Ultrasonic Three Dimensional Scanner

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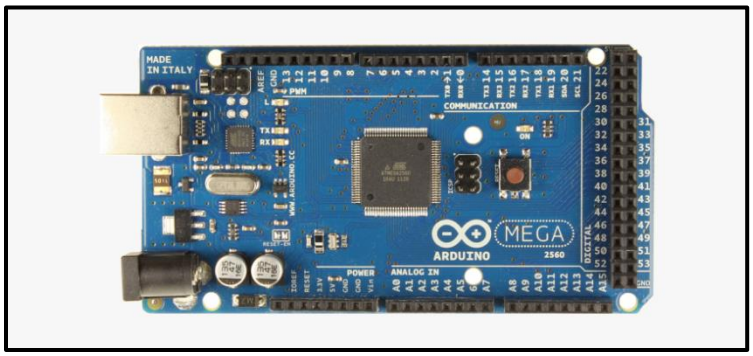
Abstract

Nowadays 3D scanner allows us to build accurate 3D digital structures in low-cost as well as in time effective manner. Digital 3-dimensional models can be constructed from the collected data. Hardware and Software assembly has been used to digitizing the objects. The developments of 3D ultrasonic scanning techniques are to be introduced in this paper. Analysis of the outer shape of object can be obtained by 3D ultrasonic scanning techniques. Any surface defect can be detected on the outer surface of object using this 3D scanner. Development board will be main component of this 3D scanner. Development board based on ATmega 2560 microcontroller is used for communication between sensor and interpretation of data. HC-SR04 Ultrasonic distance sensor is used in this scanner. HC-SR04 consists of two ultrasonic transducers. The Transmitter converts electrical signal into 40 KHz ultrasonic sound pulses. The receiver produces an output pulse when it detects reflected pulses. The time difference between transmitted and received pulse can be used to determine the distance. The sensor can measure distance between 2 cm to 400 cm with an accuracy of 3mm.
Keywords: Microcontroller, 3D scan, Ultrasonic, Sensor interface

1. Development board



Fig(1) ATmega 2560 Microcontroller

Development board will be main component for this system. It will retrieve data from the sensors then process it and send it to the serial communication port .In this scanner module development board based on Atmega 2560 microcontroller is used. It has 15 analog inputs, 13 PWM output 5 communication port and 31 digital input/output.

2. Ultrasonic sensor

Fig(2) HC-SR04 Sensor

HC-SRO4 ultrasonic sensor is very popular sensor for distance measurement. An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the

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https://doi.org/10.5281/zenodo.13822555

sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sensor and the object. Since it is known that sound travels through air at about 344 m/s (1129 ft./s), you can take the time for the sound wave to return and multiply it by 344 meters (or 1129 feet) to find the total round-trip distance of the sound wave. Round-trip means that the sound wave traveled 2 times the distance to the object before it was detected by the sensor; it includes the 'trip' from the sensor to the object AND the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half.

3. Motor Driver

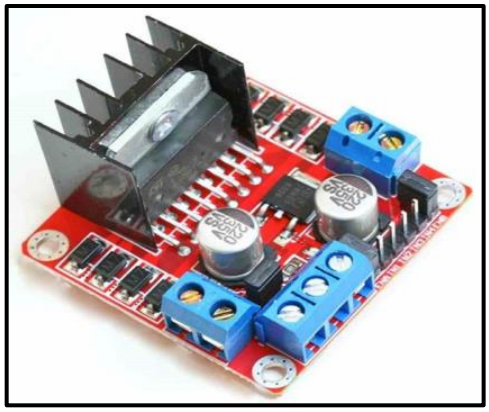
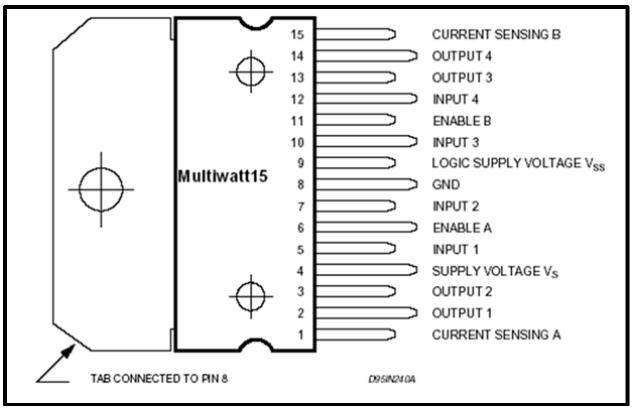


Fig (3) L298N motor driver



Fig(4) Pin diagram

This dual bidirectional motor driver is based on the very popular L298 Dual H-Bridge Motor Driver IC. This module will easily and independently control two motors of up to 2A each in both directions. It is ideal for robotic applications and well suited for connection to a microcontroller requiring just a couple of control lines per motor. It works on the concept of H-bridge. H-bridge is a circuit which allows the current to be flown in either direction. As you know current need to change its direction for being able to rotate the motor in clockwise or anticlockwise direction, Hence H-bridge IC are ideal for driving a DC motor.

In a single L298N chip there are two h-Bridge circuit inside the IC which can rotate two dc motor independently. There are two Enable pins on l298N, the pin 6 and 11 need to be high for being able to drive the motor. For driving the motor with left H-bridge you need to enable pin 6 to high and for right H-Bridge you need to make the pin 11 to high. If anyone of the either pin6 or pin11 goes low then the motor in the corresponding section will suspend working. It's like a switch.

There are 4 input pins for l298N, pin 5,7 on the left and pin 10 ,12 on the right as shown on the pin diagram. Left input pins will regulate the rotation of motor connected across left side and right input for motor on the right hand side. The motors are rotated on the basis of the inputs provided across the input pins as LOGIC 0 or LOGIC 1.

L298N Logic Table.

Let's consider a Motor connected on output pins (2and 3). For rotating the motor in clockwise direction the input pins (5 and 7) has to be provided with Logic 1 or Logic 0. In a very similar way the motor can also operate across input pin 10, 12 for motor on the right hand side.

Motor Direction	Pin 5	Pin 7
Clockwise	1	0
Anti-Clockwise	0	1
Idle(No Direction)	0	0
Idle(No Direction)	1	1

 https://doi.org/10.5281/zenodo.13822555

4. Embedded C code to obtain Top view

```
#include <Stepper.h>  //Including  library of stepper motor
const int stepsPerRevolution = 200;  //describing no. of steps per revolution
Stepper myStepper(stepsPerRevolution, 10, 11, 12, 13); // assigning stepper  motor input pin
int stepCount = 0;

//assigning input and output pin for ultrasonic sensor to microcontroller
const float trigPin = 22;
const float echoPin = 23;

//assigning initial values for variables in R,Theta and Z co-ordinate system
int r = 0;
int alpha=0;
float theta=0;
float x=0;
float y=0;
float z=0;
void setup() {

 //assigning output control pin for dc motor
  pinMode(26,OUTPUT);
  pinMode(27,OUTPUT);

//assigning output control pin for stepper motor
  pinMode(10,OUTPUT);
  pinMode(11,OUTPUT);
  pinMode(12,OUTPUT);
  pinMode(13,OUTPUT);

 //assigning input and output pin for ultrasonic sensor
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  Serial.begin(9600);  // starting serial monitor at baud rate 9600
  Serial.println("LABEL,time,x,y,z"); // labeling the outputs for plx-daq
}
void loop() {
for (r = 1; r <= 100; r += 1) // rotating the motor which move sensor to 1 mm
{      digitalWrite(26, HIGH);
       digitalWrite(27, LOW);
       delay(20);
       digitalWrite(26, LOW);
       digitalWrite(27, LOW);

 for(alpha=0;alpha<=200;alpha+=1)
{      long duration, mm;
      digitalWrite(trigPin, LOW);
      delayMicroseconds(2);
      digitalWrite(trigPin, HIGH);
      delayMicroseconds(10);
      duration = pulseIn(echoPin, HIGH);
      mm = microsecondsTomilimeters(duration); // recalling subroutine
      myStepper.step(1);
      stepCount++;
```

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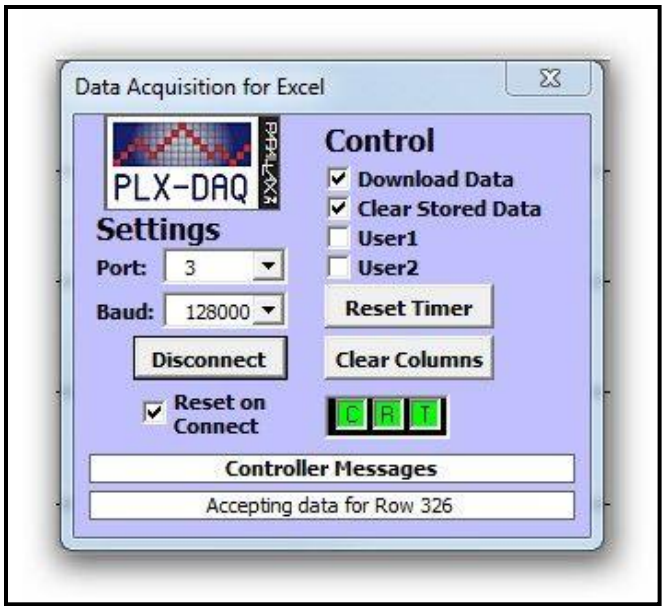
```
z=160-mm;
//obtaining data of z by subtracting  measurement from distance between sensor and platform
  theta=(alpha)*1.8;
  x=(r)*(cos(theta));
  y=(r)*(sin(theta));
  Serial.print("DATA,TIME");
  Serial.print(",");
  Serial.print(x);
  Serial.print(",");
  Serial.print(y);
  Serial.print(",");
  Serial.print(z);
  Serial.print(",");
  Serial.println("");
 } } }
long microsecondsTomilimeters(long microseconds)
{return microseconds / 2.9 / 2;}
// The speed of sound is 340 m/s or 29 microseconds per centimeter. The ping travels out and //back, so to find
```

the distance of the object we take half of the distance travelled.

5. Data acquisition software



Fig(5) PLX-DAQ Interface

Arduino board has one usb port from which we can communicate by serial communication or we can use tx and rx pin for serial communication with microcontroller. We are in need to get data instantly as it generates by microcontroller so we use serial port for real time data acquisition. Arduino IDE software comes up with it's inbuilt serial monitor and serial plotter but it doesn't helpful for this application.

PLX-DAQ is a Parallax microcontroller data acquisition add-on tool for Microsoft Excel. Any of our microcontrollers connected to any sensor and the serial port of a PC can now send data directly into Excel. PLX-DAQ has the following features:

- It can Record up to 26 columns of data.
- It can Mark data with real-time (hh:mm:ss) or seconds since reset.
- It can communicate with microcontroller on Baud rates up to 128K.
- It can Supports up to 15 communication port.

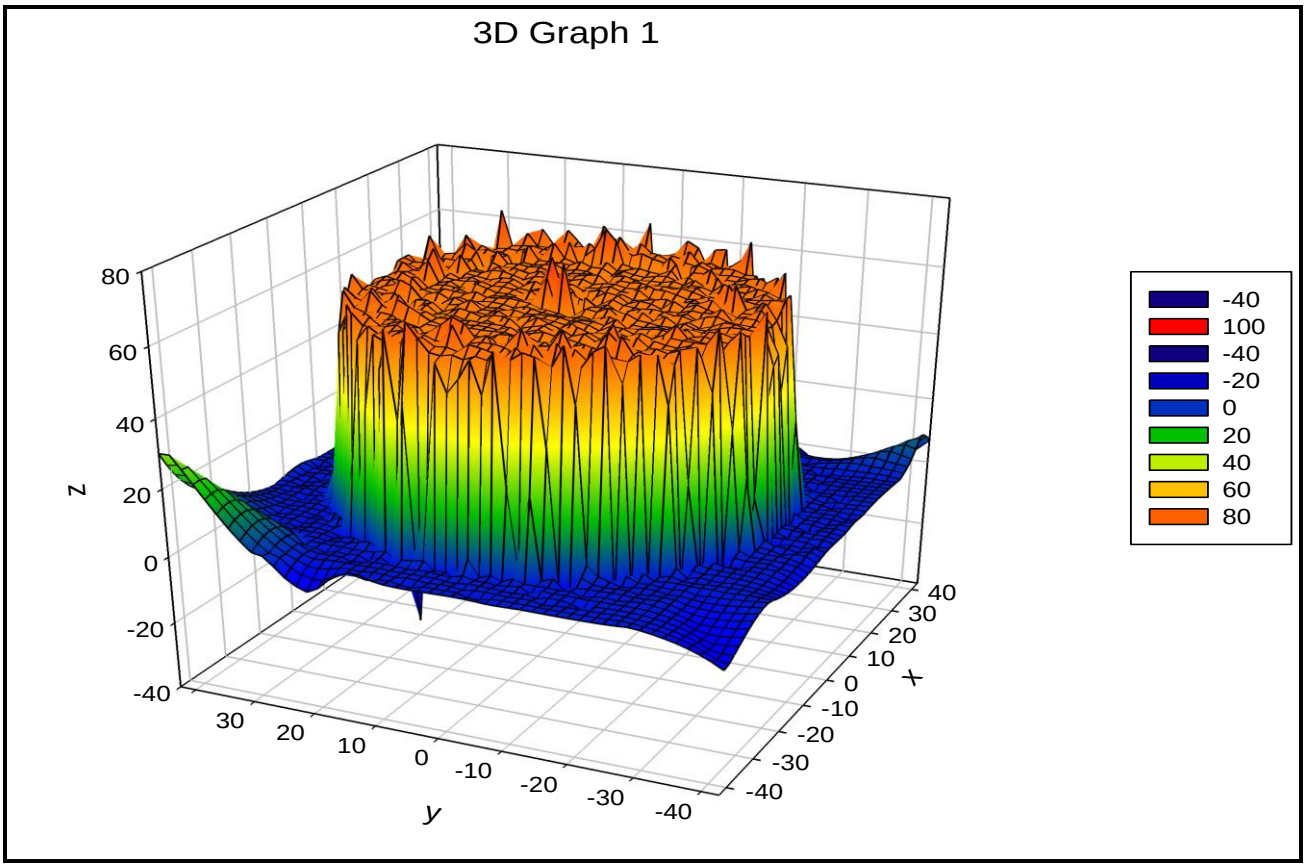
 https://doi.org/10.5281/zenodo.13822555

ISSN: 0369-8963

To get the data from Arduino You only need to download and install it, it should work fine. After installation, it will automatically create a folder named PLX-DAQ on your Desktop in which you will find a shortcut named PLX-DAQ Spreadsheet. When you want to use your Arduino to send data to excel, just open up the shortcut. Now by following further procedure one can get data from Arduino by this software.

- open the shortcut to your PLX-DAQ Spreadsheet
- excel will say "This application is about to initialize ActiveX…", just click OK
- a new window named Data Acquisition for Excel will appear
- select the usb port your Arduino is connected to (if it doesn't work at first, go through the list of ports)where it says Baud, just select the number you put in your code at Serial.begin()
- create an empty graph
- select which columns of data you want on the graph for the x and y axis
- click collect data on PLX-DAX and it should start collecting the data

6. Result of Scanned object visualised in 3D mesh graph



Fig(6) Sample scanned object

In this 3D Graph we used sigma plot to accurately plot all the data from the micro-controller. In test run I have used on cylindrical object to obtain the data of co-ordinate for small segments . There is some random pick in the plotted data which is possible due to mechanical vibration occurred during the process of scan.

Now a day 3d printer and CNC machine is most essential machines for fast ,reliable and accurate fabrication of product. All this machines are controlled by the specific signal which is generated by physical coordinate of final product so if we give this set of coordinate to 3d printer then it will replicate the object in no time also it is can be used to import coordinate for CNC machine so it will move its machining head on exactly same coordinate imported from 3d scanner.

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This 3D scanner generate top view and side view of object and we can also observe it from different angle in the sigma plot software so it will be helpful for designer to use such kind of scanner to instantly get visual image of the object. This data of coordinate of different point on the surface of object can be save in excel file for future reference and use. We can also get time required for scanning whole object .

The accuracy of this project can be increase by using laser distance measurement but a computation for such sensor requires more reliable and precise microcontroller. At this stage we have to wait until object is in scanning process and once we get all the data then we can plot it in sigma plot software. One can also use other method to acquire data from microcontroller and plot it in real time

The 3D scanner can also be used in scanning different object and surface which can be very useful in geophysics.

References

[1] https://www.arduino.cc/en/Main/ArduinoBoardMega2560
[2] http://pdf.datasheetcatalog.com/datasheet/stmicroelectronics/1773.pdf
[3] https://sensorwiki.org/sensors/ultrasound

 https://doi.org/10.5281/zenodo.13822555