3d Map modelling using ultrasonic sensor

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Objective

The objective of this experiment is to find a cheaper system to build a map for an object (2d,3d), that can replace the existing system using . If not exploring the limitations.

Requirements

We require the following items to build the proposed system:

- Arduino (Uno/Mega)
- Ultrasonic Sensors
- Servo Motors
- Jumper Wires and connecting wires
- 5v Power Supply
- Arduino IDE

Arduino

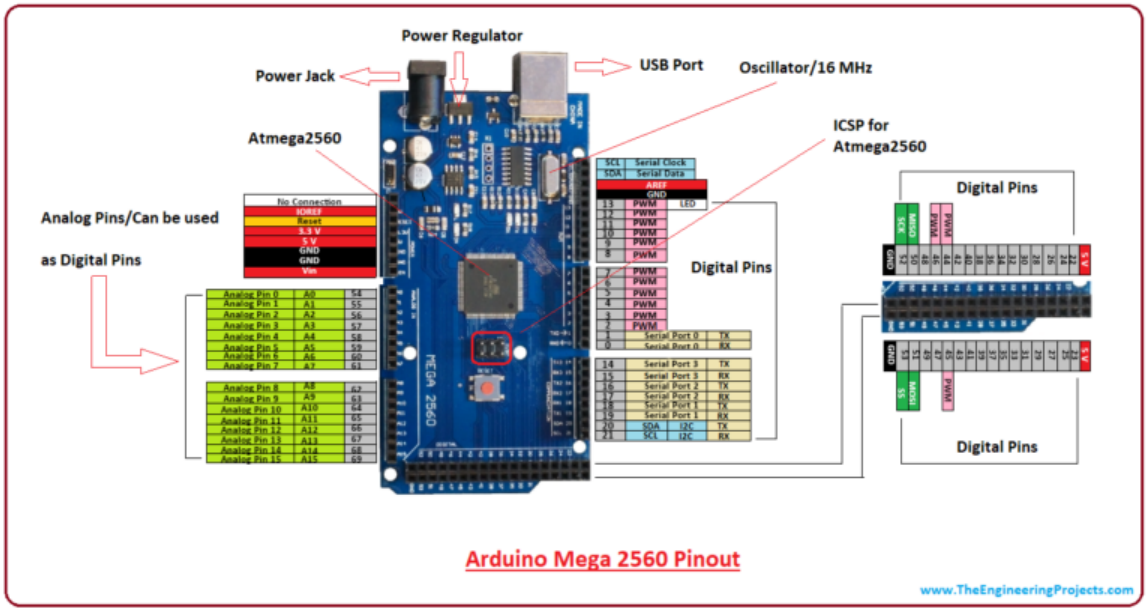

Fig 1. Arduino Mega Pin Configuration Diagram.

Following are some specifications for Arduino Mega:

- Operating Voltage = 5v
- Current per I/O pin = 20mA
- Analog Pins (can be used as digital pins) = 16
- Flash Memory = 256 KB
- SRAM = 8 KB
- EEPROM = 4 KB
- Crystal Oscillator = 16 MHz

Then the salient Features of Arduino Mega are:

- There are 54 digital I/O pins and 16 analog pins incorporated on the board that make this device unique and stand out from others.
- There is a reset button and 4 hardware serial port called USART which produces a maximum speed for setting up communication.
- There are three ways to power the board. You can either use a USB cable to power the board and transfer code to the board or you can power it up using Vin of the board or through Power jack or batter.

Ultrasonic Sensor (HC-SR04)

The ultrasonic sensor uses sonar to determine the distance to an object. Here's what happens:

1. The transmitter (trig pin) sends a signal: a high-frequency sound.
2. When the signal finds an object, it is reflected and
3. The transmitter (echo pin) receives it.

The time between the transmission and reception of the signal allows us to calculate the distance to an object. This is possible because we know the sound's velocity in the air i.e. 343m/s.

So, to calculate the distance between two objects we calculate the total time taken by the sound waves to go to object and then return back. This time's half is used to Calculate the distance using : Distance = speed * time

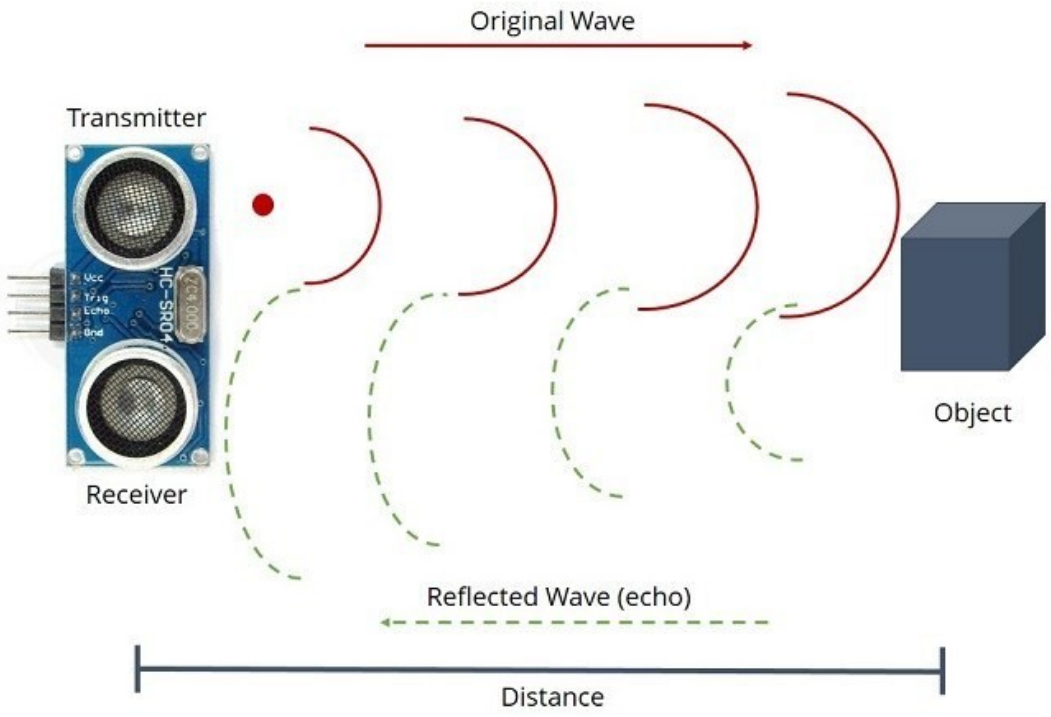

Fig 2.

Pin Configuration of HC-SR04:

- VCC: 5v power supply is given at this pin.
- TRIG: A pulse is sent here for the sensor to go into ranging mode for object detection.
- ECHO: Echo sends a signal back if the signal is detected or not. If the signal returns, a signal have been detected, if no signal then no object is detected.
- GND: To complete electrical pathway of circuit.

Servo Motor (HC-SR04)

A servo motor is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through servo mechanism**.** Servo motor works on **PWM (Pulse width modulation)** principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears.

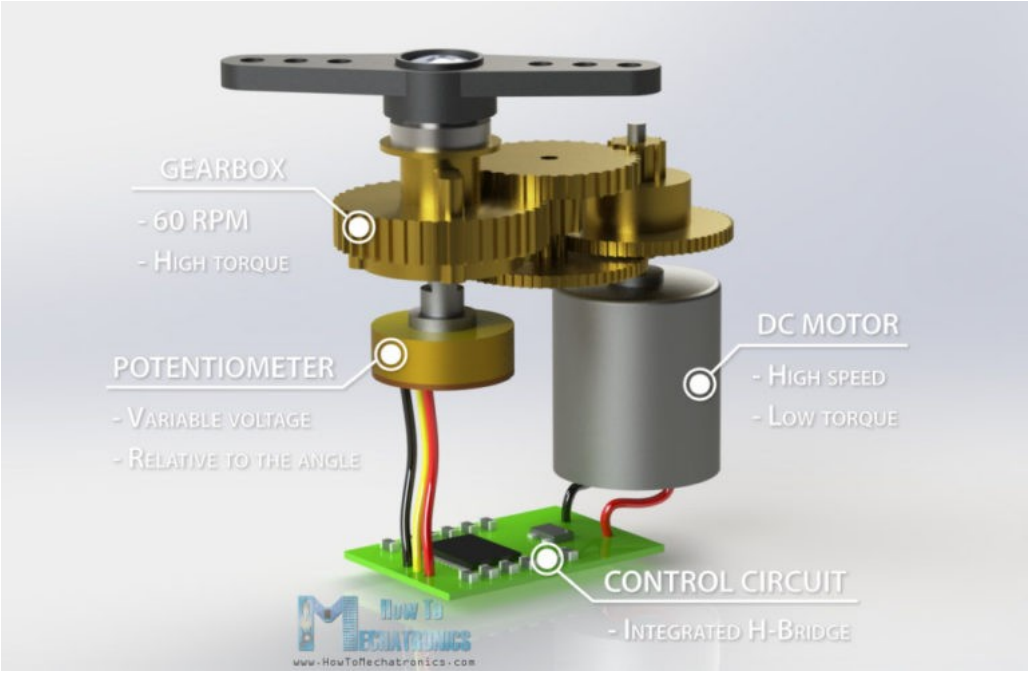

Fig 3. Schematic Diagram for Servo Motor.

The Model

Our project can be decomposed into two parts since it was an experimental project where we were trying to develop a new method to challenge.

3-D Map Generation

First we made a basic 3d map generation model that can generate a 3-d map of the object but with some limitations (as shown during mid semester).

We were able to obtain a 3d map with estimated boundaries, but the actual boundaries were varying much, so our next goal is to further optimize the boundary detection of the object.

Here we needed multiple ultrasonic sensors:

5 x ultrasonic sensors

1 x dc servo motor

The module made to measure the height of the object is made by mounting ultrasonic sensor on the axle of servo motor.

2-D Boundary Estimation

When we have made a 3d model next thing to do is to increase the boundary estimation of the model so we switched towards the 2d boundary estimation part only.

Here the modules are

4 x servo ultrasonic sensor mounted servo motor.

Algorithm to form 2d boundary:

- First take from sensors the distance of object as well as the angle at which the reading was taken.
- Calculate the actual reading to distance.
- Calculate the position of the point in a 2d Cartesian plane using distance and angle.
- Now the points from all the 4 modules are arranged in a polygon sequence in any order (clockwise or anti clockwise).
- Due to sensory errors the polygon can be irregular in shape.

To counter the irregularity of the polygon boundary, we deployed some techniques:

- Convex hull
- Averaging

Result and Conclusion

The final output contains output of the boundary as an image which we brought to as close to actual parameter as possible.

We can conclude from our experiment that it is not feasible to create precise 3d map of an object using HC-SR04 due to following reasons :

- High Sensory Errors in the sensor.
- Inter module interference

This project can be made accurate by using some other high precision sensors.