HARMONIC MOTION : TRACING PATTERNS IN A ROTATING FIELD

Internship Report submitted in partial fulfilment of the requirements for the award ofthe degree of

BACHELOR OF TECHNOLOGY

in

ELECTRONICS AND COMMUNICATION ENGINEERING

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DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

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CERTIFICATE

This is to certify that the project report entitled “HARMONIC MOTION : TRACING PATTERNS IN A ROTATING FIELD” is a bonafide work done under our supervision and is being submitted by

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Certified further that to the best of our knowledge the work presented in this thesis has not been submitted to any other University or Institute for the award of any Degree or Diploma.

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DECLARATION

We declare that the Internship project work entitled "**SMART DOOR LOCK SYSTEM**" submitted in the Department of Information Technology, Vallurupalli Nageswara Rao Vignana Jyothi Institute of Engineering and Technology, Hyderabad, in partial fulfilment of the requirement for the award of the degree of **Bachelor of Technology in ELECTRONICS AND COMMUNICATION ENGINEERING** is a bonafide record of our own work carried out under the supervision of **Dr. AYTHA RAMESH KUMAR , Associate Professor, Department of ECE, VNRVJIET.** Also, we declare that the matter embodied in this thesis has not been submitted by us in full or in any partial fulfillment of the award of any degree/diploma of any other institution or university previously.

Place: Hyderabad.

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We express our deep sense of gratitude to our beloved **Head, Department of Electronics and Communication Engineering, Associate Professor, Dr. S. Rajendra Prasad**, VNR Vignana Jyothi Institute of Engineering & Technology, Hyderabad for the valuable guidance and suggestions, keen interest and through encouragement extended throughout the period of project work.

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We express thanks to all those who contributed for the successful completion of our projectwork.

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ABSTRACT

In modern applications, the demand for accurate and efficient object detection systems has increased substantially. This project introduces a radar detection system leveraging ultrasonic sensor technology for real-time object localization. The system utilizes ultrasonic waves to measure the distance between the sensor and surrounding objects, providing a reliable method for detecting and tracking moving entities within its field of view.

The core components of the system include an Arduino microcontroller, an ultrasonic sensor , and a servo motor. The ultrasonic sensors emit pulses and measure the time taken for the echoes to return, enabling precise distance calculations. By processing these distance measurements in real-time, the system constructs a comprehensive spatial map of the environment, allowing for effective object detection.

Key features of the proposed radar detection system include high accuracy in distance measurements, adaptability to various environmental conditions, and real-time data visualization for enhanced situational awareness. The Arduino microcontroller facilitates seamless integration and control of the ultrasonic sensors, making the system versatile and easily customizable for different applications, such as robotics, surveillance, and security.

The project aims to contribute to the advancement of object detection technologies by providing an affordable and accessible solution using commonly available components. The results demonstrate the effectiveness of the ultrasonic sensor-based radar detection system in accurately localizing objects, paving the way for applications in autonomous vehicles, smart infrastructure, and beyond.

This research showcases the potential of ultrasonic sensors in radar detection, offering a scalable and cost-effective solution for object localization in dynamic environments.

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DESCRIPTION	Page

CHAPTER 1: INTRODUCTION

1.1 Introduction:

In the realm of robotics and automation, the ability to perceive and understand the surrounding environment is paramount. This project introduces a novel approach to environmental mapping through the fusion of an ultrasonic sensor, a servo motor, and an Arduino Uno microcontroller. The objective is to create a dynamic mapping system capable of scanning its surroundings, collecting distance data at various angles, and visualizing the spatial information in the form of a polar plot.

The core components of this system include an ultrasonic sensor for distance measurement, a servo motor for rotational control, and an Arduino Uno microcontroller for intelligent data processing and coordination. The ultrasonic sensor, strategically mounted on the servo motor, emits ultrasonic waves and measures the time taken for echoes to return, providing accurate distance readings. The servo motor facilitates a sweeping motion, allowing the sensor to cover a 180-degree arc.

The Arduino Uno orchestrates the synchronization between the ultrasonic sensor and servo motor. It processes the real-time distance data obtained from the sensor, calculates the average distance at each angle, and compiles a comprehensive dataset. This dataset serves as a representation of the environment, capturing the distances at regular intervals around the system.

The implementation utilizes MATLAB to visualize the gathered data in the form of a polar plot. The plot effectively represents the spatial relationships between the system and its surroundings, providing a clear map of the distances at different angles. The polar plot enables quick and intuitive interpretation of the environment, making it a valuable tool for applications such as autonomous navigation, object avoidance, or environmental monitoring.

As we delve into the details of this project, we will explore the intricacies of the code, the functionalities of each component, and the implications of utilizing such a dynamic mapping system. The fusion of ultrasonic sensing, servo control, and intelligent data processing showcases the potential for creating adaptive and perceptive robotic systems capable of interacting seamlessly with their surroundings.

1.2 LITERATURE SURVEY:

We have studied the literature surveys which gives the following information:

PAPER-1:

Radio Detection and Ranging (RADAR) has proven to be an effective tool for urban sensing and through-wall imaging. Nowaday's detecting object in the border region continuously is difficult. RADAR techniques are used to detect the objects in the border region with the combination of thermal radar and ultra sound radar. This project proposes the method to identify and differentiate the objects using digital image processing. The proposed work presents the sharpening filter is used to remove the noise. Texture based segmentation is used to detect the shape of the object and HOG algorithm is used to extracts the feature based on the intensity variation in the image.

https://ieeexplore.ieee.org/document/8550829

PAPER-2:

Automotive radar perception is an integral part of automated driving systems. Radar sensors benefit from their excellent robustness against adverse weather conditions such as snow, fog, or heavy rain. Despite the fact that machine-learning-based object detection is traditionally a camera-based domain, vast progress has been made for lidar sensors, and radar is also catching up. Recently, several new techniques for using machine learning algorithms towards the correct detection and classification of moving road users in automotive radar data have been introduced. However, most of them have not been compared to other methods or require next generation radar sensors which are far more advanced than current conventional automotive sensors. This article makes a thorough comparison of existing and novel radar object detection algorithms with some of the most successful candidates from the image and lidar domain

https://aiperspectives.springeropen.com/articles/10.1186/s42467-021-00012-z

PAPER-3:

N. Gupta and A. K. Agarwal, "Object Identification using Super Sonic Sensor: Arduino Object Radar," 2018 International Conference on System Modeling & Advancement in Research Trends (SMART), Moradabad, India, 2018, pp. 92-96, doi: 10.1109/SYSMART.2018.8746951.

Abstract: A Object Radar is a device (Tool) that is used to measure the distance from the object to the device Which is used for the purposes of surveying, determining focus in photography, or getting the information about the location and angle of the object. In this technical project, we had made simple object radar using the ULTRASONIC SENSOR (HC-SR04). This Radar Device works by calculating a distance range from 4 cm to 40 cm with angle range between 15° to 165°. In this device Servo Motor is used for the rotation of the ultrasonic sensor between the angles. "Processing Development Environment" software is used to demonstrate the result on a PC Screen after processing the information received by the Ultrasonic Sensor.

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8746951&isnumber=8746843

PAPER-4:

In this paper, attempts are made to detect some basic shape of objects using ultrasonic sensor arrays with Artificial Neural Network (ANN). For this purpose two types of ultrasonic sensor array are designed on prototype basis using HCSR04 ultrasonic sensors. The time of flight (TOF) variations of the sensors are considered as the features for the recognition unit. The objects are kept at a fixed distance from the sensor array to measure the TOF. The TOF of different sensors varies with the different object's shape. The two tools of ANN named `Function Fitting' and `Pattern Recognition' are used as shape recognition unit. These tools are trained with particular objects data

https://ieeexplore.ieee.org/document/9290607

PAPER-5:

In this paper, we are going to talk about Radar System controlled by an Arduino. This Radar System consists of an Ultra-sonic Sensor and servo motor. These are the main components of the system. The basic function of the system is to detect objects within its defined range. The Ultra-sonic Sensors are connected to the servo Motor. The servo motor rotates about 180 degrees and provides visual representation on the processing IDE. The processing IDE provides graphical representation and also gives the angle or position of object and the distance of object. This system is controlled by an Arduino UNO board. This board is sufficient to control the ultrasonic sensor and to interface the sensor with the display device. The main applications of this RADAR System are navigation, positioning and object identification, mapping and spying or tracking and various applications

Radar system using Arduino and Ultrasonic sensor (jetir.org)

PAPER-6:

There is a need to observe restricted zones to abstain from intruding. Presently employing humans for this work is exorbitant and furthermore it is unrealistic for observing a territory 24×7. So, for this reason an ultrasonic sensor for unauthorized human/creatures or object recognition system can be used. This system can observe a zone of restricted area and cautions authorities with a buzzer as an alert. This can be implemented with a microcontroller circuit that is associated with a ultrasonic sensor mounted on a servo engine for monitoring of objects

http://www.ijmtst.com/volume7/issue06/IJMTST7010.pdf

CHAPTER 2: METHODOLOGY

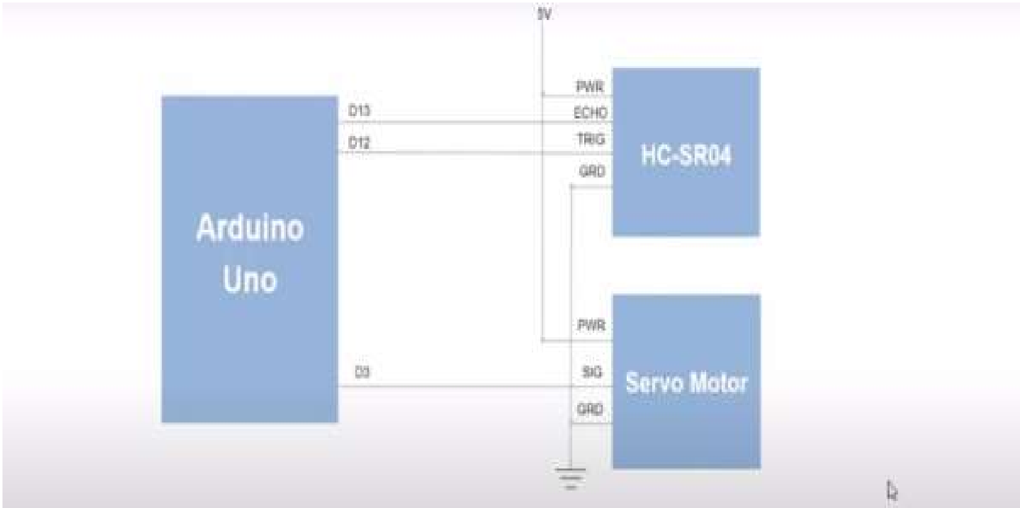
2.1 WORKING:

The project introduces a dynamic element to its environment mapping capabilities by incorporating a servo motor that enables the ultrasonic sensor to actively sweep through a 180-degree arc. This sweeping motion, orchestrated by the Arduino Uno microcontroller, ensures a comprehensive coverage of the surroundings. The servo motor's pan-and-tilt mechanism enhances the system's adaptability and responsiveness, allowing it to adjust its view dynamically. This feature is particularly valuable in scenarios where real-time monitoring and tracking of objects are crucial.

The iterative data collection process, involving both forward and reverse sweeps, contributes to the system's accuracy. The averaging of distance measurements during the reverse sweep further refines the dataset, resulting in a more robust representation of the environment. The resulting polar plot not only offers a visual representation of spatial information but also serves as a practical tool for decision-making in autonomous systems.

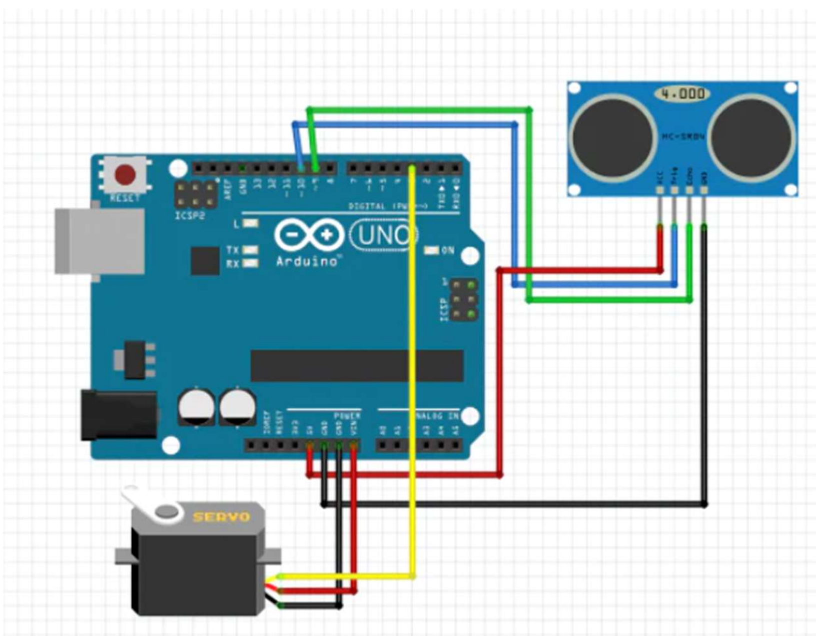
Beyond its immediate applications in autonomous navigation and obstacle avoidance, the project lays the groundwork for advancements in adaptive robotics. The collaborative integration of ultrasonic sensing, servo control, and intelligent data processing exemplifies a holistic approach to environmental awareness. This approach not only addresses current challenges in robotics and surveillance but also positions the system as a versatile solution for future innovations in smart infrastructure, environmental monitoring, and beyond. The project showcases the potential of combining hardware and software components to create sophisticated, perceptive systems capable of navigating and interacting with the world intelligently.

BLOCK DIAGRAM

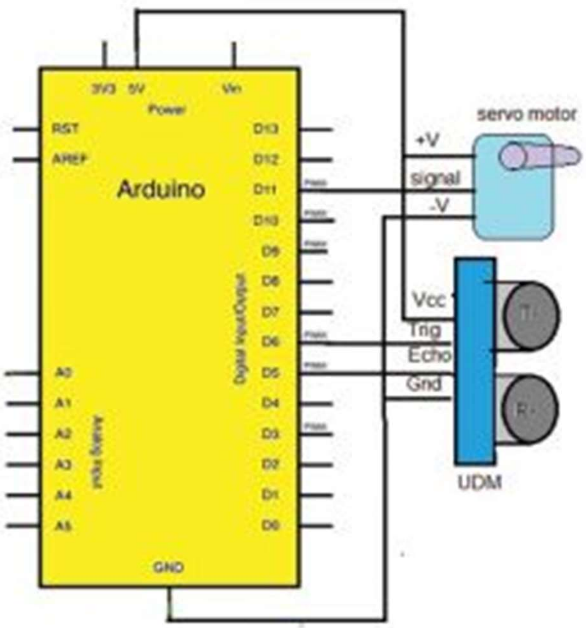


2.2 DESIGN:

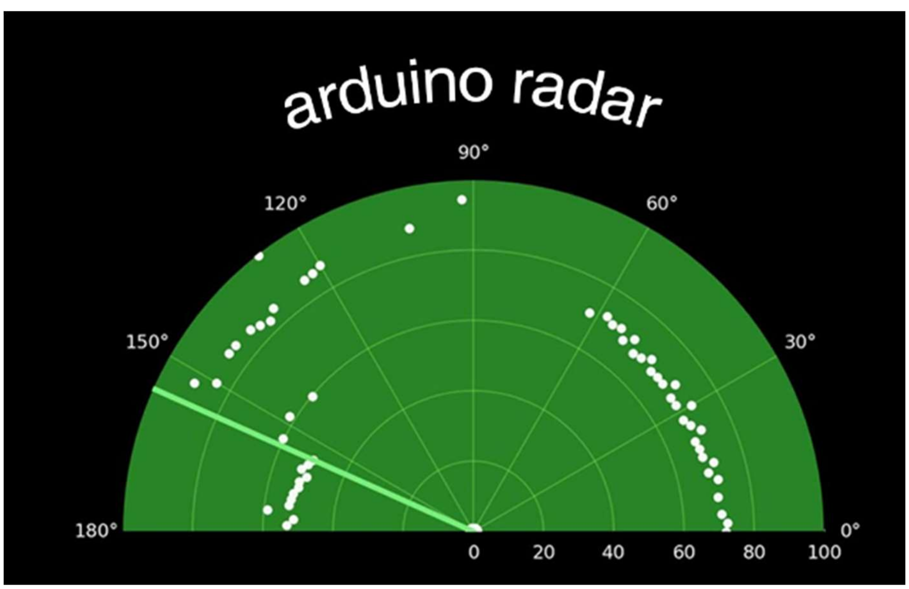
(a)



(b)


Arduino
Power
servo motor
+V
signal
-V
Vcc
Trig
Echo
Gnd
UDM
GND

(c)


arduino radar
90°
120°
60°
150°
30°
180°
0°
0
20
40
60
80
100

2.2.1 DESCRIPTION OF DESIGN:

The project design revolves around creating a sophisticated environment mapping system using an Arduino Uno microcontroller, an ultrasonic sensor, and a servo motor. The design can be outlined as follows:

1. Component Selection:
- **Arduino Uno Microcontroller**: Chosen as the central processing unit due to its versatility and ease of integration with sensors and actuators.
- **Ultrasonic Sensor**: Employed for distance measurement, utilizing ultrasonic waves to determine the distance between the sensor and objects in its vicinity.
- **Servo Motor:** Used for controlled sweeping motion, allowing the ultrasonic sensor to cover a 180-degree arc.

2. Hardware Integration:
- The ultrasonic sensor is strategically mounted on the servo motor, forming a cohesive hardware unit. This design choice facilitates systematic scanning of the environment by adjusting the sensor's orientation through the servo motor's pan-and-tilt mechanism.

3. Sweeping Motion:
- The servo motor is controlled by the Arduino Uno to perform a sweeping motion. This motion covers a 180-degree range, ensuring comprehensive coverage of the environment. The servo motor's controlled movement allows the ultrasonic sensor to capture distance data at different angles.

4. Data Collection and Processing:
- During the sweeping motion, the Arduino Uno processes real-time distance data obtained from the ultrasonic sensor. The distances are logged into a comprehensive table, capturing the spatial information at regular intervals.

5. Reverse Sweep and Averaging:
- To enhance accuracy, a reverse sweep is performed, and the obtained distances during the reverse sweep are averaged with the existing values in the table. This iterative process refines the dataset and contributes to the creation of a more robust representation of the environment.

6. Visualization:
- MATLAB is utilized for visualization, employing its polar plot capabilities to represent the spatial map of the environment. The polar plot offers an intuitive display of distance information at different angles, enhancing the system's interpretability.

CHAPTER 3: PROCESS & REQUIREMENTS

3.1 SOFTWARE REQUIREMENTS:

MATLAB:

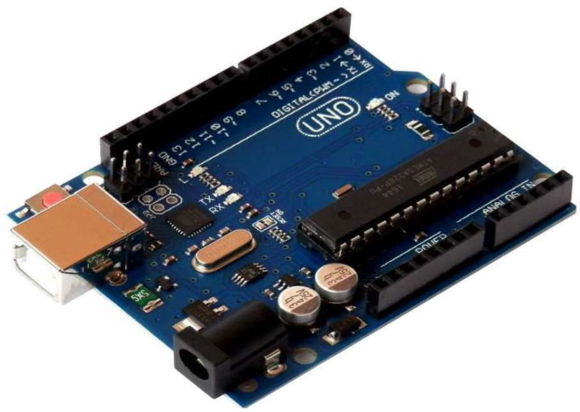
In this project, the primary software used is the MATLAB programming environment. MATLAB. Furthermore, the software design incorporates the Arduino IDE for initial firmware programming, allowing the Arduino Uno to execute precise control over the servo motor and ultrasonic sensor. The MATLAB script, acting as the intelligence hub, engages in real-time communication with the Arduino Uno through serial connectivity. This dynamic interaction enables the Arduino Uno to continuously feed distance data to MATLAB during the servo motor's sweeping motion. MATLAB, in turn, performs crucial tasks such as data logging, reverse sweeping, and data averaging, enhancing the accuracy and reliability of the spatial mapping dataset. The polar plot visualization generated by MATLAB offers an insightful representation of the environment, making it a valuable tool for applications such as autonomous navigation and obstacle avoidance.

The adaptability and responsiveness of the system are underscored by MATLAB's capabilities in orchestrating the complex interplay between hardware components. By seamlessly integrating data analysis and visualization processes, MATLAB transforms raw distance data into a comprehensive spatial map, showcasing the potential of intelligent systems in understanding and navigating dynamic environments. This collaborative marriage of hardware and software components forms the backbone of the project, highlighting the importance of MATLAB as a sophisticated platform for real-time analytics and visualization in cutting-edge robotics and automation applications.

3.2 COMPONENTS DESCRIPTION:

The project employs three primary components: the Arduino Uno microcontroller, an ultrasonic sensor, and a servo motor.

1. Arduino Uno Microcontroller:

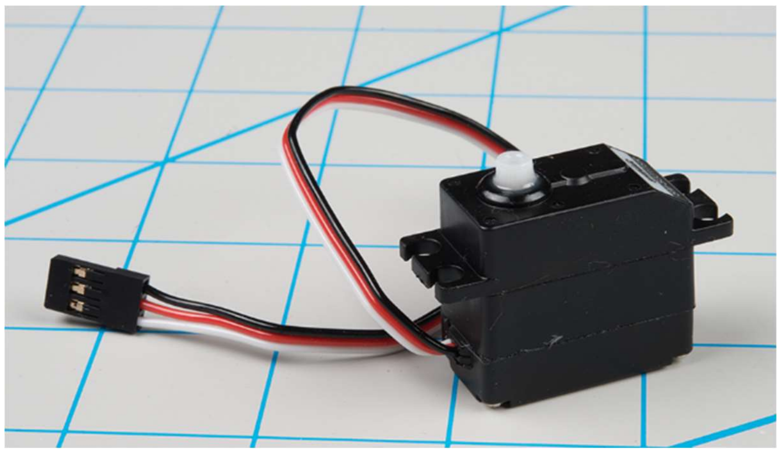


- The Arduino Uno serves as the central processing unit, orchestrating the operation of the entire system. Its role involves executing the programmed firmware to control the servo motor's sweeping motion, reading data from the ultrasonic sensor, and managing the real-time communication with MATLAB. The versatility and open-source nature of the Arduino platform make it an ideal choice for interfacing with various hardware components seamlessly.

2. Ultrasonic Sensor:

- The ultrasonic sensor is a key sensory component responsible for measuring distances in the environment. Mounted on the servo motor, it emits ultrasonic waves and measures the time taken for the echoes to return. This time delay is used to calculate the distance between the sensor and objects in its field of view. The sensor's strategic placement on the servo motor enables systematic scanning of a 180-degree arc, allowing the system to capture distance data at different angles.

3. Servo Motor:



- The servo motor provides controlled rotational motion to the ultrasonic sensor. The pan-and-tilt mechanism of the servo motor enables the sensor to sweep across a specified range, covering a 180-degree field of view. This sweeping motion ensures comprehensive coverage of the environment, allowing the system to collect distance measurements from multiple perspectives. The servo motor's precise control and ability to adjust the orientation of the sensor dynamically contribute to the adaptive nature of the environment mapping system.

3.3 WORKING CODE:

```
clear all;
a = arduino('COM7', 'Uno', 'Libraries', {'Ultrasonic', 'Servo'});
sensor = ultrasonic(a, 'D12', 'D13');
servo_motor = servo(a, 'D3');
i = 1;
table = zeros(180,2);
for theta = 0 : 1/180 : 1
    writePosition(servo_motor, theta);
    dist1 = readDistance(sensor);
    pause(.04);
    dist2 = readDistance(sensor);
    dist = (dist1+dist2)/2;
    table(i,1) = (i-1);
    table(i,2) = round(dist * 100,2);
    i = i + 1;
end
j = 1;
for theta = 1 : -1/180 : 0
    writePosition(servo_motor, theta);
    dist1 = readDistance(sensor);
    pause(.04);
    dist2 = readDistance(sensor);
    dist = (dist1+dist2)/2;
```

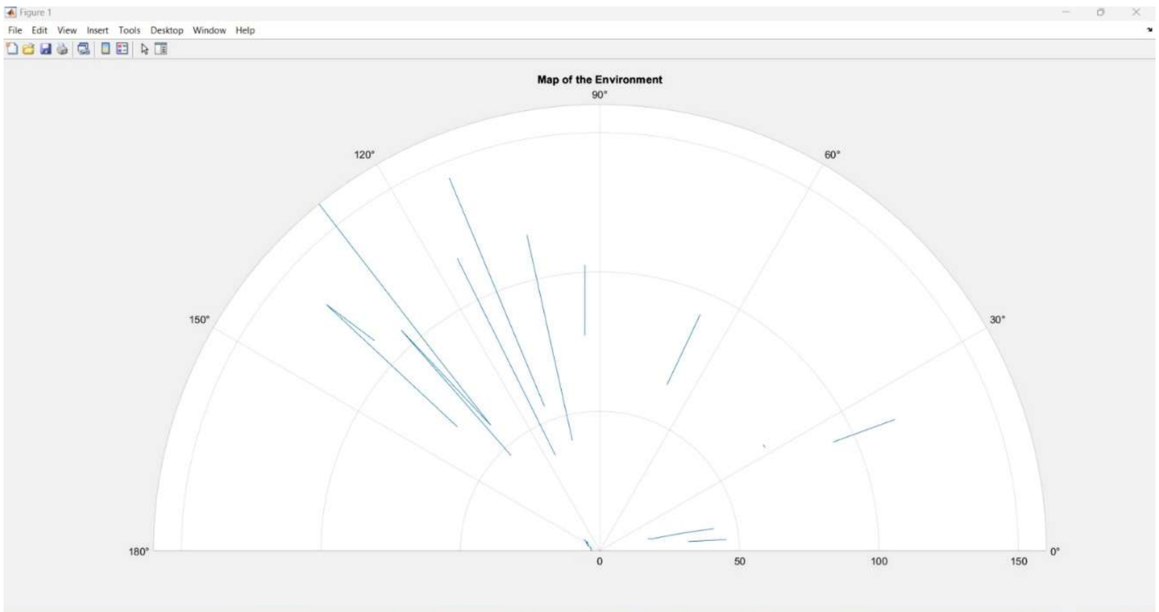
```
  table(i-j,2) = (table(i-j,2) + round(dist * 100,2))/2;

 j = j + 1;
end
polarplot (table(:,1)*pi/180, table (:,2));
disp(polarplot (table(:,1)*pi/180, table (:,2)))
title('Map of the Environment');
thetalim([0 180]);
grid on;
```

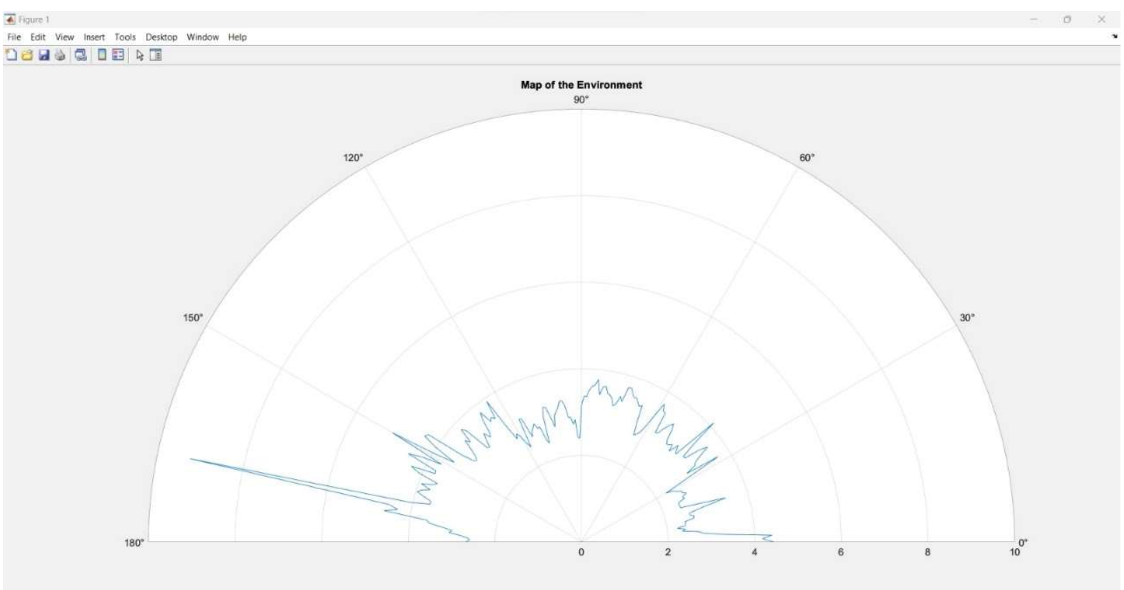
CHAPTER 4: RESULT

4.1 RESULT:

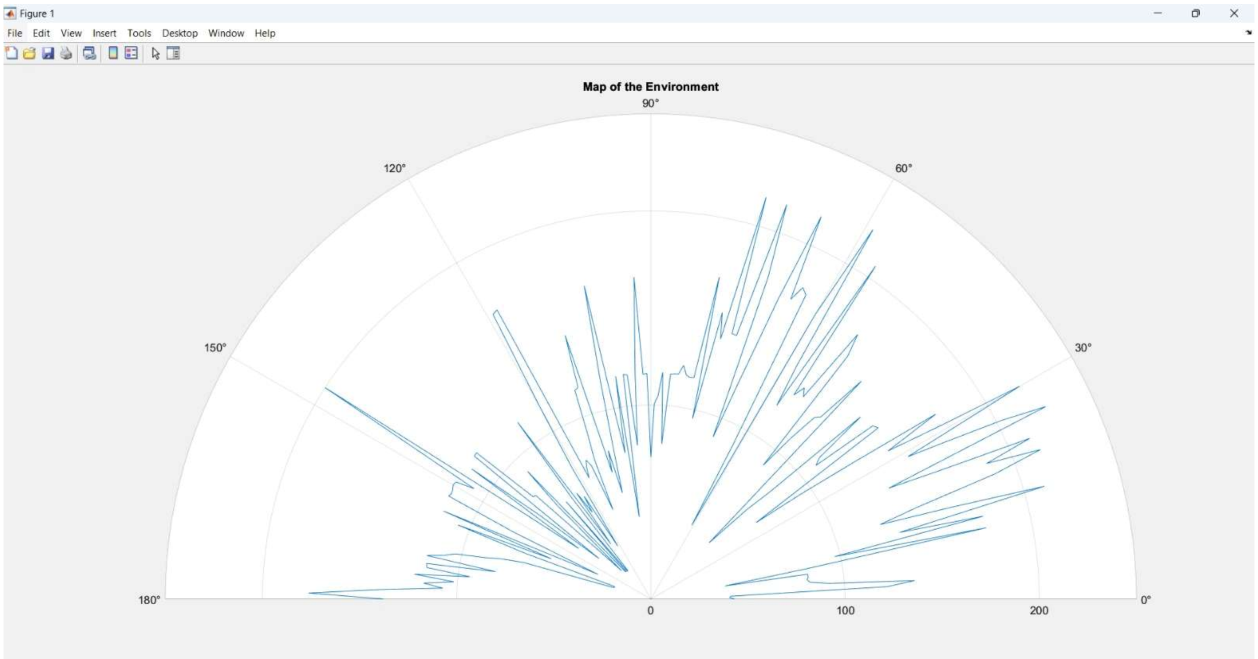
1. First Case – With less number of objects



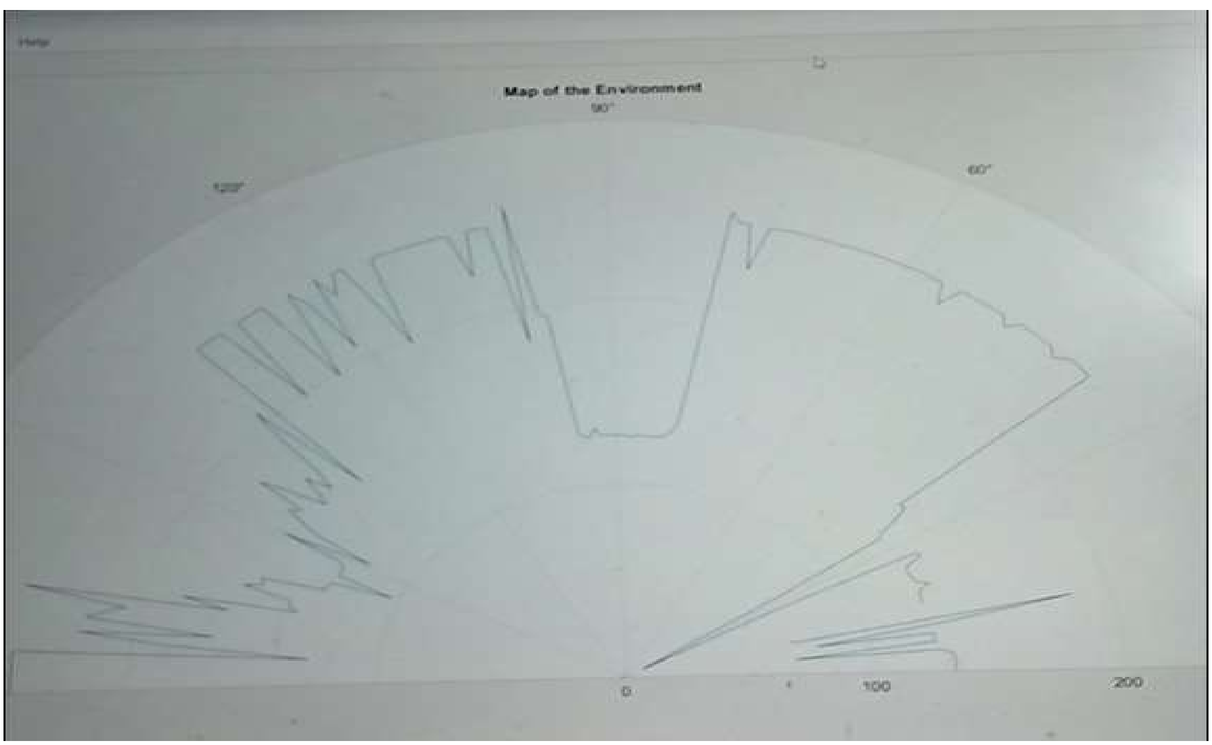
2. Second Case – With moderate number of objects



3. Third Case – With more number of objects



4. Fourth Case – With maximum number of objects



CHAPTER 5: CONCLUSION

5.1 CONCLUSION:

In conclusion, the described project successfully demonstrates the development of a sophisticated environment mapping system through the collaborative integration of an Arduino Uno microcontroller, an ultrasonic sensor, and a servo motor. The system's ability to actively scan and map its surroundings, facilitated by the servo-controlled sweeping motion, contributes to creating a comprehensive spatial representation of the environment. The iterative data collection process, involving both forward and reverse sweeps, enhances the accuracy of the spatial dataset.

The utilization of MATLAB as the primary software platform underscores the significance of real-time data processing and visualization. MATLAB's polar plot capabilities offer an intuitive representation of the environment, making the system a valuable tool for applications such as autonomous navigation and obstacle avoidance. The seamless collaboration between the hardware and software components highlights the adaptability and responsiveness of the system, showcasing its potential in addressing a range of real-world challenges.

This project not only serves as a practical demonstration of environmental mapping but also lays the groundwork for future innovations in adaptive and perceptive robotic systems. The collaborative synergy between ultrasonic sensing, servo control, and intelligent data processing opens avenues for applications in robotics, surveillance, smart infrastructure, and beyond. Overall, the project underscores the significance of interdisciplinary integration in creating intelligent systems capable of understanding and interacting with their dynamic environments.

CHAPTER 6: FUTURE SCOPE

6.1 FUTURE SCOPE:

1. Enhanced Sensor Technologies:
   - Investigate and integrate advanced sensor technologies beyond ultrasonic sensors, such as LiDAR or depth-sensing cameras
2. Machine Learning Integration:
   - Explore the incorporation of machine learning algorithms for real-time data analysis and decision-making
3. Multi-Robot Collaboration:
   - Extend the project to a multi-robot system where multiple units equipped with similar sensors collaborate for collective environmental mapping.
4. 3D Mapping and Visualization:
   - Extend the system to generate three-dimensional maps of the environment. Integrate 3D visualization techniques to provide a more comprehensive representation of spatial information, allowing for enhanced understanding and analysis.
5. Autonomous Navigation Algorithms:
   - Develop and implement advanced autonomous navigation algorithms based on the spatial mapping data. This could include path planning, obstacle avoidance, and dynamic re-routing strategies for improved robotic autonomy.
6. Edge Computing Implementation:
   - Explore the feasibility of implementing edge computing capabilities directly on the Arduino or a dedicated edge device. This can lead to faster real-time data processing and reduced reliance on external computing resources.
7. Integration with IoT Platforms:
   - Investigate the integration of the environment mapping system with Internet of Things (IoT) platforms for remote monitoring and control. This could enhance the system's accessibility and enable real-time data sharing across different devices and locations.
8. Human-Robot Interaction:
   - Explore applications involving human-robot interaction, where the mapped environmental data is used to assist or collaborate with humans in shared spaces. This could have applications in areas like smart homes, healthcare, or industrial settings.

9. Energy-Efficient Hardware Design:
- Optimize the hardware design for energy efficiency, particularly in scenarios where the system operates on battery power. Investigate low-power components and sleep mode strategies to extend the system's operational duration.

10. Real-World Deployment and Validation:
- Conduct real-world deployment and validation of the system in diverse environments. Evaluate its performance under different lighting conditions, terrains, and obstacle scenarios to ensure robustness and reliability.

11. Interdisciplinary Collaboration:
- Collaborate with experts from diverse fields, including environmental science, urban planning, or industrial automation, to explore innovative applications and address specific domain challenges using the developed mapping system.

CHAPTER 7: REFERENCES

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7. C. H. S. Reddy, A. M. Tiwari and B. Murgan, "Ultrasonic Sensor and Raspberry Pi with android app," Journal of Chemical and Pharmaceutical Sciences, vol. 5, no. Special Issue, 2016.

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