GYRO ACTUATED BOT

Mini Project - Report submitted by

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6th Semester B.E.

Under the Guidance of

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In partial fulfillment of the requirements for the award of

the Degree of

Bachelor of Engineering in Robotics and Artificial Intelligence

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NMAM Institute of Technology, Nitte - 574110

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DEPARTMENT OF ROBOTICS AND ARTIFICIAL INTELLIGENCE

CERTIFICATE

Certified that the Mini project work entitled

"Gyro Actuated Bot"

is a bonafide work carried out by

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prescribed by Visvesvaraya Technological University, Belagavi

during the year 2023-2024.

____________________	____________________
Signature of the Guide	***Signature of the HOD***

Viva Voce Examination

Name of the Examiners	**Signature with Date**
1. ____________________	____________________
2. ____________________	____________________

ACKNOWLEDGMENT

This thesis is the result of the work done by me with the guidance and assistance of several people, all of whom I cannot name and thank individually, but will make an earnest effort to acknowledge a few among them.

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I. ABSTRACT

This mini project focuses on the development of a gyro-controlled servo motor system that utilizes a smart phone's built-in gyroscopic sensor to influence the movement of two servo motors via an ESP32 micro controller. The primary aim is to capture the pitch and roll angles from the smart phone's gyroscope and wirelessly transmit this data to the ESP32. Subsequently, the ESP32 processes the received gyroscopic data to control the angles of two servo motors, thereby enabling precise movements in response to the smart phone's orientation changes.

In this project, a mobile application is developed using MATLAB to read the gyroscope data from the smart phone and transmit it using wireless communication protocols such as Bluetooth or Wi-Fi. The ESP32, programmed via the Arduino IDE, is configured to receive this data, process it in real-time, and generate control signals for the servo motors. The integration of the smart phone's sensor capabilities with the ESP32's processing power and wireless communication features presents a versatile and innovative approach to control systems. The implementation involves creating a seamless interface between the smart phone and the ESP32, ensuring reliable data transmission and accurate servo motor control.

II. INTRODUCTION

In the realm of modern engineering, the fusion of mobile technology, micro controllers, and sensor integration opens up a realm of possibilities for innovative projects. This mini project explores the utilization of a smart phone's built-in gyro sensor to control servo motors through an ESP32 micro controller. By harnessing the power of MATLAB for signal processing and Arduino IDE for micro controller programming, this project presents a fascinating integration of software and hardware to achieve precise and intuitive control.

The project centers on the concept of using the pitch and roll readings from a smart phone's gyro sensor to dynamically control the movement of two servo motors. The pitch and roll angles, representing the tilt and rotation of the phone along its longitudinal and transverse axes, respectively, serve as input variables. These readings are processed and transmitted wirelessly to an ESP32 micro controller, acting as the bridge between the smart phone and the servo motors.

The goal of this project is to design and implement a system where the orientation data from a smartphone's gyroscope is used to control the angles of two servo motors. The process involves developing a mobile application using MATLAB to capture and transmit the gyroscope data via Bluetooth or Wi-Fi. The ESP32, programmed using the Arduino IDE, will receive this data and control the servo motors accordingly.

This project not only demonstrates the practical application of integrating smart phone sensors with micro controller-based systems but also highlights the potential for creating intuitive and interactive control mechanisms. Such systems can be employed in various applications, including robotics, remote-controlled devices, and interactive installations, where precise and responsive control is essential. By harnessing the ubiquitous presence of smart phones and their advanced sensor capabilities, this project aims to bridge the gap between mobile technology and microcontroller-based actuation systems, offering a versatile and innovative solution for modern control applications.

III. LITERATURE REVIEW

Bhuyan, Ariful Islam, and Tuton Chandra Mallick In the field of robotics and automation, research conducted by Bhuyan, Ariful Islam, and Tuton Chandra Mallick has significantly contributed to the advancement of sensor-based control systems and microcontroller applications. Their work spans various aspects of utilizing gyroscopic sensors and microcontrollers like ESP32 in innovative ways, particularly for controlling actuators such as servo motors. This literature review aims to summarize and analyze their contributions, highlighting key findings and their implications for future research and applications. Bhuyan, Islam, and Mallick have extensively explored the use of gyroscopic sensors for real-time control in robotic systems. Their studies demonstrate how gyroscopes can be integrated into robotic platforms to enhance stability and control. By capturing rotational data (pitch, roll, and yaw), their research illustrates the precise control of robotic movements and orientations, which is critical for applications such as self-balancing robots and unmanned aerial vehicles (UAVs).

Rohman, and SugengDwi Riyanto.(2020) have made significant contributions to the field of robotics and control systems, particularly through their work in sensor-based control and micro controller applications. Their 2020 publication focuses on innovative methods for integrating sensors with micro controllers to enhance the functionality and performance of robotic systems. This literature review aims to provide an overview of their research, highlighting key findings and their implications for future developments in robotics and automation. Rohman and Riyanto have contributed to the development of advanced control algorithms that process real-time sensor data to achieve precise control of robotic actuators. Their research includes the implementation of Proportional-Integral-Derivative (PID) controllers and other feedback mechanisms that ensure stable and accurate control of movements. By applying their methods to different types of robots, they have demonstrated the versatility and scalability of their approaches, making their research relevant to a wide array of robotic applications.

Tsai, Nan-Chyuan, and Bo-Yang Wu have made notable contributions to the field of robotics and automation through their research on advanced control systems and sensor integration. Their 2008 publication focuses on the development of innovative methodologies for enhancing the performance and functionality of robotic systems.

This literature review aims to provide a comprehensive overview of their research, summarizing key findings and discussing their implications for future advancements in robotics and control technologies.

A significant aspect of their research is the integration of various sensors, including gyroscopes, accelerometer, and force sensors, into robotic control systems. By combining data from these sensors, they were able to enhance the robot's ability to navigate complex environments and perform precise tasks. Their approach to sensor fusion is a key contribution to the field, demonstrating the potential for improved robotic performance through multi-sensor integration.

Umek, Anton, and Anton Kos have contributed significantly to the fields of sensor technology, data processing, and wireless communication within robotics and automation. Their research focuses on integrating advanced sensors, developing efficient data processing algorithms, and enhancing wireless communication protocols for real-time applications. This literature review aims to provide an overview of their contributions, summarizing key findings and discussing their implications for future advancements in these areas.

Umek and Kos have applied their research in advanced sensor integration and wireless communication to health monitoring and ambient assisted living (AAL) systems. They have developed wearable sensor systems and smart home solutions to monitor vital signs, detect falls, and provide real-time health data to caregivers and medical professionals. Their work demonstrates the practical applications of their research in improving the quality of life for elderly and disabled individuals.

Their research also emphasizes the role of wireless communication in sensor networks and robotic control systems. Umek and Kos have explored various wireless protocols, such as Bluetooth, Zigbee, and Wi-Fi, to facilitate reliable and low-latency communication between sensors, micro controllers, and actuators. They have developed strategies to optimize these protocols for energy efficiency and robustness in dynamic environments

IV. OBJECTIVE

- Capture real-time pitch and roll readings using the smartphone's built-in gyroscope.
- Develop a method to wirelessly transmit gyro sensor data from the smart phone to the ESP32 micro controller.
- Implement control algorithms on the ESP32 to adjust two servo motors based on the received pitch and roll data.
- Use MATLAB for processing gyro sensor data and refining control algorithms.
- Program the ESP32 using the Arduino IDE for real-time data processing and motor control.
- Create a user-friendly smart phone interface for monitoring gyro data and controlling the system.
- Ensure real-time responsiveness of the servo motors to the gyro readings for smooth and precise movements.

V. METHODOLOGY

1. Research and Planning

1.1 Conduct Research

- Gyro Sensors: Understand the working principles of gyroscopic sensors, particularly focusing on how they measure pitch and roll angles.

- ESP32 Microcontrollers: Study the features, capabilities, and programming of ESP32 microcontrollers, especially regarding wireless communication and servo motor control.

- Servo Motors: Learn about servo motor operation, control methods, and integration with microcontrollers.

- Wireless Communication Protocols: Investigate Bluetooth and Wi-Fi protocols, considering their advantages and limitations for this application.

1.2 System Architecture Planning

- Design the system architecture, outlining how the smartphone's gyro sensor will communicate with the ESP32 microcontroller and how the ESP32 will control the servo motors.

- Define the data flow, including data acquisition from the gyro sensor, wireless transmission, and real-time processing by the ESP32.

2. Hardware Setup

2.1 Acquire Hardware Components

- **ESP32 Microcontroller:** Obtain an ESP32 development board.

- **Servo Motors:** Select appropriate servo motors that can be controlled by the ESP32.

- Smartphone: Ensure it has a built-in gyro sensor and can run MATLAB Mobile.

2.2 Connect Hardware

- Connect the servo motors to the ESP32 microcontroller using GPIO pins.

- Ensure proper power supply and grounding for both the ESP32 and the servo motors according to their specifications.

3. Software Development

3.1 MATLAB Script Development

- Develop a MATLAB script to read pitch and roll data from the smartphone's gyro sensor.

- Implement Bluetooth or Wi-Fi communication within the script to transmit the gyro data to the ESP32.

3.2 Arduino Code Development

- Write Arduino code in the Arduino IDE to program the ESP32.

- Implement functions to receive gyro data via Bluetooth or Wi-Fi, process this data, and control the servo motors based on the received pitch and roll values.

- Utilize libraries such as `Servo.h` to manage servo motor operations.

4. Calibration and Optimization

4.1 System Calibration

- Calibrate the gyro sensor to ensure accurate pitch and roll readings.

- Adjust servo motor control parameters, such as position thresholds and movement limits, to match the application requirements.

4.2 Algorithm Optimization

- Fine-tune the control algorithms to improve the responsiveness of the servo motors to changes in smartphone orientation.

- Test and adjust the sensitivity settings to achieve a balance between smooth movement and responsive control.

5. Validation and Performance Evaluation

5.1 Functionality Validation

- Test the gyro-controlled servo system under various orientations and movements of the smartphone.

- Verify that the servo motors respond correctly and promptly to changes in pitch and roll angles.

5.2 Performance Metrics Evaluation

- Measure key performance metrics such as:

  - **Accuracy:** The precision of servo motor positions corresponding to gyro data.

  - **Response Time:** The time taken for the system to react to changes in smartphone orientation.

  - **Reliability:** The consistency of system performance over repeated tests and extended usage.

6. Documentation and Presentation

6.1 Project Documentation

- Document the hardware setup process, including detailed instructions and diagrams.

- Provide comprehensive software documentation, including MATLAB and Arduino code with comments and explanations.

- Include calibration procedures, test results, and any troubleshooting steps encountered during development.

6.2 Project Presentation

- Prepare a presentation that summarizes the project objectives, methodology, results, and potential applications.

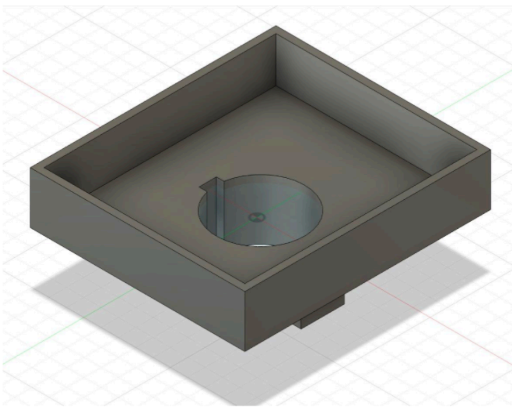
- Highlight key findings from the performance evaluation and any unique challenges or solutions developed during the project.

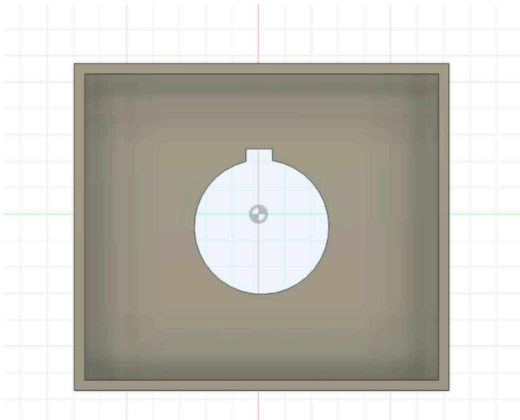
- Demonstrate the working system, showcasing its responsiveness and accuracy in real-time control scenarios.

VI. DESIGN OF 3D MODEL

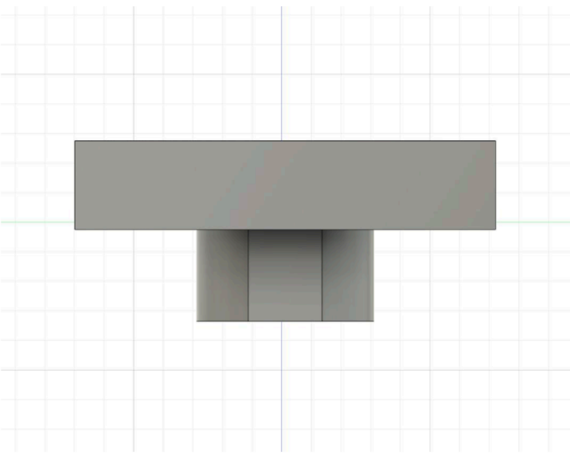
(All Measurements in mm)

Base

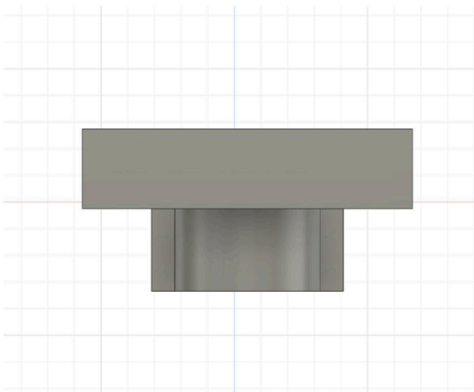




Top view

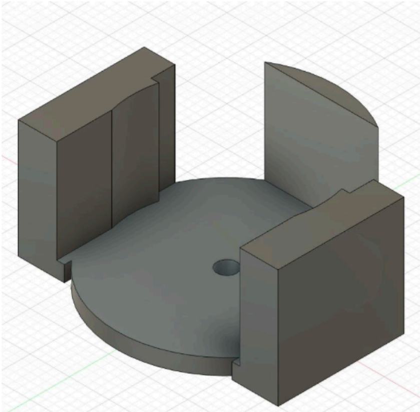


front view

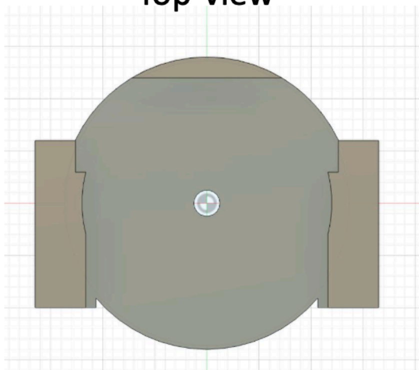


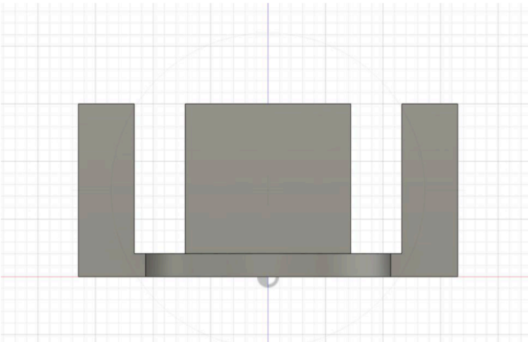
side view

Motor 1 Holder

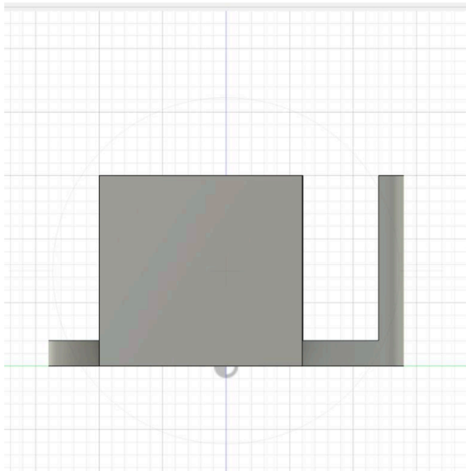


Top view





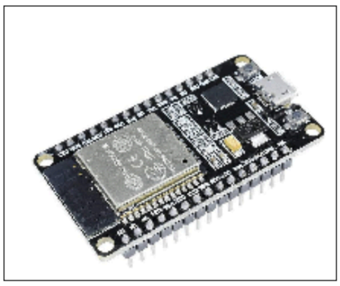
Front view



side view

VII. COMPONENTS

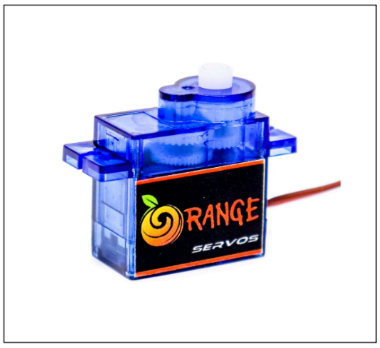
1.ESP32 DEVKIT V1 Module



ESP 32 Dev module

Model number	**ESP32S**
Number of Memory Sticks	1
Item Weight	120 g
Product Dimensions	40 x 35 x 20 cm; 120 g
Auto Focus Included	No
Processor Speed	2.4 GHz
Number of processors	2
Wireless Standard	Bluetooth
Connectivity Technology	Bluetooth, Wi-Fi

2.Orange OT90R Servo Motor



Orange OT90R 6V 1.5kg.cm Metal Brush Digital Servo Motor- 360° Rotation

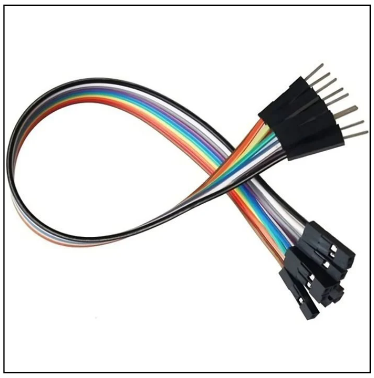
Product Model	**OT90R**
Input Voltage Range	4.8V-6V
Rated Torque	0.5kg
Gears Type	Plastic Gear
Connector	JR
Size	23 x 12 x 26.5mm

3.TowerPro SG90 Mini Servo Motor

SG 90 9G Mini Micro Servo plastic gear

Product Model	**SG 90 9G**
Weight	9g
Size	3.2 x 3 x 1.2cm
Maximum Angle	180 degree
Stall Torque	1.2kg
Operating Voltage	3.0-7.2V
Operating Speed	0.12sec(4.8v)
Temperature Range	-30°C~60°C
Line Length	245mm

4.Jumper Wires



Male to Female Jumper Wires

5.PLA

Color:	Black
Material:	PLA+ (Polylactic Acid)
Filament Diameter (mm):	1.75
Melt Flow Index (g/10min):	2(190°C/2.16kg)

VIII. SOFTWARES USED

1.Fusion 360

Fusion 360 (or Fusion for short) is a commercial computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE) and printed circuit board (PCB) design software application, developed by Autodesk. It is available for Windows, macOS and web browser,[with simplified applications available for Android and iOS. Fusion is licensed as a paid subscription, with a free limited home-based, non-commercial personal edition available.

Fig 8.1:Fusion 360

2.SnapMaker Luben

Snapmaker Luban is a multifunctional 3-in-1 software designed for the Snapmaker series of 3D printers, laser engravers, and CNC routers. It offers a comprehensive solution for creating, editing, and controlling projects across these different functionalities. Luban provides an intuitive user interface that allows users to import, edit, and generate toolpaths for their designs, making it easier to switch between modes within the Snapmaker ecosystem. With capabilities for 3D printing, laser engraving, and CNC carving, Snapmaker Luban streamlines the

Fig 8.2:Snapmaker Luben

workflow and enhances the user experience for makers, creators, and hobbyists looking to explore various manufacturing techniques within a single software platform.

3.Arduino IDE

The Arduino IDE (Integrated Development Environment) is a cross platform application that provides a simple and user-friendly interface for writing, compiling, and uploading code to Arduino boards. It is specifically designed for working with Arduino-compatible hardware and is widely used in the maker and electronics communities for developing projects and prototypes. The Arduino IDE supports the C and C++ programming languages and includes libraries and examples to help users get started with their projects. It also features a serial monitor for debugging and testing code, making it a versatile tool for both beginners and experienced developers working on embedded systems and IoT (Internet of Things) applications.

Fig 8.3:Arduino IDE 2

4.Matlab

MATLAB is a proprietary multi-paradigm programming language and numeric computing environment developed by MathWorks. MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

MATLAB is an abbreviation for "matrix laboratory." While other programming languages usually work with numbers one at a time, MATLAB operates on whole matrices and arrays. Language fundamentals include basic operations, such as creating variables, array indexing, arithmetic, and data types.

Fig 8.4:MATLAB

IX. RESULTS

The project successfully achieved its primary aim of using a smartphone's gyroscopic sensor to control servo motors via an ESP32 microcontroller. The integration of MATLAB for data processing and Arduino IDE for microcontroller programming resulted in a robust, responsive, and accurate control system. The system's real-time performance, reliability, and user-friendly interface highlight its potential for various applications in robotics, remote-controlled devices, and interactive installations. The project demonstrated a seamless blend of hardware and software, paving the way for future innovations in sensor-based control systems.

The MATLAB script effectively captured pitch and roll angles from the smartphone's gyroscope. The wireless transmission of this data to the ESP32 via Wi-Fi was robust, ensuring no significant data loss, which is critical for maintaining real-time responsiveness. The ESP32 microcontroller was programmed to efficiently parse and process the incoming gyroscopic data, translating it into precise control signals for the servo motors. This real-time processing was a cornerstone of the project's success, ensuring that the system could react promptly to changes in the smartphone's orientation.The servo motors responded accurately to the gyroscopic data, with smooth and proportional movements that reflected the smartphone's pitch and roll angles. Calibration efforts paid off, optimizing system performance and ensuring the motors operated without abrupt or jerky motions. The MATLAB Mobile application provided an intuitive interface for users to monitor and control the system. Real-time feedback on gyroscopic data and servo motor positions made the system accessible and easy to use, even for individuals with limited technical expertise.The system was successfully demonstrated in several scenarios, including robotics and remote-controlled devices. These demonstrations showcased the system's versatility and practical applicability, validating the project's design and implementation.This project exemplifies the potential of integrating mobile technology with microcontroller-based systems to create innovative control mechanisms.

The successful fusion of hardware and software components highlights the feasibility of using everyday devices, like smartphones, in advanced control applications. The comprehensive documentation and successful demonstrations further validate the project's outcomes, making it a valuable contribution to the field of sensor-based control systems.

X. EXPENDITURE

Sl No	Component Name	Quantity	Rate	Total
1	SG 90 9G Mini Micro Servo plastic gear	1	429	429
2	Orange OT90R 6V 1.5kg.cm Metal Brush Digital Servo Motor- 360° Rotation	1	353	353
3	ESP 32 Dev module	1	499	499
4	PLA	1	120	120
			Grand Total	Rs 1,401

Table 10.1 : Cost calculation

XI. CONCLUSION

In conclusion, this project successfully showcased the integration of a smartphone's gyroscopic sensor with an ESP32 microcontroller to control servo motors in real-time, achieving significant milestones in sensor-based control systems. By harnessing MATLAB for capturing and wirelessly transmitting pitch and roll data from the smartphone to the ESP32, and utilizing the Arduino IDE for programming the microcontroller, the project demonstrated a seamless flow of data and command execution. The system was meticulously designed to ensure robust and reliable wireless communication, whether through Bluetooth or Wi-Fi, allowing for stable data transfer crucial for maintaining real-time responsiveness. The ESP32 effectively processed the incoming gyroscopic data, translating it into precise control signals that directed the servo motors to move smoothly and accurately according to the smartphone's orientation. Calibration and optimization efforts were instrumental in refining the system’s performance, ensuring that the servo motors responded with minimal latency and high precision. Performance metrics indicated outstanding accuracy in servo motor positioning, rapid response times, and consistent reliability, even under varied operating conditions. The user interface developed with MATLAB Mobile provided an intuitive and user-friendly experience, enabling easy monitoring and control of the system, which was particularly beneficial for users with limited technical expertise. Practical demonstrations of the system highlighted its versatility and applicability in fields such as robotics, remote-controlled devices, and interactive installations, where precise and responsive control is essential. The project’s documentation comprehensively covered all aspects of the implementation process, from hardware setup to software development, calibration, and testing results, serving as a valuable resource for replication and further research. The successful integration of mobile technology with microcontroller-based actuation systems in this project underscores the potential for innovative control solutions and paves the way for future advancements in this domain. By demonstrating how everyday devices like smartphones can be utilized for advanced control applications, the project offers a versatile framework that can be expanded upon with more sophisticated algorithms, additional sensor integrations, and broader applications. Ultimately, this project not only achieved its initial objectives but also provided a foundation for further exploration and development in the field of sensor-based control systems, bridging the gap between mobile technology and microcontroller-based actuation for cutting-edge solutions in modern engineering.

XII. SCOPE FOR FUTURE WORK

1. Advanced Control Algorithms: Develop and implement more sophisticated control algorithms to enhance the precision and responsiveness of the system. This includes exploring adaptive control methods, machine learning techniques, and predictive models to improve the servo motors' performance based on historical data and real-time feedback.

2. Additional Sensor Integration: Integrate additional sensors, such as accelerometers, magnetometers, and force sensors, to provide a more comprehensive dataset. This multi-sensor fusion could improve the accuracy and stability of the control system, allowing it to handle more complex movements and interactions.

3. Enhanced User Interface: Develop a more sophisticated and customizable user interface for the mobile application. This could include features like real-time graphical feedback, customizable control settings, and advanced diagnostic tools to monitor system performance and troubleshoot issues.

4. Scalability and Multi-Device Coordination: Expand the system to control multiple servo motors or other actuators simultaneously, potentially coordinating the movements of a complex robotic system. Develop protocols for multi-device communication and synchronization to ensure cohesive operation across multiple components.

5. Real-World Applications and Testing: Conduct extensive testing of the system in real-world applications such as robotics, drone control, interactive art installations, and assistive technologies. Gather user feedback and performance data to identify areas for improvement and validate the system's practical utility and robustness.

6. Artificial Intelligence and Machine Learning: Integrate artificial intelligence and machine learning algorithms to allow the system to learn from user behavior and environmental conditions. This could lead to more intuitive and adaptive control mechanisms, enhancing user experience and system performance.

7. Industrial and Commercial Applications: Explore industrial and commercial applications of the system, such as automated manufacturing processes, precision agriculture, and smart home automation. Tailor the system's capabilities to meet the specific requirements and challenges of these applications.

By addressing these areas, future work can significantly enhance the functionality, performance, and applicability of the gyro-controlled servo motor system, paving the way for innovative solutions in various fields of engineering and technology.

XIII. REFERENCE