ACOUSTIC RADAR DISPLAY

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DECLARATION

I certify that this dissertation does not incorporate without acknowledgement, any material previously submitted for a Degree or Diploma in any university and to the best of my knowledge and belief it does not contain any material previously published or written or oral communicated by other person except where due reference is made in the text.

L.G.T.Jayasinghe

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Your name

ACKNOWLEDGEMENT

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ABSTRACT

With the growing number of innovations a major issue with the obstacle detection for Robots. For the issue of that Acoustic Radar Display can be used as solution. This advanced Arduino display system can be used to monitor local patch area and can also scan suspicious object. System continuously scans the area and gives a visual representation on detecting an object, simultaneously; the radar provides the angle as well as distance of the object from the source.

Main application of this RADAR display comes into different field of navigation, positioning, object identification, mapping, spying or tracking and different applications. These less investment system are also suitable for indoor applications.

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ABBREVIATIONS

PCB – Printed Circuit

IC – Integrated Circuit

US – Ultrasonic sensor

PC – Personal Computer

IDE - Integrated Development Environment

1 INTRODUCTION

RADAR is an object detection system which uses radio waves to determine the range, altitude, direction, or speed of objects. Radar systems come in a variety of sizes and have different performance specifications. Some radar systems are used for air-traffic control at airports and others are used for long range surveillance and early-warning systems. A radar system is the heart of a missile guidance system. Small portable radar systems that can be maintained and operated by one person are available as well as systems that occupy several large rooms (Dutt 2014).

The modern uses of radar are highly diverse, including air traffic control, radar, astronomy, air-defense systems, antimissile systems, antimissile systems; marine radars to 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 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. (Onoja, Oluwadamilola et al. 2017)

2 BACKGROUND

This project working principle is linked by the following components which is ultra-sonic sensor connected to the microcontroller (I have chosen Arduino) digital input and output pins. Then we have stepper motor which is also connected to digital output and input pins. Both main components ultra-sonic sensor and stepper motor are connected simultaneously, so that when stepper motor rotates from 0 degree to 180 degree from extreme right to extreme left the motor will rotate nearby its axis. Utilize Computer screen to demonstrate the data (azimuth, distance and angle) through software called “Processing development Environment”

Figure 1-Front and Side view of project

2.1 Objective of the project

The main objective of this project is to detects obstacles and display its visual representation in the Processing Application This will help human kind for surveillance a large area from a watch station. This will reduce manpower and effectiveness of security, because machines are more accurate and efficient then human.

2.2 Concept of the project

Concept of this project is to provide accurate and real time information to user for the easy management

2.3 Required modules

Figure 2 -Arduino Nano

Figure 3- HC-SR04 Ultrasonic Sensor

Figure 4-28BYJ-48 Stepper Motor

Figure 5-ULN2003 Driver Board

2.4 Features of the system

- Real time monitoring
- Can see through the medium consisting of fog, snow, rain, darkness, clouds etc.
- Penetrate and see through insulators
- Distinguish fixed objects as well as moving target types
- Easy to handle

2.5 Applications

This Radar Display have various applications for security purposes and it is mainly used for mapping.

- Application in air force: It is used in airplanes or aircraft machines which have implemented radar system in it to detect the objects that comes in a way. It is also used to calculate height readings.
- Application in marine: This radar system also used in ships or marine. It is implemented on big ships to calculate the distance of other boats or ships, with the help of these sea accidents can also be reduced by not colliding. It can also be

implemented on ports to see the distance of other ships and to monitor or control the ship movements.

- Applicaton in meterology: Meteorologists also uses radar systems to track or monitor the wind. It has been become important equipment for climate testing. For example to detect tornados, storms.

3 THEORY

3.1 Serial communication

Serial communication is the process of sending data one bit at a time sequentially, over a serial bus. Data consists of serial communication in 3 types; as; data, synchronization and party bits. Universal Asynchronous Receiver/Transmitter or UART for short represents the hardware circuitry (module) being used for the serial communication. This UART consists with transmit (Tx) and receive (Rx) line. The Tx and Rx channels in the microcontroller needs to be connected respectively at the device's Rx and Tx. The board rate (speed of the data transmission) is 115200.

3.2 Ultrasonic Sensor

An ultrasonic sensor is an instrument that measures the distance to an object using ultrasonic sound waves. The sensor consists with pins such as; VCC, Triger, Echo and GND. An ultrasonic sensor uses a transducer to send and receive ultrasonic pulses that relay back information about an object's proximity. High-frequency sound waves reflect from boundaries to produce distinct echo patterns.The basic formula the sensor works as formula 1

$$\mathbf{s = ut} \text{ ---} \quad (1)$$

Where s,u,t respectively for distance, velocity and the time.

The distance can be as follow

$$\mathbf{l = 1/2(t \times c)} \text{ ---} \quad (2)$$

Where l is the distance, t is the time between the transmitting and receiving and c is the speed of sonic. The value is multiplied by ½ due to t is the time for both go and return distance. Where c is 340 m/s.

An optional sensor modification which is RawEcho wire connected to Pin 10 of US sensor U1 IC allows multiple objects to be detected with each ping.

3.3 Stepper Motor

The 28BJY-48 5V DC motor has a "stride Angle" of **5.625/64** degrees per step.

One complete revolution therefore requires 360/5.625*64 equals 4096 steps.

This motor may be run using one of three possible modes:

- Wave-stepping: lowest torque, max speed, coarse movement
- Full-stepping: highest torque, max speed, coarse movement
- Half-stepping: medium torque, half speed, smooth movement

From experiment "full-stepping" (which has the most torque) requires a minimum delay of 2mS for reliable starting, whereas "half-stepping" only requires 1mS.

As a result the rotation speeds are the same. Since there is no speed advantage "half-stepping" has been chosen for smoothness of rotation and reliable starting.

The required "half-stepping" motor pattern to achieve this is shown below.

Clockwise Rotation

Index	1a	1b	2a	2b
1	1	0	0	0
2	1	1	0	0
3	0	1	0	0
4	0	1	1	0
5	0	0	1	0
6	0	0	1	1
7	0	0	0	1
8	1	0	0	1
9	1	0	0	0
10	1	1	0	0
11	0	1	0	0
12	0	1	1	0
13	0	0	1	0
14	0	0	1	1
15	0	0	0	1
16	1	0	0	1

Figure 6 - half step sequence of binary control numbers

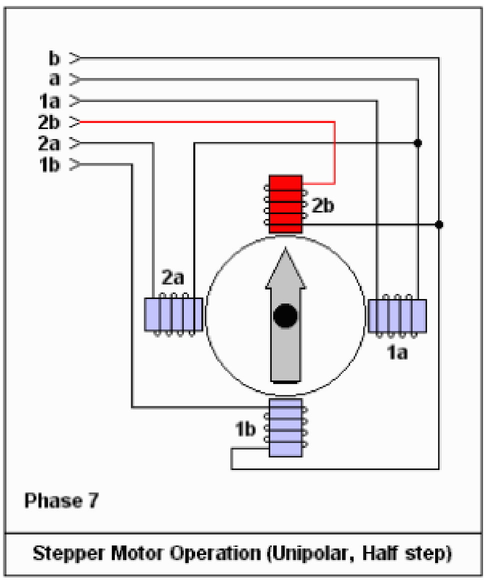


Figure 7 - Stepper motor operation (Half step)

4 METHODOLOGY

The block diagram of the initially created system as follows

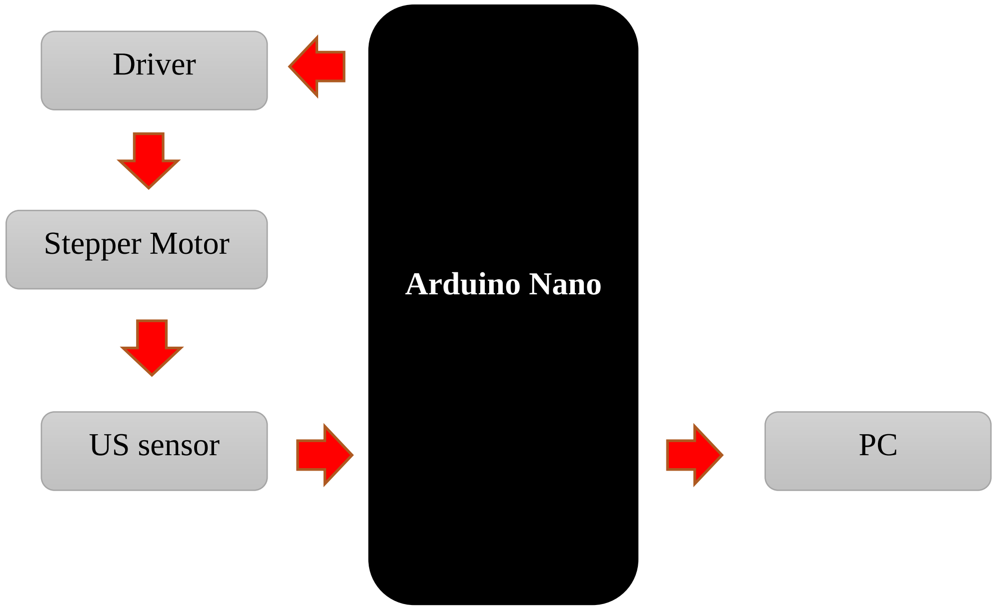


Figure 8 - Block diagram of the Display

As Figure 8, the 4 ultrasonic sensor is input, Driver of the motor and PC are outputs of the system. And the stepper motor drive with support of driver and US sensor rotate on behalf of stepper motor. Arduino works as an intermediate tunnel to pass data to the computer to display the results.

Eagle software used to make the PCB diagram. As per figure in below designed for the initial system.

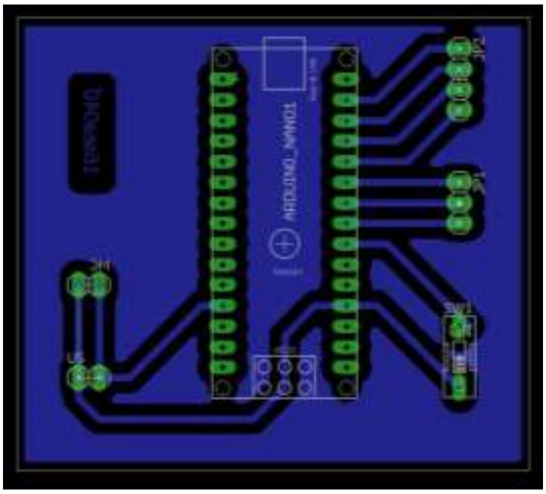


Figure 9 - The PCB diagram

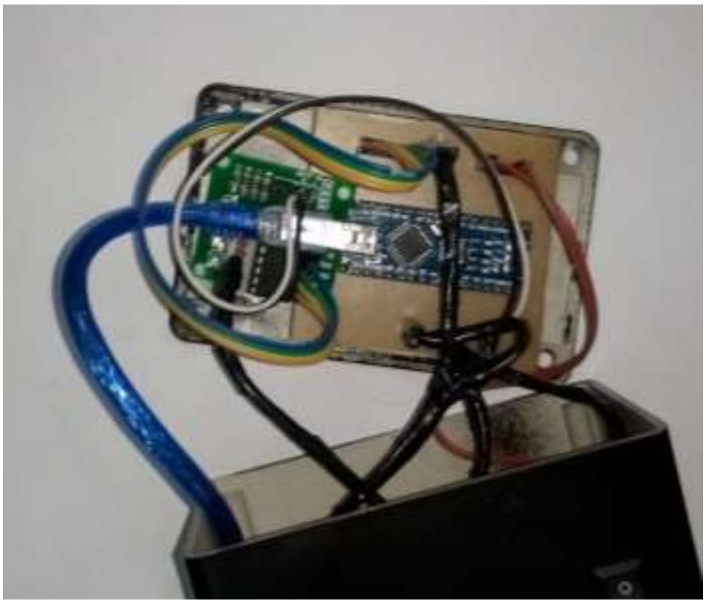


Figure 10 - Finalize PCB

4.1 Mechanical

All parts are housed inside a plastic encloser. Power is obtained from your USB port.

The circuit comprises an Arduino, an ultrasonic sensor, a stepping-motor, and a micro-switch for moving the sensor to its “home” position. The micro-switch is necessary as it is not possible to rotate the stepping motor by hand due to its 64:1 internal gearing.

When first powered up the Arduino rotates the sensor to its “home” position, as determined by the micro-switch, then “polls” the display until it gets a response.

The 28BJY-48 stepping motor has a “stride angle” of 5.625/64 degrees which means that 1 degree steps are not possible (even though graticule is labelled 0..180 degrees).

Fortunately, 180/stride-angle = 180*64/5.625 = 2048 which is evenly divisible by 8. If increment a number from 0..2048 and divide by 8 there are 256 occasions when we get a remainder of zero. Simply send a “ping” whenever the remainder is zero. This equates to a “ping” every PI/256 radians or 0.703125 degrees.

4.2 Software

The display then takes control and continually asks the Arduino to supply the following data:

- Azimuth
- Distance1
- Distance2
- Direction

The “distance(s)” for each “azimuth” are then displayed on the screen. The “direction” information is used to create the illusion of “dots” appearing behind the “beam” as it rotates.

The Arduino automatically moves to the next “ping” position whenever data is sent to the display.

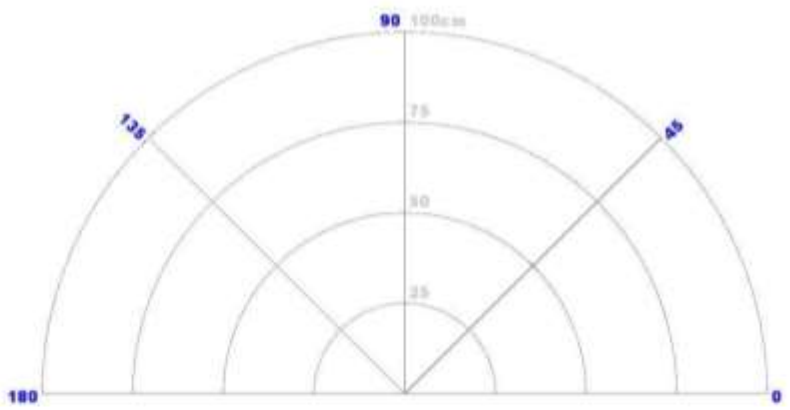
The “Processing 3” software used for writing the display. It supports 2D and 3D graphics and is very similar to the Arduino IDE (Integrated Development Environment). The main visual differences are a “graphics window” when the code is running and the use of a “draw()” function instead of the Arduino “loop()”.

4.3 Display

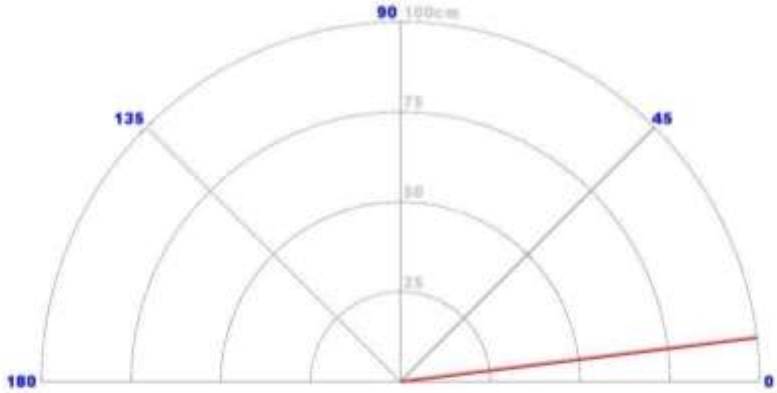
4.3.1 The Graticule

Chose to create a 180 degree graphics display as it provides a “radar shadow” in which to stand while experimenting. Such a display is also compatible with a stepper motor. A full 360 degree display can be obtained by tweaking the code.

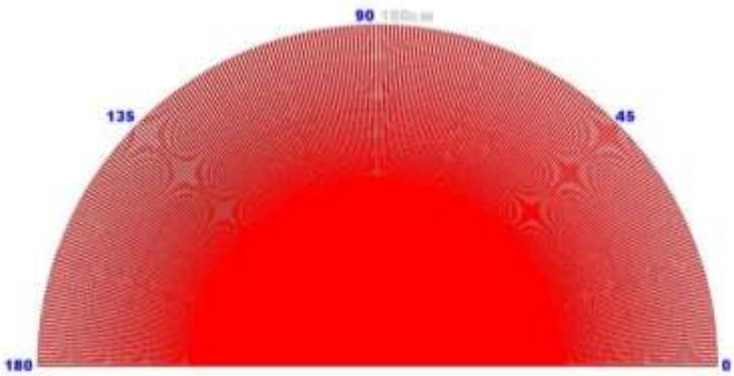
The followings explain how the graticule was created:



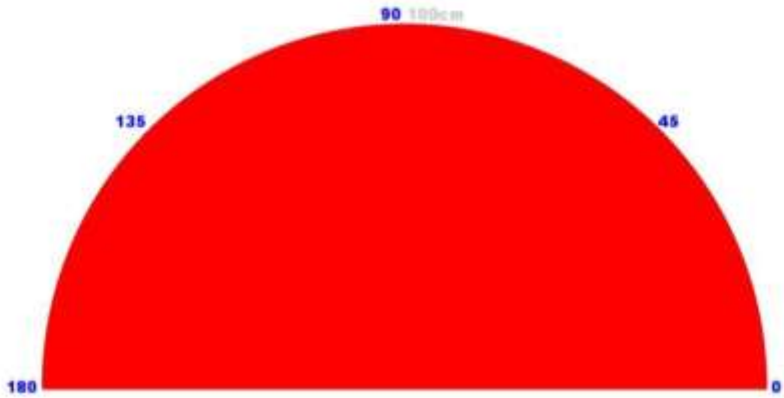
The graticule comprises a number of “arcs” and “lines”. Angled labels are shown in this photo but ere later dropped in favour of horizontal text which is easier to read.



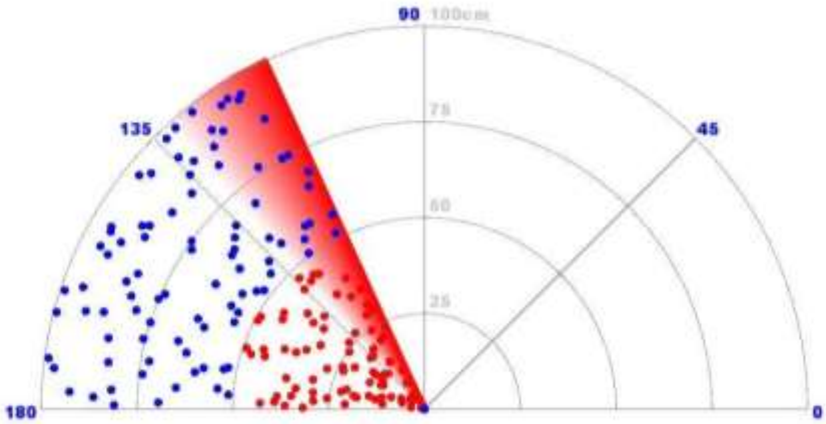
Shows a red line depicting the “beam”. The text in the label is now horizontal.



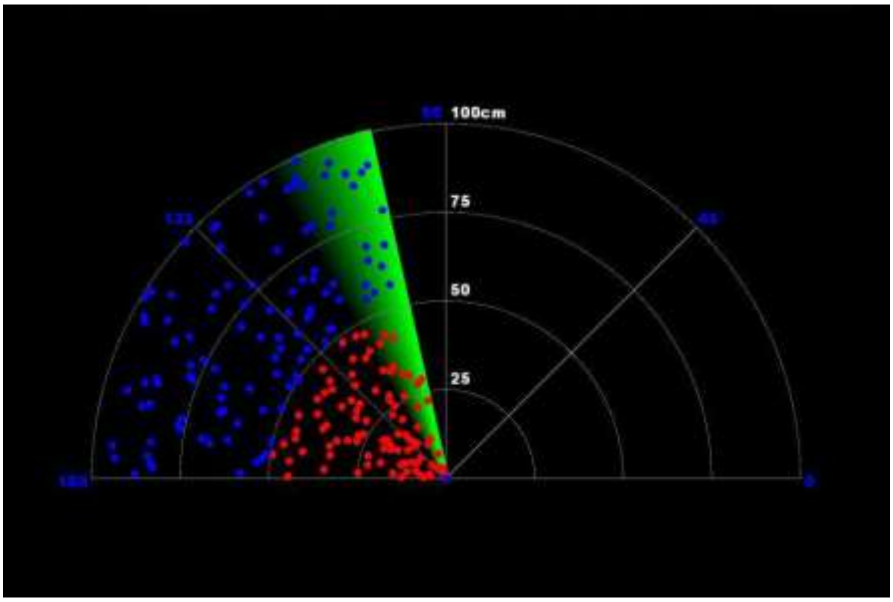
The red line has been rotated 0..180 degrees through 256 azimuth positions. In this image the outer parts of the graticule are not covered as the beam-width is too narrow. This results in some strange artifacts.



Increasing the beam-width has eliminated these artifacts.



Random dots have been introduced to represent primary (red) and secondary (blue) echos. The range, which can be changed, has been set to exactly 100cm to match the display. A fading beam pattern has also been introduced. The technique used to create this “fading beam”.



The colour scheme has been changed to add a touch of realism.

4.3.2 Animation

The animated portions of the graphics display use 3D graphics to greatly simplify the code. To understand how this is possible let’s draw a “30 degree line” of constant radius from an XY start coordinate of (0,0).

2D graphics requires the use of sin(30) and cos(30) to calculate the XY end coordinates of the line:

```
X=cos(30)*radius = 0.866*radius

Y=sin(30)*radius = 0.5*radius

line(0,0,X,Y);
```

3D graphics doesn't require the use of trigonometry. We simply rotate the XY grid coordinates about the Z-axis then draw a horizontal line no maths required.

```
pushMatrix();               //preserve our current grid coordinates

rotateZ(radians(30));       //rotate our XY grid coordinates about the Z-axis

line(0,0,radius,0);         //draw a "horizontal" line on the rotated grid

popMatrix();                //restore our grid coordinates
```

Either way works but this second method lends itself to "ping" intervals of PI/256 radians.

4.3.3 Fading Lines

The fading beam pattern uses a clever technique found at internet (effect 2020)

The beam is given its own virtual screen. Prior to drawing any line the "alpha" (opacity) of all previous lines is reduced by a small amount. Ultimately the earliest lines become invisible which gives the illusion of a fading "fan" pattern.

This virtual screen, which is never erased, is then merged with the contents of the main screen whenever the display is refreshed.

4.4 System's overflow

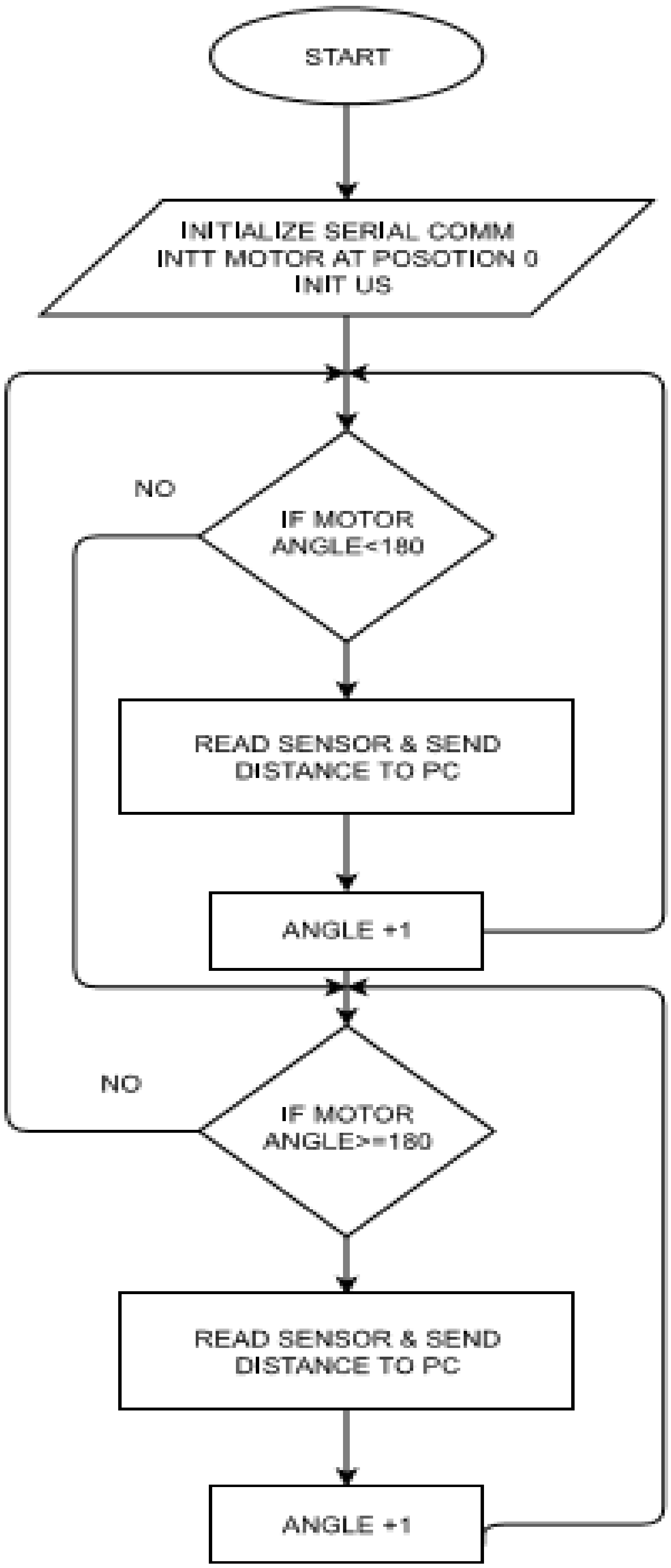


Figure 11 - Flowchart

As Figure 11 showing above, shows how the internal functionality of the display works. Starting from the very first ultrasonic sensor, it gets the distance.

Initially, upload the code to Arduino after making the connections. Can observe the stepper strat with micro switch sweeping from 0^0 to 180^0 and again back to 0^0. Since the Ultrasonic Sensor is mounted over the stepper, it will also participate in the sweeping action.

In the Processing Sketch, make necessary changes in the COM Port selection and replace it with the COM Port number to which Arduino is connected to.

If note the Processing Sketch, used the output display size as 1280×720 (assuming almost all computers now-a-days have a minimum resolution of 1366×768) and made calculation with respect to this resolution.

When Click the top left “Run” button in Processing window and project will burst into life.

Figure 12 - Run Mode of Display

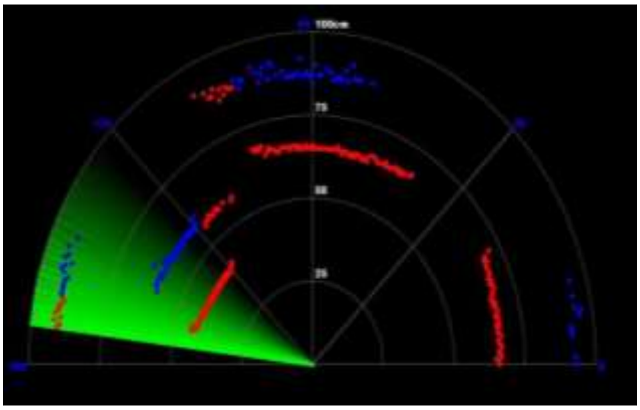


Figure 13 - Output of Processing

5 RESULTS AND ANALYSIS

In this project I have mentioned that this display is designed consisting following components such as, a stepper- motor, an ultra-sonic sensor and a micro-controller (Arduino). System's objective is to track the distance and angle of the object and to represent this information graphically, means its output should be in graphical form which will be represented through processing software. I have an idea of an efficiency of this radar by testing objects at different levels and observe how faster or smoothly it detects an object that it finds in a way and gives us an expected range of the obstacle. Following figure show the results of the monitor screen of our design when the sensor rotates through the area and detects obstacle in the way. The red area indicates the presence of obstacle and below the angle of incident and distance is being displayed.

5.1 Testing of the project

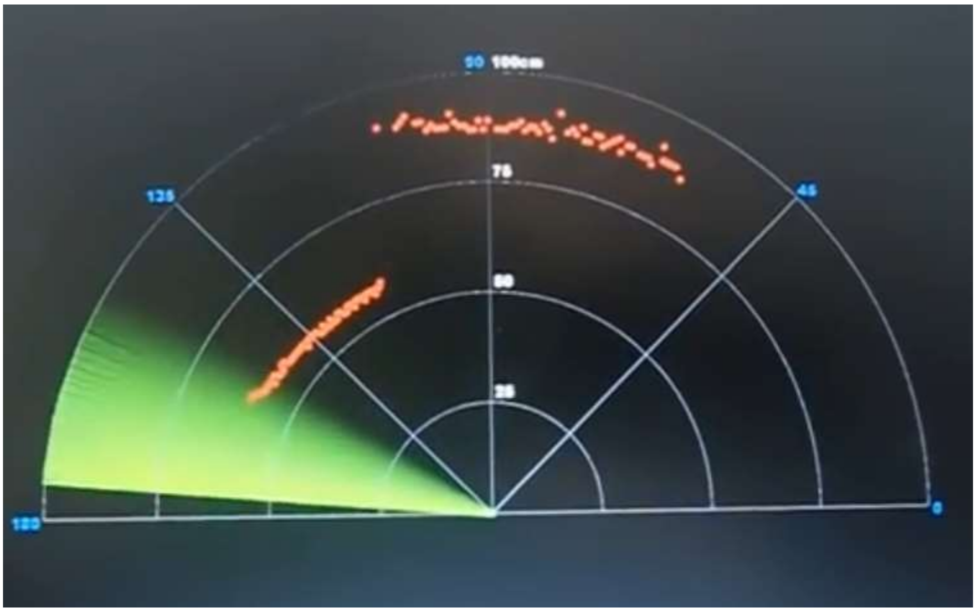


Figure 14 - Detection of objects in different places

a) Object 1 is placed 57cm far from the radar, radar gives the distance 55.5 cm,

- error =(57-55.5)/55.5)*100= 2.703%
- efficiency 1 = 100-error =97.30%

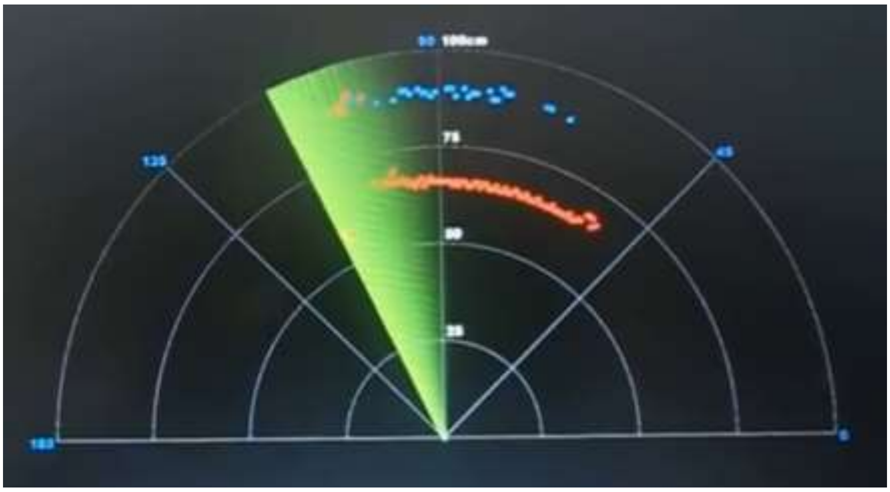


Figure 15 - Detection of objects in a Raw

b) Two objects placed at a distance of 63cm & 87cm ,radar gives the distance 62.5cm & 86cm

- error = ((63-62.5)/62.5)*100 = 0.8
- efficiency =100-error= 99.2%

After the observations and calculations we can conclude that this system is 98.25% efficient.

6 DISCUSSION

Arduino being open-source, has many copies legally available in market to purchase like the one's I found, which is quite reasonable, so these CLONE NANO's are associated with some problems, because of alternate parts being used to make it cheaper.

- Missing Serial Communication (CH340) drivers.
- Improper Port selected.
- Improper Board Settings.
- Missing Bootloader.
- Static Damaged.

From the project more distant objects require a larger surface area as much of the acoustic energy is lost as the beam spreads plus the return echo also spreads.

When try mounting the sensor vertically so that the transmit and receive beam-widths overlap.

7 CONCLUSION

Numerous advanced control methods gave designers to have more command over different advanced applications. In this project, the Arduino based acoustic radar display mapping method of whole system is assessed on small principles. The field that I have chosen for design “Acoustic Radar Display is a very vast field and future scope of this technology is very high. I have tremendous applications in which radar display have been implemented or used. There is a lot of future scope of this design because of its security capacity. It can be used in many applications. This framework can also be developed or modified according to the rising needs and demand. As I have designed a short range radar therefore project was specified and limited. This display can only detect objects from 0 to 180 degrees only because the stepper motor that I have programmed to rotate only to this range. So, due to this limitation design cannot be applied to places or areas for obstacle detection on a larger scale. Usage of a 360 degrees rotating stepper motor can make the system more efficient. I look forward to modify this system and enhance work by using a fully 360 degrees rotating and a higher ranged ultrasonic sensor. Can further add features to this project i.e. making it mobile, mounting an alarm system to it which turns on when obstacle is detected. Further modifications could be an obstacle avoiding robot with surveillance system.

8 REFERENCES

Dutt, A. (2014). Arduino based RADAR System, GRIN Verlag München, Germany.

effect, Fading. (2020). from https://forum.processing.org/two/discussion/13189/a-better-way-to-fade.

Onoja, A. E., A. M. Oluwadamilola, A. J. A. J. o. E. S. Lukman Adewale and Applications (2017). "Embedded System Based Radio Detection and Ranging (RADAR) System Using Arduino and Ultra-Sonic Sensor." **5**(1): 7-12.

APPENDIX

Datasheet of ultrasonic sensor –

https://www.mouser.com/datasheet/2/813/HCSR04-1022824.pdf

Datasheet of Arduino Nano -

https://www.arduino.cc/en/uploads/Main/ArduinoNanoManual23.pdf

Datasheet of ULN2003 Driver –

https://www.seeedstudio.com/document/pdf/ULN2003%20Datasheet.pdf

Datasheet of 28BJY-48 stepper motor –

http://robocraft.ru/files/datasheet/28BYJ-48.pdf