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Potential Applications of Ultrasonic Sensor

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Abstract: ***An ultrasonic sensor HC-SR04 uses ultrasonic waves to detect various objects. The operation of this ultrasonic sensor is not obstructed by sunlight or black material, so regardless of the lighting conditions it is able to work properly. This property makes it useful in number of applications. This sensor is used to make an Obstacle Sensing Robot (OSR) which when detects the presence of an object while working, is able to avoid collision with that object and change its path automatically. Various complimenting materials have been used to make the robot communicate with all its parts or components and to make it run. Further, after successful completion of obstacle sensing robot, a Maze Solving Robot (MSR) with the same hardware was implemented. It is capable to solve mazes and come out of mazes on its own without any external help.***

Keywords: OSR, MSR, Trigger, Echo.

1. Introduction

Ultrasonic sensor uses ultra sound waves to detect objects. It uses one transmitter and one receiver. Transmitter will transmit the ultrasonic waves which will be received by the receiver. The applications of the ultrasonic sensor are very viable in practical application. This paper will shed light on two of the applications of the ultrasonic sensor. First application is of the obstacle detector and the second application is of the maze solving robot. These two applications may look very similar to each other but there is a very wide difference in their approach towards algorithm. And their applications will be briefed in this paper on the later stages.

2. Ultrasonic Sensor

Ultrasonic sensor has a transmitter and a receiver is present in the sensor. This transmitter will transmit ultrasonic waves. These waves get reflected from the object in its path and these reflected waves are received by the receiver.

The "Trig" pin is present to transmit the waves. And the "Echo" pin is present which detects those sent waves. The time between the sent and received waves is measured and it is then converted into distance. A short 10uS pulse is given to the trigger input, which will start the ranging. The module will send out a burst of ultrasound at 40 kHz for 8 cycles and raise its echo. When echo gets an input, time between the sent and received pulse is calculated. This measured time is converted into distance in cm or inches as required according to the following formula.

Distance in cm = microseconds / 29 / 2.
Distance in inch = microseconds / 74 / 2.

The timing diagram is shown in Figure 1.1 below.

The Ultrasonic Sensor can be used in many different applications. It is very viable because of its accuracy and cost.

Two of the potential applications of Ultrasonic Sensor are in Obstacle Sensing Robot and in Maze Solving Robot. Both of these applications will be discussed later in this paper. The materials required in both the cases are same. But the basic concept and code are very different in both the cases

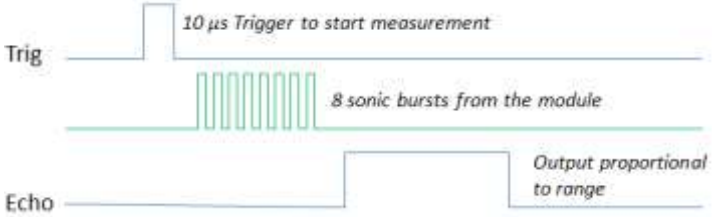

Figure 1.1 Timing Diagram

3. Material Illustration

All the materials required to make OSR has been mentioned below in Table 1 along with their quantity.

Table 1 Materials Used

Sr. No.	Material	Quantity
1	Ultrasonic Sensor HC - SR04	1
2	Arduino UNO R3	1
3	Motor Driver L298N	1
4	Battery operated motor 300 rpm	2
5	Wheel	2
6	Spherical Wheel	1
7	Container for Robot	1

3.1 Arduino UNO R3

An Arduino UNO is a microcontroller board which is based on ATmega328P. It contains everything which is needed to support the microcontroller. Because of the Arduino used here, all the components used in this project are able to communicate to each other very effectively. It measures the distance by taking input from ultrasonic sensor and depending on that input it generates output for the motor driver to run the motors. Its specifications are given in Table 2.

Table 2 Specifications of Arduino UNO R3

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

3.2 Motor Driver

Motor driver L298N is used here to control the direction and speed of motors. The direction of the motor is controlled by giving HIGH to one terminal of motor and LOW to other terminal. To reverse the direction of motor the values are reversed. And the speed of these motors is controlled with the help of pulse width modulation. If the motor is given sudden HIGH input then it can damage the motor. So PWM is used here which gives this HIGH input to motor gradually. This way the motor lasts much longer and damage is prevented. The longer the pulses, the faster will the motor run and vice versa.

4. Block Diagram and Pin Diagram

4.1 Block Diagram

The block diagram is shown in Figure 4.1 which explains the working of OSR. The ultrasonic sensor has a transmitter (Tx / Trig pin) and a receiver (Rx / Echo pin) which are connected to Arduino. The Arduino activates the ultrasonic sensor and ultrasonic waves are sent through transmitter. When receiver receives those waves, the time interval gets known and through calculations, the distance in centimeters is determined.

If there is no obstacle in its path, i.e. the distance is long enough, the inputs of motor driver will stay same as earlier and the OSR will continue to move in the same direction. However, if any obstacle is detected then input of motor driver will be changed. The OSR will then reverse for a moment and then turn by 90 degrees and thereby it avoids collision with the obstacle and successfully changes its path.

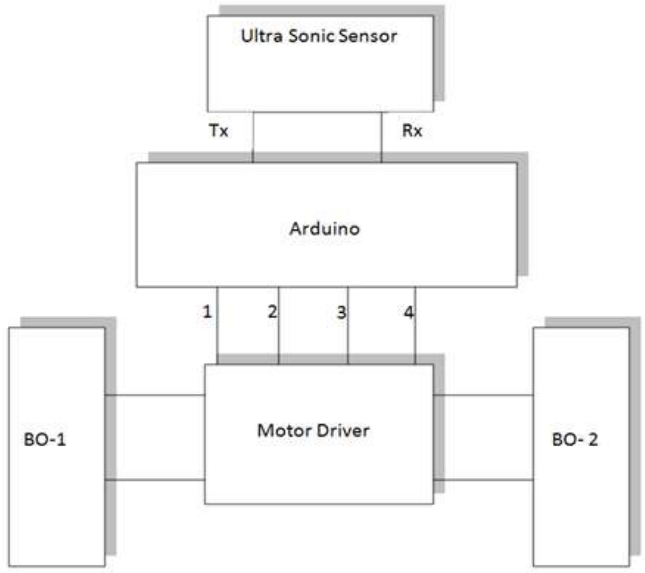

Figure 4.1

4.2 Pin Diagram

The exact connections are shown below in Figure 4.2.

5. Obstacle Sensing Robot (OSR)

OSR is made by combining all the materials mentioned above. In a container, all those materials were placed and connected to each other according to the pin diagram. The OSR is a moving robot which moves in forward direction. It keeps on moving in that direction until it detects an obstacle in front of it. As soon as the obstacle is detected, the robot stops moving and take revere and then turn in right direction thereby changing its path. This way it is capable of avoiding collision with objects.

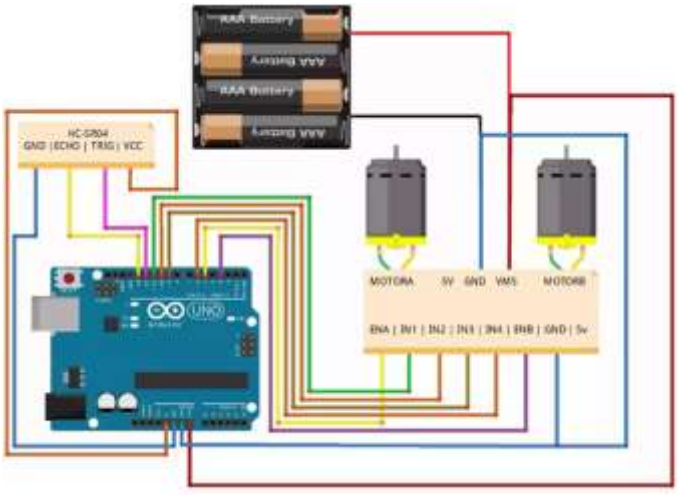

Figure 4.2

5.1 Algorithm in Detail for OSR

The working of the code for OSR is explained in detailed here.

1. All the pins connected to the Arduino except the Echo pin is set as OUTPUT, while the Echo pin is set as INPUT. This means all the pins that are set as OUTPUT will be given data from Arduino while the pins that are set as INPUT, Arduino will get data from it.
2. The Trig pin is set LOW for few microseconds to avoid false triggering. Then it is set as HIGH for 5 microseconds, which is when it will transmit the ultrasonic waves. After 5 microseconds, it is again set LOW.
3. With "pulseIn" function present for the Echo pin, the Arduino will get to know the time required for the ultrasound to come back. By using appropriate formula, this time is converted to distance in centimeters.
4. If this distance is more than 10 cm, then both the motors will move in the same direction that is forward direction. The pwm_speed is set at 255 (maximum value), so the motor will run at full speed, that is, 300 rpm.
5. If the distance is less than 10 cm, then the direction of rotation of both the motors will be reversed for 1.25 seconds, so the OSR will take reverse for few seconds. Then the right motor will be give LOW at both inputs and left motor will rotate in same direction for 2 seconds. This will make the motor to turn right by approximately 90 degrees.
6. Now again the distance is measured by ultrasonic sensor and the loop is repeated.

6. Maze Sensing Robot (MSR)

The MSR uses the same hardware as used in OSR. A different code will be uploaded to Arduino. The code will be explained in detail in Algorithm section.

There are many different kind of mazes present. And there are also many different algorithms to solve those mazes. Wall follower is one method to solve mazes that is implemented here.

6.1 Algorithm in detail for MSR

1. All the pins except Echo pin are set as output as they will be getting some output from Arduino depending upon the data processed. Since Arduino need to read data from Echo pin for time, it is set as input.
2. The MSR will move in forward direction for few seconds, that is, it will move from one block to another.
3. After it reaches the other block, right motor will be stopped and other will rotate in same forward direction for few seconds. This will make the MSR to turn in right direction.
4. Now in this right direction, the ultrasonic sensor will measure the distance. If there is no wall in front of the robot then that means the path is available in that direction. The measured distance will be more than 13 cm as measured by the ultrasonic sensor. The MSR will then move forward by one block as stated in step 2 and all subsequent steps will be followed.
5. However, if there is any wall in front of it then that means there is no path in right direction. The measured distance will be less than 13 cm. Now, the right motor will move in forward direction and left motor will be stopped. This will make the MSR to turn in left direction by 90 degrees, so it will be back again in front direction.
6. Distance will be measured again by ultrasonic sensor. If there is path available, MSR will move forward as in step 2 and subsequent steps will be repeated.
7. If there is no path in front direction, the MSR will again rotate in left direction by 90 degrees by keeping the right motor on and stopping the left motor. The MSR will be in left direction.
8. Again, distance will be measured. If path is available, MSR will move forward like in step 2 and subsequent steps will be repeated.
9. If path is not available then, the only path left is the backward direction. The MSR will rotate by 90 degrees in left direction, so now it is facing in backward direction. All the steps from step number 2 will be followed again until the MSR solves the maze.

7. Results and Discussion

The code made by using the algorithm as explained above works, and the OSR is successfully able to detect the objects by using its ultrasonic sensor. The distance set to detect objects or obstacles can be varied very easily in the code thereby giving it great flexibility. After detecting the obstacle, OSR is able to change its path by 90 degrees in right direction. Hence, the OSR was able to work due to flawless working of ultrasonic sensor. Since the sensor is only present on the front side, it will not be able to detect potholes if present in path.

The Maze Solving Robot (MSR) was also successfully implemented. Since the code is made by using the measurement in terms of block size, MSR is capable of solving maze of any block size. Right hand rule was followed by the MSR to complete the maze. If left hand rule needs to be followed to complete the maze then it can be done pretty easily by changing the algorithm a little bit. Hence, the MSR was also able to work in perfect manner. The only limitation that was observed was that due to the presence of only 1 sensor on the front side of the robot, it had to rotate in every direction to check for path, due to which its efficiency decreases.

8. Conclusion

The ultrasonic sensor, because of its capability to detect any obstacle that comes in front of it very precisely, it has many potential applications. The implemented OSR sensed the obstacles and changed its path. Implementing it on the front and rear side of vehicles increases safety. The MSR was also able to solve the maze using right hand rule (wall following method) to complete the maze. Different algorithms can also be efficiently implemented to solve the mazes which are not simply connected. This sensor is very viable as its biggest advantage is low cost and accurate performance.

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