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Distance Sensing with Ultrasonic Sensor and Arduino

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Abstract: A sensor is a device that converts one type of energy to another. Arduino is a small microcontroller board with a USB plug to connect to the computer. The Arduino board senses the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lcds, speakers, motors and GS module. *Ultrasonic Sensor* ***measure the distance of target objects or materials through the air using "non-contact" technology. They measure distance without damage and are easy to use. The output Signals received by the sensor are in the analog form, and output is digitally formatted and processed by microcontroller. In present work, it is used to detecting an obstacle, along with its exact distance. The internal analog to digital converter is used is calibrated to get almost accurate distance measurement. The measured distance is also displayed on an LCD screen.***

Keywords: ATmega328, Servo motor, Ultrasonic Sensor.

I. Introduction

Bats are wonderful creatures. Blind from the eyes but the vision is sharper than humans, Ultrasonic ranging is the technique used by bats. Ultrasonic sensor provides an easy way in distance measurement. The sensor is perfect for distance measurements between moving or stationary objects. Ultrasonic Sensor measure the distance of the objects in air through non-contact technique. They measure distance without damage and are easy to use and reliable.

These distance measurement sensors connect with all common types of automation and telemetry equipment. Machinery and processes in a wide range of industries use distance measurement sensors where size or position feedback is required. Distance measurement sensors are used to control or indicate the position of objects and materials. Distance measurement sensors can determine the dimensions of objects such as height, width and diameter, using one or more sensors.

The echo time response of ultrasonic sensor detector is based on time of travel after trigger pulse to the surrounding objects is non-linear and depends on the reflectance characteristics of the object surface.

Ultra Sonic sensors are widely used for distance measurement purposes. They offer low cost and a precision of less than 1 cm in distance measurements of up to 6m [1, 4]. However, the most popular method used in these measurements is based on the time of flight (ToF) measurement. This ToF is the time elapsed between the emission and subsequent arrival after reflection of an Ultrasonic pulse train travelling at the speed of sound. This causes large response times for a single measurement.

II. Theory of Operation

This application is based upon the reflection of sound waves. Sound waves are defined as longitudinal pressure waves in the medium in which they are travelling. Subjects whose dimensions are larger than the wavelength of the impinging sound waves reflect them, the reflected waves are called the echo. If the speed of sound in the medium is known and the time taken for the sound waves to travel the distance from the source to the subject and back to the source is measured, the distance from the source to the subject can be computed accurately.

This is the measurement principle of this application. Here the medium for the sound waves is air, and the sound waves used are ultrasonic, since it is inaudible to humans. Assuming that the speed of sound in air is 1100 feet/second at room

temperature and that the measured time taken for the sound waves to travel the distance from the source to the subject and back to the source is t seconds, the distance d is computed by the formula

d=1100 X 12 X t inches.

Since the sound waves travel twice the distance between the source and the subject, the actual distance between the source and the subject will be d/2.

A single I/O pin is used to trigger an ultrasonic burst (well above human hearing) and then "listen" for the echo return pulse. The sensor measures the time required for the echo return and returns this value to the microcontroller as a variable-width pulse via the same I/O pin. Ultrasonic sensors have definitely diversified functions including "detection" of what you cannot see, "measurement" of length, thickness and amount, and "destruction" of objects.

Ultrasonic sensors are generally used for anti-collision and rangefinder purposes by measuring the distance to an obstacle [1] some application ideas where Ultra Sonic sensors can be used are: security systems, parking assistant systems, interactive animated exhibits and robotic navigation.

III. Hardware

The Block diagram of Ultrasonic Distance Detection with Arduino is as shown in fig 1.

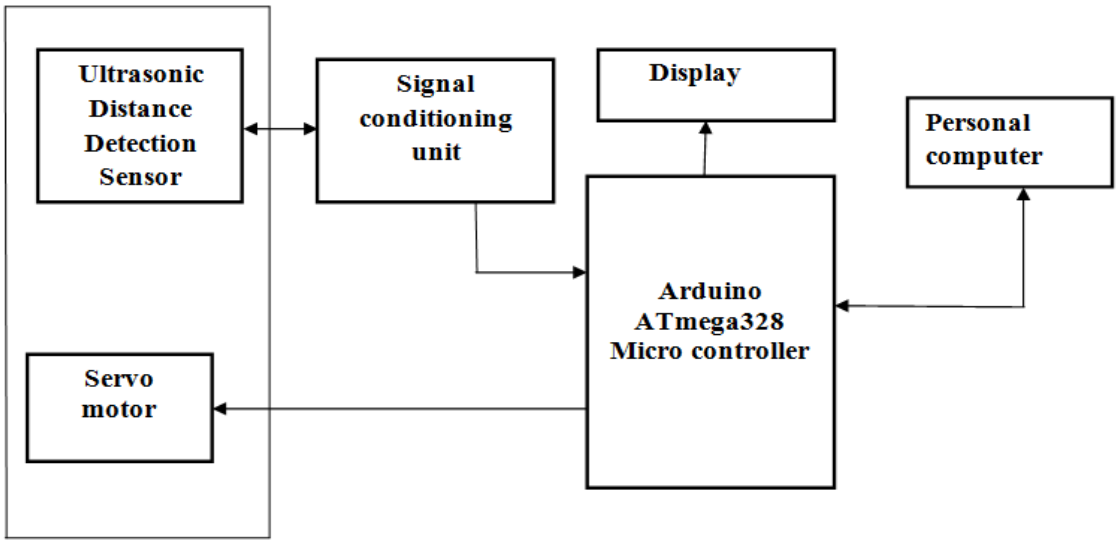

Figure1: Block diagram of Ultrasonic Distance Detection with Arduino

In this work, distance of the object is measured through ultrasonic distance sensor and the sensor output is connected to signal conditioning unit and after that it is processed through Arduino microcontroller. The measured results are displayed in liquid crystal display. The results are transferred to personal computer. The sensor is attached to servo motor to find the polar distance around the sensor upto 180^0 rotations. This application is also used to find the obstacles detection and the exact distance can also be obtained. The measured distance is displayed on the LCD display. The hardware components the system as explain below

- The ultrasonic distance sensor module with signal conditioning
- Servo motor
- Arduino-ATmega 328 Microcontroller
- Personal computer

The ultrasonic distance sensor module

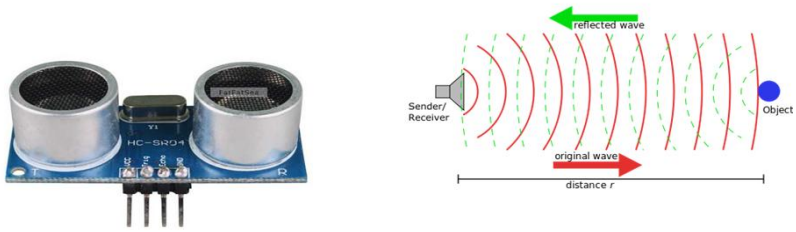

Fig 2: The ultrasonic distance sensor module with working process

This device is used to measure the distance from an object. It can detect objects that are within a range of 2cm – 450cm (.78" – 14' 9"). The device uses two digital pins to communicate the distance found.

Ultrasonic Range Detection Sensor [2], works by sending an ultrasound pulse at around 40 KHz, It then waits and listens for the pulse to echo back, calculating the time taken in microseconds. We can trigger a pulse as fast as 20 times a second and it can determine objects up to 3 metres away and as near as 3cm. The snapshot of the sensor and working process of the sensor is shown in fig 2. The sensor needs a 5V power supply to run.

The Timing diagram is shown in figure 3. 10uS pulse is required to the trigger input and start the ranging, and then the module will send out an 8 cycle burst of ultrasound at 40 kHz and raise its echo. The Echo is a distance object that is pulse width and the range in proportion. Then calculate the range through the time interval between sending trigger signal and receiving echo signal. We suggest to use over 60ms measurement cycle, in order to prevent trigger signal to the echo signal. There are only four connections, +5v, Gnd, trigger and Echo.

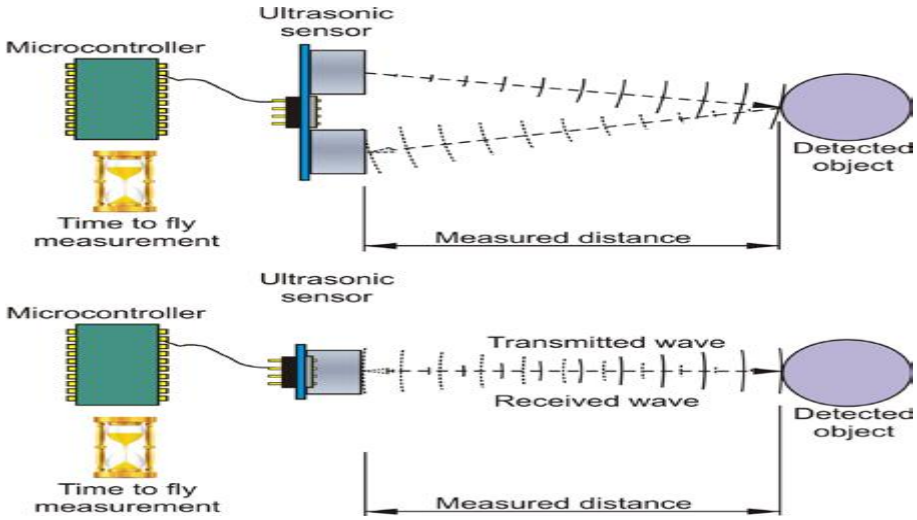

Figure 3. Ultrasonic sensor working diagram

The Ultra Sonic sensor works as a burst signal is transmitted for short duration (is emitted) by the emitter. After that there will be a silent period. This period is actually called "response time" and is the time waiting for reflected waves. The acoustic emitted signal may find an obstacle or not. If an obstacle is found, the acoustic signal will be bounced back from the obstacle. This back-bounced signal is called "echo". The echo is received by the receiving transducer and is converted into electrical signal. Usually this signal is amplified, filtered and can be converted into digital form [3]. Using the elapsed time between transmission and reception, the distance between the Ultra Sonic system and obstacle/object can be calculated.

Servo Motor

A servomotor is a rotary actuator / linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing. A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The motor is attached with the sensor to find the distance range around the sensor for 180^0 rotations. The motor is controlled and interfaced with Arduino microcontroller to rotate in clockwise and anticlockwise direction.

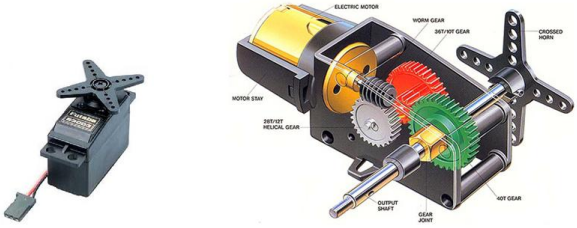

Fig4: servo motor with internal diagram

Arduino-ATmega 328 Microcontroller

The Arduino Uno is an open-source microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs) and 6 analog input. It contains everything needed to support the microcontroller, and it can be simply connected to a computer with a Universal Serial Bus (USB) cable to get started.

The Arduino Uno can be programmed with the Arduino Integrated Development Environment (IDE). The C-based simple program code for the Arduino is referred to as a sketch. Collection of sketches for specific functionalities is referred to as libraries. The Arduino can be programmed upto 32 KB memory. Arduino can function autonomously without being connected to a computer, or alternatively programmed to respond mainly to commands sent from the computer via various software interfaces or to the data acquired from the input channels. The Arduino UNO based on ATMega-328 Microcontroller

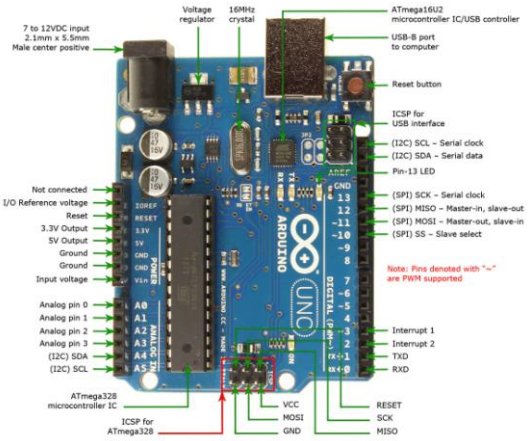

Figure 5: Arduino UNO Based on ATMega-328 Microcontroller

The ultrasonic sensor is attached with the servo meter. The servo motor rotates rotate in clockwise and anticlockwise direction. The sensor measure the distance around the sensor. The measured distance is calculated using Arduino controller within a pre-defined time interval. The analog output read from the sensor module is transferred to personal computer through serial port via Arduino. Photographs of the present project work are shown in fig 6.

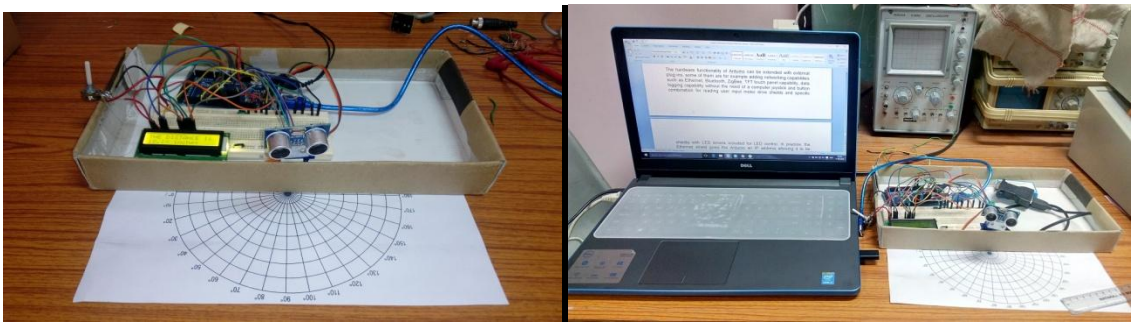

Figure 6: Photographs of the present project work

Conclusion

The objective of the project was to design and implement an ultrasonic distance meter. The device described here can detect the target and calculate the distance of the target. The ultrasonic distance meter is a low cost, low a simple device for distance measurement. The device calculates the distance with suitable accuracy and resolution. It is a handy system for non-contact measurement of distance. The device has its application in many fields. It can be used in car backing system, automation and robotics, detecting the depth of the snow, water level of the tank, production line. This device will also have its application in civil and mechanical field for precise and small measurements.

For calculating the distance using this device, the target whose distance is to be measured should always be perpendicular to the plane of propagation of the ultrasonic waves. Hence the orientation of the target is a limitation of this system. The ultrasonic detection range also depends on the size and position of the target. The bigger is the target, stronger will be the reflected signal and more accurate will be the distance calculated. Hence the ultrasonic distance meter is an extremely useful device

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