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Arduino Based Ultrasonic RADAR System

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Abstract

Radar is an object detection system which uses radio waves to determine the range, altitude, direction, or speed of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations, and terrain. The radar dish or antenna transmits pulses of radio waves or micro waves which bounce off any object in their path. The object returns a tiny part of the wave's energy to a dish or antenna which is usually located at the same site as the transmitter. The modern uses of radar are highly diverse, including air traffic control, radar astronomy, air-defense systems, antimissile systems ;marine radar start locate landmarks and other ships; aircraft anti-collision systems; ocean surveillance systems, outer space surveillance and rendezvous systems; meteorological precipitation monitoring; altimetry and flight control systems; guided missile target locating systems; and ground-penetrating radar for geological observations. High tech radar systems are associated with digital signal processing and are capable of extracting useful information from very high noise levels.
The Arduino based project requires a ultrasonic sensor, the sensor released the waves which we want to measure the distance of a object. The microcontrollers of the Arduino board can be programmed using C and C++ languages. When a code is written in Arduino UNO IDE software and connected to the board through a USB cable, Arduino boards have lot of applications in the present day scenario, so we have decided to do a small project on them

. KEYWORDS-Arduino, Ultrasonic sensor, Servo motor, Simulation

I Introduction

Over t Weknoweverything produces sound wave just by existence and effect flow of air around them with their natural frequency. These frequencies are beyond hearing range of humans. Wave of frequency range of 20000hz and thereabouts are called ultra-sonic wave and these waves can be detected by an ultrasonic sensor which helps us to get various knowledge. An Ultrasonic detector usually has a transducer which convert sound energy into electrical energy and electrical energy into sound energy. They are used for measuring object position and orientation, collision avoidance system, surveillance system etc. Ultrasonic technology provide relief from problem such as linear measurement problem, as it allows user to get non-contact measurements in this way distance between object and its speed etc can me easily measured. Speed of travel of sound wave depends upon square root of ratio

between medium density and stiffness. Also, property of speed of sound can also be changed by natural environment condition like temperature. So basically, an ultrasonic sensor sends ultrasonic waves which travels in air and gets reflected after striking any object. By studying the property of reflected wave, we can get knowledge about objects distance, position, speed etc.

A processing software and an Arduino software is used with hardware system for detection of objects various parameters. One of the most common application of ultra-sonic sensor is range finding. It is also called as sonar which is same as radar in which ultrasonic sound is directed at a particular direction and if there is any object in its path it strikes it and gets reflected back and after calculation time taken to come back we can determine distance of object. in real life this method is used by bats here.

Objective and Aim of Work

The goal of this project is to create a working Ultrasonic radar system that is capable of monitoring a particular area. the ultra-sonic sensing technology since its emergence and some of these include home security systems, robotics applications, distance measurement, tank level measurement, in production lines, and proximity detection applications. These innumerable applications have made it possible to solve technical problems faster and cheaper without compromising safety, quality and stability.

II. Literature Review

This paper The evolution and research efforts in radar have been enormously successful, and have vitally changed computing. Eventually the researchers working on radar to design and develop and improve security and user interfaces and capable enough fulfill the intended performance criteria desired in the different environment. Radar is an object detection system that uses electromagnetic waves to identify the range, altitude, direction, or speed of both moving and fixed objects such as aircraft, ships, motor vehicles, weather formations, and terrain and when instead of electromagnetic waves, we use ultrasonic waves, it is called an ultrasonic radar. The main components in any Ultrasonic radar are the Ultrasonic Sensors. Ultrasonic sensors work on a principle similar to radar or sonar which evaluates attributes of a target by interpreting the echoes from radio or sound waves. This project aims on the use of Ultrasonic Sensor by connected to the raspberry PI board and the signal from the sensor further provided to the screen formed on the laptop to measure the presence of any obstacle in front of the sensor as well as determine the range and angle at which the obstacle is detected by the sensor. In 1842, Christian Doppler effect is the apparent change in frequency or pitch when a sound source moves either toward or away from the listener, or when the listener moves either toward or away from the sound source.

In 2010, Milenko S. Andri´c,Boban, P.Bondˇzuli´c, and Bojan M. Zrnic’ s paper the database of radar echoes from various targets has been described. The database is available for public download. The spectral analysis conducted in this paper is used to extract very basic information that could be used for classification.

In 2012, Alexander Angelov, Andrew Robertson, Roderick Murray-Smith, Francesco Fio's paper has presented results for classification problems in the automotive radar context using different neural network architectures. The basic need of this project is home security, and for security some project also implemented previous different method as they such are PIC motion sensor based security system, arduino based security system. In our project a new advancement simple technique is used, in this project a digital photo camera is interfacing through microcontroller and for operating camera shutter basically two relays are used. In which one relay is used for when object is within 20-30 cm range then it capture the image and that other instant other relay will stops the dc motor and whole moving equipment will stop.

In 1790, Lazzaro Spallanzo was first whose discovered the BAT movement with the help of hearing for movement not seeing forward. Jean-Dawel Col- ultrasonic security system discovered sonography 1826 using an underwater bell, and determine the speed of sound in liquid. Therefore further study and research work proceed slowly on time to time. In 1881, when Pierce Curie's design the modern ultrasound transducer and he concluded that the relationship between electrical voltage and pressure on any crystalline material, and on that time TITANIC tragedy influences to take more interest to work in this field and as a consequences

Paul Langevin search the hydrophone to detect the iceberg and that device was the first ultrasonic transducer.

Working Principle of RADAR

Radio waves are a form of electromagnetic energy that may be sent into the atmosphere by radar devices. The speed of light is exhibited by these signals. The radar receiver processes these waves after they are reflected back from targets in the radar's path. The radar can measure an object's distance, velocity, and location in relation to the radar system's position thanks to these pulses that are returned. [13]

III. Different Sensors for RADAR applications

i. Ultrasonic Sensor For Object Detection

The most common ultrasonic sensors exploited in several state-of-art approaches are the HC-SR04 [26] and HC-SR05 [15] sensors, which can be used both indoor and outdoor since ultrasonic technology is not sensible to light variations and to low light environments. This kind of sensors is composed of a transmitter and a receiver enabling the computing of the distance from an object without losing in accuracy, except in presence of objects made of sound-absorbing materials which obviously make the measurements inaccurate. The measurements are performed through a sequence of ultrasonic pulses at the

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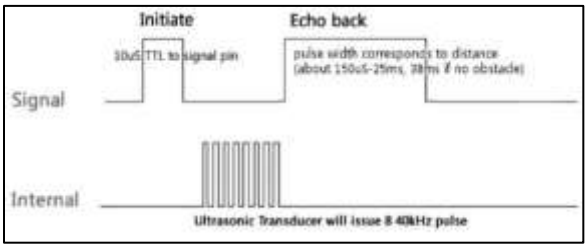

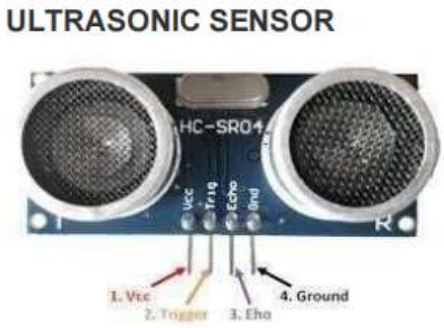

Fig. 1. Example of the HC-SR05 during the detection of an obstacle detection in its working range

frequency of 40 KHz that can hit objects in the range of 2cm to 400cm [26]- [27]. If an object is in the sensor's range, the ultrasonic pulses are reflected by the surface of the object and their echoes are then retrieved by the receiver, as shown in Fig. 1. Exploiting the information about the timing interval between the sending of the pulse and the reception of its echo, it is possible to compute the distance from the obstacle through the connected microcontroller board, such as Arduino [28]. To enable the communication between the ultrasonic sensor and the microcontroller board, it is necessary to connect the digital pins of the sensor to the board, i.e.: (*i*) the *Trig pin* is used to send to the HC-SR05 a pulse of 5 Volt for a duration of at least 10 μs, (*ii*) the *Echo pin* is used to receive a signal that identifies the echoes retrieved by the receiver. Through these pins, the microcontroller manages the sensor and sends the ultrasonic pulses retrieving their echoes

Fig. 2. Timing diagram of the ultrasonic sensor

PRACTICAL IMPLEMENTATION

A.Making On Arduino Board

Since, we believe in learning by doing. So, we decided to make our own arduino board instead of using the readymade board. So, the steps required to make an arduino board are as follows:

Boot-loading an Atmega328 using the Arduino board/AVR Programmer by uploading the boot loader to the Microcontroller.

Making the connections on a general purpose PCB, connecting the crystal osicillator, capacitors, connectors for the connections to Arduino board etc.

Providing the power supply, usually 5 volts. Arduino is Ready to use.

After you have done all this, then only the minimum circuitry like crystal oscillator, capacitors, connectors, power supply is required to complete the board. The same circuit can be made on the PCB, either designed or general purpose. Since, Arduino is an Open-Source. Hence, it is easy to make and can have any enhancements as per the requirements.

B.Connecting Servo Motor

A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration.

A normal servo motor has three terminals:

1.VCC 2.GND 3.PULSE

A servo motor works at normally 4.8 to 6 volts. Ground is provided by connecting it to the Ground of the Arduino. The total time for a servo motor pulse is usually 20ms. To move it to one end of say 0 degree angle, a 1ms pulse is used and to move it to other end i.e 180 degrees, a 2ms pulse is applied. Hence, according to this to move the axis of the servo motor to the center, a pulse of time 1.5 ms should be applied. For this, the pulse wire of the servo motor is connected to the Arduino that provides the digital pulses for pulse width modulation of the pulse. Hence, by programming for a particular pulse interval the servo motor can be controlled easily.

C.Connecting Ultrasonic Sensor:-

An Ultrasonic Sensor consists of three wires. One for Vcc, second for Ground and the third for pulse signal. The ultrasonic sensor is mounted on the servo motor and both of them further connected to the Arduino board. The ultrasonic sensor uses the reflection principle for its working. When connected to the Arduino, the Arduino provides the pulse signal to the ultrasonic sensor which then sends the ultrasonic wave in forward direction. Hence, whenever there is any obstacle detected or present in front, it reflects the waves which are received by the ultrasonic sensor. If detected, the signal is sent to the Arduino and hence to the PC/laptop to the processing software that shows the presence of the obstacle on the rotating RADAR screen with distance and the angle at which it has been detected.

IV. Conclusion

In conclusion, various sensor technologies, apart from ultrasonic sensors, are utilized in radar systems for object detection, tracking, and ranging. Each sensor type has its unique principles of operation, advantages, limitations, and applications. Every type of sensor has distinct qualities and features that are appropriate for particular radar applications. For example, infrared sensors work well in low-visibility environments and are excellent at identifying things based on their thermal outputs. Because of their all-weather performance and long-range detection capabilities, microwave sensors are frequently used in radar systems. For applications like autonomous cars and terrain mapping, laser sensors, often known as lidar, offer high-resolution imagery and precise range. Doppler radar sensors are frequently used in traffic monitoring and speed measuring systems because of their ability to identify moving objects. Millimeter-wave sensors are useful for security screening and surveillance applications because they provide precise spatial resolution and can pass through non-metallic obstacles. Understanding the characteristics of different sensor technologies is essential for selecting the most suitable sensors for specific radar applications, considering factors such as detection range, resolution, accuracy, and environmental conditions.

ADVANTAGES

• The ultrasonic sensor has high frequency, high sensitivity and high power.

•These sensors easily interface with microcontroller or any type of controller

•These sensors have greater accuracy then other methods for measuring the thickness and depth of parallel surface.

• These sensors could easily sense the nature, shape and orientation of that specific objects which is within the area of these sensors.

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