written for Arduino is called a "sketch". Arduino programs are written in C or C++. The Arduino IDE comes with a software library called "Wiring" from the original Wiring project, which makes many common input/output operations much easier [4].

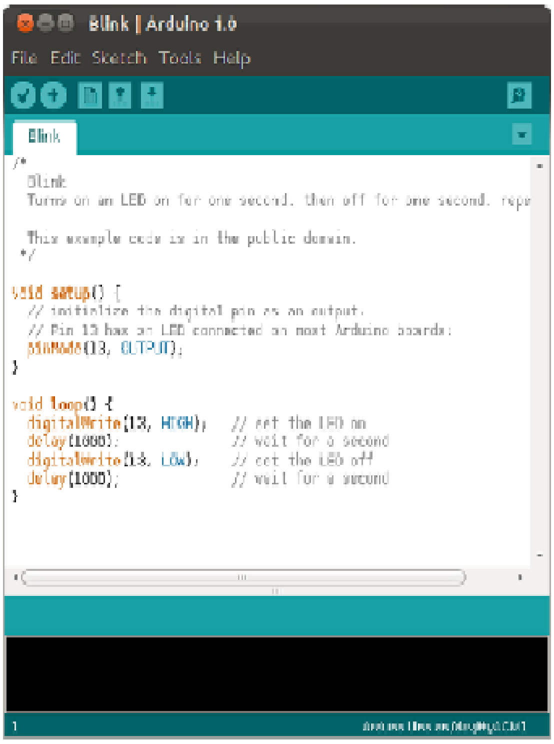

Fig 5.1: Arduino Software IDE

Users only need define two functions to make a runnable cyclic executive program:

- setup(): a function run once at the start of a program that can initialize settings
- loop(): a function called repeatedly until the board powers off.

V. HARDWARE COMPONENTS

A. ARDUINO UNO BOARD

Fig 7.1: Arduino Uno Board

Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Pre-programmed into the on-board microcontroller chip is a boot loader that allows uploading programs into the microcontroller memory without needing a chip (device) programmer [5].

B. DC MOTOR

A dc motor is an electromechanical device that converts electrical energy into mechanical energy that can be used to do many useful works. DC motors comes in various ratings like 6V and 12V. It has two wires or pins. When connected with power supply the shaft rotates. Its direction of rotation can be changed by reversing the polarity of input.

Fig 7.2 DC Motor

C.DC MOTOR CONTROLLER (L293D)

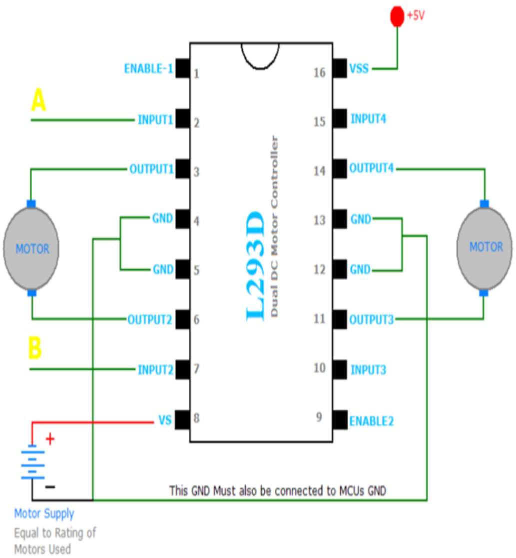

Fig 7.3: Motor Controller Using L293D

The chip controls two DC motors, so there are two more output pins **(output3 and output4)** and two more input **pins(input3 and input4).** The INPUT3 and INPUT4 controls second motor in the same way as listed above for input A and B. There are also two ENABLE pins they must be **high (+ 5v)** for operation, if they are pulled low (GND) motors will stop. The speed of DC motor can also be controlled with MCU. PWM or pulse width modulation technique is used to digitally control speed of DC motors. This is done using the ENABLE pins [6].

D. TRANSCEIVER-nRF24L01

The nRF24L01 is a single chip 2.4GHz transceiver with an embedded baseband protocol engine designed for ultra low power wireless applications. The nRF24L01 is configured and operated through a Serial Peripheral Interface (SPI).

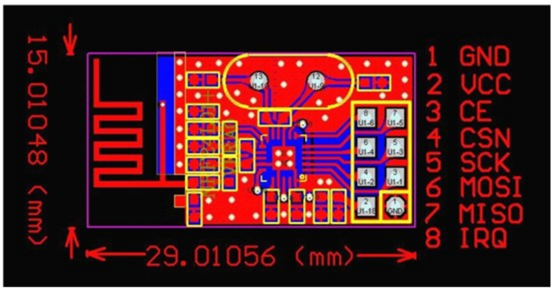

Fig 7.4: nRF24L01+Module

The nRF24L01 module can be controlled in many ways, one of which is Arduino. There should be at least two Arduino boards and at least two RF modules, one to transmit and the other to receive [7].

E.IR Proximity Sensor

Fig 7.5: IR Proximity Sensor

A **proximity sensor** is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks

ISSN: 2278 – 7798

for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target.

The maximum distance that this sensor can detect is defined "nominal range". Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object [8].

VI. OVERVIEW

The leader in the convoy setup is identified based on the priority value send by the central control. The robot that has the same priority value as the priority send by the central control is identified as the current leader. The commands for the robots in the convoy are also sent by the central control along with the priority value. Depending on the command send by the central control, the robots in the convoy move. The commands are send from user to central control through the Arduino IDE serial monitor.

The distance between the robots must also be maintained so as to avoid collision. The distance is estimated using IR proximity sensors; these sensors are able to detect the presence of nearby objects without any physical contact. In case the current leader fails, and the acknowledgement is not received within a given time, the priority value is incremented. The new priority value is then sent by the central control system. And the robot with this new priority value takes up the leadership. The convoy setup again works properly with its new leader.

Commands to a slave robot are send by its immediate leader. In case of failure if a slave robot, the leader performs the same task as the Central Control, it increments the priority and sends the command to the next slave in line.

Communication is established with the help of pipes. Each robot is allocated a pair of two unidirectional pipes for reading commands from Central Control or leader and writing acknowledgments to slave robot.

VII. RESULT

Unlike the earlier convoy set-up where the malfunctioning of the leader halted the entire system, the convoy set up was built in an auto-leading manner. The features Of the Convoy Setup are

1. Identifying the leader in the convoy setup based on the priority value broadcast by the central control.
2. That robot that has the same priority value as the priority broadcast by the central control is identified as the current leader.
3. The commands for the robots in the convoy are also broadcast by the central control along with the priority value.
4. Depending on the command broadcast by the central control, the robots in the convoy move.
5. The distance between the robots must also be maintained so as to avoid collision.
6. The distance is estimated using IR proximity sensors; these sensors are able to detect the presence of nearby objects without any physical contact.
7. In case the current leader fails, and the acknowledgement is not received within a given time, the priority value is incremented by 1.
8. The new priority value is then broadcast by the central control system. And the robot with this new priority value takes up the leadership.
9. The convoy setup again works properly with its new leader.
10. Pipe pairs are allocated for each robot for communication.

The major advantage of the developed convoy system is that when this idea is extended in military area, human lives can be saved. The existing systems have human driven convoys, but now since the convoy is controlled using a central control, the human force is not directly involved. So human lives can be saved and moreover the convoy setup will not halt even if the current leader fails.

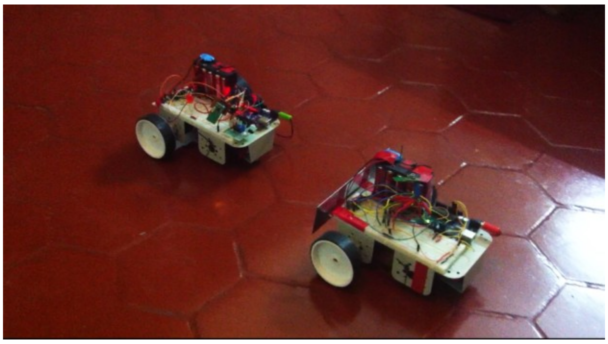

Fig 7.6: Final Robots

VIII. CONCLUSION

In this system, the convoy setup was made in an auto-leading manner. The leader was found out using priority values. The commands were sent along with the priority value. The distances between the robots were maintained using IR Proximity Sensors. If the current leader had failed and the acknowledgement had not reach within a specified time limit, then the priority value was incremented and again sent by the central control. And in this way, the new leader was selected. Now all the slaves followed the new leader in the convoy setup. Therefore the convoy setup was maintained without halting the entire system. Thus the above automated solution can be applied for a variety of applications that seek to benefit military and civilian interests. These include robotic convoy, a convoy is basically a group of vehicles that travel together that mutually support and protect each other.

IX. Future Scope

1. The convoy can made with any number of robots.
2. The setup can be made to incorporate angular turns, for this Digital Compass can be used.
3. Bluetooth or Wi-Fi can be used to send commands and priority instead of the transceiver (nRF24L01+module). So that the signal transmission can be extended to a wide range.

ACKNOWLEDGMENT

The author would like to thank the anonymous reviewers for their valuable comments.

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ISSN: 2278 – 7798