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FABRICATION OF AN ULTRASONIC SHORT RANGE RADAR VEHICLE SYSTEM

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Abstract*-As a fast moving modern era accelerated by scientific and technological advancement towards future, security concerns also increases. In the modern era, radar plays a vital role in the surveillance system to detect any suspicious objects as well as it plays an undeniable role in air traffic controlling system. The model describes a Short Range Radar system based on Ultrasonic Sensor and Programming. In this project the fabrication of a Radar system prototype mounted on a RC car vehicle is depicted where the sensor is driven by a servo and a circuit is used to synchronize them in the micro controller. Then necessary programming is done to visualize for detection of objects on another software named Processing. According to the position of any object, the distance and angle are visualized on screen. The main aim of this model is to enhance security and controlling system economically coupled with portability.*

Keywords: Radar, Ultrasonic Sensor, RC Car, Processing Software.

1. INTRODUCTION

RADAR is an object detection system that uses radio waves to determine the range, altitude, direction or speed of objects. Radar systems come in a variety of sizes and have different performance specifications. Some Radar systems are used for air-traffic control [1] at airports and others are used for long range surveillance and early protection systems. Ground Penetrating Radar [2] is used for geological observations, mine inspection, locating underground pipes.

Small portable radar systems can be maintained and operated by one person are available as well as systems that occupy several large rooms.

Radars send out electromagnetic waves similar to wireless computer networks and mobile phones. The signals are sent out as short pulses which may be reflected by objects in their path, in part reflecting back to the radar. When these pulses intercept precipitation, part of the energy is scattered back to the radar. This concept is similar to hearing an echo, in that same way, the pulse reflects off precipitation and sends a signal back to the radar. From this information the radar is able to tell where the precipitation is occurring and how much precipitation exists. When instead of electromagnetic waves, ultrasonic waves are used it is called Ultrasonic radar.

An Ultrasonic radar system usually operates in the ultra-high-frequency (UHF) or microwave part of the radio-frequency (RF) spectrum [3]. Most radar systems determine position in two dimensions: azimuth and radius. The display is in polar coordinates. A rotating antenna transmits RF pulses at defined intervals. The delay between a transmitted pulse and the echo, or return pulse, determines the radial position of the plotted point(s) for each azimuth direction on the display. The greater the echo delay from a particular object in space, the farther from the display centre its point appears.

Ultrasonic sensor is the heart and soul of an Ultrasonic short range radar system. Ultrasonic sensors work on a principle similar to a sonar which evaluates attributes of a target by interpreting the echoes from radio or sound waves respectively. They generate high frequency sound waves and evaluates the echo which is received back by the sensors. The sensors calculate the time interval between sending the signal and receiving the echo to determine the position of the object [4]. This system is a however comparable to the natural phenomena of the movement of a bat. The system typically use a transducer which converts electrical energy into sound energy of above 20,000 Hz, then upon receiving the echo the sound energy is converted into electrical energy which can be measured and displayed.

2. RESEARCH MODEL

This project focuses on the design and construction of an Ultrasonic Radar System having a carrier which can be controlled via Bluetooth. The main objective is to design a simple, reliable and cost effective device which can detect any kind of thing, let it be a materialistic object or a living being in any environment within its range. The sensor transmits echoes of ultrasonic waves and if obstructed by anything the echoes returns and are

received by the sensor. Depending upon the time taken to transmit and return, a program calculates the distance of the object which obstructed the flow of ultrasonic waves. The construction was divided into several stages and each stage was tested separately.

1. The design of the project of ultrasonic sensor mainly executes the following conditions:
2. Upon the start of the device a map is shown on the monitor with a range of approximately 180 degrees, with a spike rotating according to the sensor rotation.
3. If no object is detected or not within the range of the radar, the map stays in green colour.
4. If an object is detected or found within the range of the sensor, that portion of the map will turn in red colour, the remaining undisturbed zone stays green.
5. The distance and the angle of the object from the device is shown on the display.
6. The device is mounted on a Bluetooth controlled vehicle so that it can be moved forward or backward thus apparently increasing the range of the device.

To design and fabricate the project, the project was divided into several stages which are as following:

1. Design of the ultrasonic sensor based radar system.
2. Implementation of several parts of the circuit.
3. Programming of the polar co-ordinates calculation.
4. Programming to visualize the radar map.
5. Detection of object.
6. Mounting the device upon a Bluetooth controlled vehicle.

3. CONSTRUCTION OF THE ULTRASONIC RADAR & VEHICLE

In this project the construction of the ultrasonic based radar is mainly focused. Along with the ultrasonic sensor which is run by a servo and arduino the total setup is mounted on a robotic car which can be controlled remotely by wireless communication system which is connected to an android application. By using the android application which operates on Bluetooth technology one can easily control the vehicle and then connect the radar system with the computer.

At first the basic Radar project was built, then to increase the mobility of the system the RC car project which can be considered as a carriage medium of the basic project was developed.

3.1 Required Components

Mechanical and Electrical system includes:

1. Ultrasonic sensor (HC-SR04)
2. Servo motor
3. Arduino Mega
4. DC motor
5. Arduino motor shield (L298N)
6. Bluetooth module
7. Power supply (LiPo battery)

Software system includes:

1. Arduino IDE software
2. Processing software.

3.2 Construction of the Radar Section

The development of the Ultrasonic Radar system was done in three steps. These steps are

1. Developing the circuit diagram according to which the devices will be implemented.
2. Developing two software programs on Arduino IDE and Processing software.
3. Implementing the devices as per the circuit diagram and connecting the devices with the developed programmes.

The first step towards developing the program was to develop the circuit diagram. The circuit diagram as shown in the figure consists of Arduino UNO, Servo motor, Breadboard, Ultrasonic sensor.

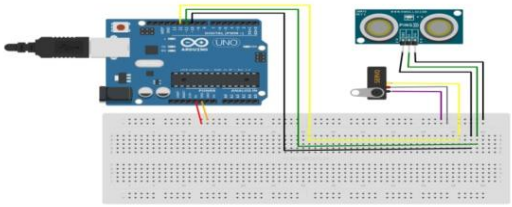

Fig 1: Circuit Diagram

As shown in the Figure 1, the 10, 11, 12 no. ports of the Arduino UNO is connected to the Breadboard points. The 5V and Gnd ports are also connected to the respective ports of the Breadboard. On the other hand the four pins of the Ultrasonic sensor named as VCC, Trig, Echo, Gnd and three ports of the Servo motor are also connected to the breadboard accordingly.

3.3 Radar Programming

For the Radar project two software was used to run the setup. So to run these two software, two source code were developed. These source code was one for the Arduino IDE another is for the Processing software.

The Arduino source code was developed to receive the values for the angle and the distance measured by the sensor. This code calculates the time of echo via sensor and results the distance and the angle measurement of that echo from the sensor itself. The cause of echo is considered as an object. The program is developed in such a way so that when the sensor transmits any sound in the ultrasonic range and the sounds echoes back when hitting any target object, the program calculates the distance of travel of that echo and thus the distance of that object is measured. The program that was developed in the Arduino is based on the following velocity- time and distance equation as shown in Eq. (1)

$$D = \frac{vt}{2} \tag{1}$$

The Processing function was developed to visualize the calculated object. The program connects with the sensor in such a way that, it takes the input signals from the ultrasonic sensor and represents it visually. As the servo and the sensor rotates there appears a green screen on the monitor which also rotates. If there is no object within the sensor range then the screen stays green. Whenever any object comes within the measuring distance of the sensor that particular portion turns red and

when the sensor moves past the object it again turns green. Thus this colouring code system enables to easily understand if there is any object or intruder in the specified measuring zone. Also there was some problem faced when programming the processing code. Resolution scarcity was one of the main problems, the processing software for full functionality requires a bigger screen with high definition graphics. As our screen was not that big enough so hundred percent pictorial representation of the Radar screen was not possible.

3.4 Construction of the RC Car Section

After the completion of the Radar setup a Bluetooth controlled RC car was developed as a vehicle to carry the setup and also to increase the portability of the project. The RC car was also developed in the following two stages

1. Developing a circuit diagram in arduino and arduino motor shield.
2. Developing a program in arduino to run and control the vehicle by an android application via Bluetooth.

The first stage was to develop a circuit schematic for the arduino and the motor shield with the Bluetooth module. The schematic figure is given below

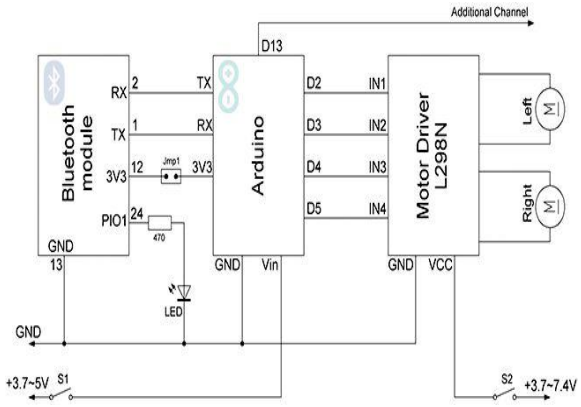

Fig 2: Circuit schematic of the Arduino Mega with the Motor Shield and Bluetooth Module.

An Arduino programming was developed to run the vehicle and also for the connectivity. The program allows to limit the rpm of the DC motors connected to the wheels as per user's choice. It also enables the vehicle to move sideways. After the programming and the circuit drawing, necessary wiring for the implementation of the RC car was done. This program allows the Bluetooth module to connect with any RC car controller application. For this project an app named as Arduino Bluetooth RC Car [4] was used. The program is designed in such a way that it links with the app by Bluetooth technology. The app has a built in command protocol system so that when a user presses front/back/right/left button the vehicle gets the command through the Bluetooth program and executes the command accordingly. Thus it gives a great advantage in case of mobility and the application interface is designed in such a way that anyone can control it thus giving a great user advantage.

4. RESULT

The project enables to establish an Ultrasonic Radar system prototype which is mounted on a remote controlled car. After the arrangement and implementation of the necessary logical steps, appending the segregated sections and execution of necessary coding, the project was completed. The system is able to calculate the distance and angular measurement as well as depict the pictorial view of the system.

Some figures of the final arrangement and results are given below

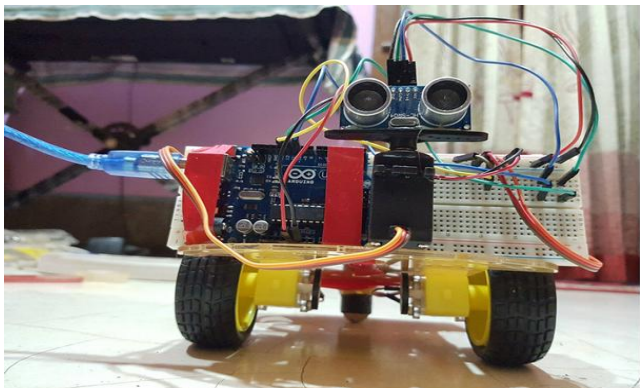

Fig 3: Ultrasonic Radar Vehicle.

The visualization of any detected object programmed by the Processing software is shown in the monitor which is shown below in Figure 4.

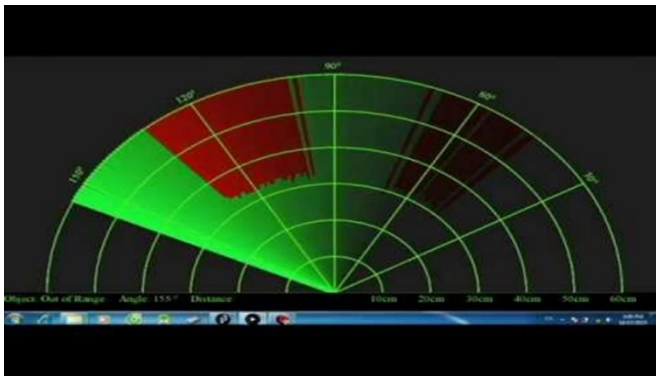

Fig 4: Screenshot of Radar in Processing Software.

The measured values which shows the distance of any object from the Radar programmed by the Arduino IDE is also shown below in Figure 5.

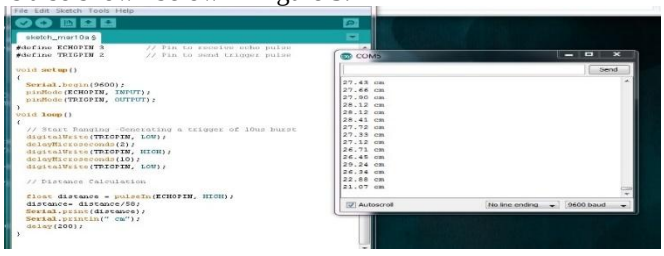

Fig 5: Screenshot of Arduino (Distance) Program.

5. Discussion

Although the Radar depicted here is just a small prototype and designed and fabricated on the basis of simplicity with indigenous materials and by local fabrication, by advanced research and proper arrangement and by using hi-tech instruments, better resolution, more portability, and more features, including complementary navigation systems can be introduced. By changing design and more extensive research in the future, hopefully some limitations such as overall data transmission by complete wireless network, as well as the rotation of the servo motor to a complete 360 degrees can be achieved which will co-ordinate with the Processing as well as Arduino.

6. ACKOWLEDGEMENT

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8. NOMENCLATURE

Symbol	Meaning	Unit
UHF	Ultra high frequency	(Hz)
RF	Radio Frequency	(Hz)
D	Distance	(m)
v	Velocity	(ms^{-1})
t	Time	(s)