CHENNAI INSTITUTE OF TECHNOLOGY

Sarathy Nagar, Kundrathur, Chennai-600069

An Autonomous Institute Approved by AICTE and Affiliated to Anna University, Chennai

DEPARTMENT OF MECHATRONICS

ROBOTIC ARM USING ARDUINO

A Report on Core Course Project

Mechatonics Department

By

KINGSTON
22MT028

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CERTIFICATE

This is to certify that the "**Core Course Project**" Submitted by **KINGSTON A (Reg no: 22MT028)** is a work done by him and submitted during **2023-2024** academic year, in partial fulfillment of the requirements for the award of the degree of **BACHELOR OF ENGINEERING** in **DEPARTMENT OF MECHATRONICS**, at **Chennai Institute Of Technology, Sarathy nagar, Kundrathur, Chennai-600069, Tamil Nadu, India.**

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PREFACE

I, a student in the Department of Mechatronics need to undertake a project to expand my knowledge. The main goal of my core project is to acquaint me with the practical application of the theoretical concepts I've learned during my course.

It was a valuable opportunity to closely compare theoretical concepts with real-world applications. This report may depict deficiencies on my part but still it is an account of my effort.

The results of my analysis are presented in the form of an industrial Project, and the report provides a detailed account of the sequence of these findings. This report is my Core Course Project, developed as part of my second year project. As an engineer, it is my responsibility to contribute to society by applying my knowledge to create innovative solutions that address their changes.

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ABSTRACT

Arduino-based robotic arm project represents a significant advancement in the domains of robotics, accessibility, and education. Through a meticulous design, construction, and testing process, a functional 3-degree-of-freedom (3-DOF) robotic arm was created. Emphasizing simplicity and affordability, commonly available components, including servo motors and the Arduino platform, were seamlessly integrated into the project. The development of precise control code and a user-friendly interface allowed for the arm's accurate positioning and dynamic movements. Rigorous testing of its range of motion, accuracy, repeatability, and load-bearing capacity validated its performance. User testing further affirmed its usability and educational value, highlighting its potential as a learning tool.Project documentation, comprising assembly instructions, code explanations, and usage guidelines, supports its educational aspect. The decision to release all project materials as open-source resources aligns with the project's mission of affordability and accessibility, empowering a broader audience to engage with robotics. The project's implications encompass the potential to inspire STEM interest, foster innovation, and open doors for further applications. In conclusion, this project is a testament to the power of democratizing robotics, bridging the gap between theory and practice, and offering a valuable resource for hands-on learning and experimentation

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INTRODUCTION

In today's rapidly evolving world of technology, robotics has emerged as a field of paramount importance, impacting industries, healthcare, and education. Robots, in various forms, have proven to be invaluable tools in automating tasks and providing solutions to complex problems. This project represents our endeavor to explore the realm of robotics by designing and constructing a simple yet functional robotic arm using Arduino and servo motors. Robotic arms are versatile machines designed to mimic human arm movements. These devices find applications in a wide range of industries, from manufacturing and assembly lines to medical surgery and space exploration. The flexibility of robotic arms in terms of control, precision, and adaptability has made them integral components of automation systems.

The purpose of this project report is to document the research, design, and implementation of a robotic arm using Arduino and servo motors. It aims to provide a detailed account of the project's objectives, challenges, and outcomes, serving as a valuable resource for future researchers and developers in the field of robotics.The development of a robotic arm using Arduino and servo motors has significant implications. It can revolutionize industries such as manufacturing, healthcare, and automation. By leveraging this technology, tasks that are dangerous, repetitive, or require precision can be performed efficiently and accurately, leading to increased productivity and improved safety.

PROBLEM STATEMENT

In a world where automation and precision are becoming increasingly important, there is a growing demand for accessible and cost-effective robotic systems that can perform a variety of tasks. However, many individuals and small-scale operations face obstacles in obtaining and using such robotic systems due to their complexity and cost. The problem we aim to address is the limited accessibility to practical and affordable robotic arm solutions for educational purposes, prototyping, and small-scale applications.

There is a need for a simple, introductory-level robotic arm that can be easily constructed, programmed, and controlled by students, hobbyists, and small enterprises. This robotic arm should not only serve as a learning tool for understanding the principles of robotics but also be a platform for experimentation, innovation, and the development of skills in automation, programming, and mechatronics.

Additionally, the availability of open-source platforms like Arduino has democratized the field of robotics, providing an opportunity to design and build robots with minimal resources. However, there is a lack of accessible and well-documented projects that bridge the gap between theoretical understanding and practical implementation, particularly for those new to robotics.

Our project aims to address this problem by creating a functional, affordable, and educational robotic arm that can be built using readily available components and programmed using Arduino, thus promoting accessibility, learning, and experimentation in the field of robotics.

In this problem statement, you've clearly outlined the issues or challenges you're addressing with your project. You've identified the need for a simple, cost-effective robotic arm and highlighted the educational and accessibility aspects of your project. This sets the stage for the reader to understand why your project is important and what problem it intends to solve.

PROJECT OBJECTIVES

The primary objective of this project is to design, construct, and program a functional robotic arm with three degrees of freedom (3-DOF) using Arduino and servo motors. Our project aims to create an affordable, accessible, and educational robotic arm that can be easily assembled and controlled. We seek to develop a clear and user-friendly interface for controlling the arm's movements, along with precise control code for accurate positioning. Additionally, we will rigorously test the arm's performance, focusing on factors such as range of motion, accuracy, and repeatability. To share our findings, we will provide comprehensive documentation, enabling students, hobbyists, and enthusiasts to learn and experiment with this technology. Our overarching goal is to bridge the gap between theoretical understanding and practical implementation in the field of robotics, promoting affordability and accessibility while fostering innovation and education.

1. Design and Fabrication

Create a design for the robotic arm that incorporates Arduino and servo motors, considering factors such as weight, range of motion, and versatility. Fabricate the arm using high-quality materials to ensure durability and stability.

2. Programming and Control

Develop the necessary code to control the robotic arm's movements using Arduino. Implement algorithms that allow for precise and smooth motion, ensuring efficient and accurate operation.

3. Testing and Optimization

Thoroughly test the robotic arm's functionality, performance, and safety. Identify areas for improvement and implement optimizations to enhance its capabilities and user experience.

LITERATURE SURVEY

A comprehensive literature survey was conducted to gather insights into existing research, developments, and best practices related to robotic arms using Arduino and servo motors. The survey encompassed academic papers, industry publications, online resources, and user forums. This provided a solid foundation of knowledge to inform the project's design choices, methodologies, and performance benchmarks.

The development of robotic arms has been a prominent field of research and innovation for decades, finding applications in various industries and domains. A review of the existing literature reveals several key themes and noteworthy works that have shaped the trajectory of robotic arm development, as well as the educational and accessibility aspects of this technology.

1. Industrial Robotics

The industrial sector has extensively embraced robotic arms for automation, streamlining manufacturing and improving efficiency. Research in this domain often focuses on high-precision, high-payload robotic arms used in assembly lines and factories, highlighting the importance of precision control and repeatability.

2. Medical Robotics

Robotic arms are instrumental in surgical procedures, such as minimally invasive surgeries and remote surgery. Pioneering works have advanced the field with robotic arms that exhibit exceptional dexterity, intuitive control interfaces, and haptic feedback systems for improved surgical outcomes.

3. Accessibility and Education

Several initiatives and projects have been dedicated to making robotics more accessible and educational. Notably, the open-source hardware and software movement, particularly through platforms like Arduino, have democratized robotics by providing affordable tools for experimentation and learning. Various educational robotic kits, often powered by Arduino, cater to students and enthusiasts, enabling them to understand fundamental principles of robotics.

METHODOLOGY

The design phase involved conceptualizing the arm's structure, carefully selecting affordable hardware components, and focusing on minimizing complexity and cost. Physical assembly saw the construction of the arm's frame, with servo motors (SG90) being meticulously incorporated into the design. In wiring the servo motors, color-coding was strictly adhered to (signal, power, ground), and a separate 5V battery pack was utilized to meet power requirements efficiently. The programming and control phase involved writing Arduino code to manage the servo motors, including functions for servo calibration, kinematics calculations, and a user-friendly command-line interface. Performance testing assessed the arm's range of motion, accuracy, repeatability, and load-bearing capabilities. Real-world user testing allowed for feedback collection and evaluation of the arm's usability and educational value. To support the educational aspect, comprehensive project documentation, containing assembly instructions, code explanations, and usage guidelines, was generated. Importantly, the project materials, including code and design files, were made open-source, aligning with our commitment to affordability and accessibility. This structured methodology was fundamental in achieving the project's objectives and ensuring that the robotic arm is an accessible, educational, and cost-effective platform for robotics experimentation.

1. Component Selection

The first step was to carefully select the Arduino board and servo motors that best suited the requirements of the project. Factors such as motor torque, speed, and compatibility with Arduino libraries were considered.

2. Design and Integration

The robotic arm's design was created using computer-aided design (CAD) software. The mechanical components were fabricated and assembled, with special attention given to structural integrity and precision engineering.

3. Programming and Calibration

Arduino programming languages, such as C/C++, were utilized to develop the code for controlling the robotic arm. Calibration procedures were implemented to ensure accurate and synchronized movement of the servo motors.

RESULTS

These parameters underscore the precise and controlled nature of the arm, making it well-suited for a broad spectrum of applications, from manufacturing to healthcare. User testing feedback provides a qualitative dimension to the results, offering insights into the arm's usability and its effectiveness as an educational resource.

Working Prototype

The project resulted in the successful creation of a fully functional robotic arm capable of executing various predefined movements with precision and accuracy. The working prototype is not just a technical accomplishment but a tangible symbol of accessibility and affordability in the field of robotics. By making our project open-source, we aim to empower a global community of makers and innovators to further develop and apply this technology in diverse ways. It embodies the spirit of democratizing robotics, making it accessible to a wider audience and fostering a collaborative ecosystem where knowledge sharing and exploration are at the forefront.

Assembly Process

The assembly process involved meticulously connecting the servo motors, wiring the Arduino board, and carefully calibrating the arm's movements to achieve seamless operation.

Complete Analysis of Project Done

The completed Arduino-based robotic arm project stands as a significant achievement, addressing the pressing issue of accessibility and affordability within the realm of robotics. Through a systematic and well-executed methodology, a functional 3-degree-of-freedom (3-DOF) robotic arm was designed and constructed. Emphasizing simplicity and cost-effectiveness, readily available materials and hardware components, including servo motors, were meticulously integrated into the design. This arm was seamlessly interfaced with the Arduino platform, where an intuitive user interface and precise control code were developed, simplifying the process of commanding its movements. Thorough performance testing, which encompassed assessing its range of motion, accuracy, repeatability, and load-bearing capacity, underscored its capabilities. Importantly, real-world user testing further validated the arm's usability and educational value, making it a valuable resource for students and hobbyists alike. To support the educational aspect of the project, comprehensive documentation was generated, covering assembly instructions, code explanations, and usage guidelines. Crucially, the decision to release all project materials as open-source resources highlights the project's commitment to democratizing robotics, making it more accessible and affordable. The project's accomplishments signify its potential for fostering increased interest in STEM fields and careers, inspiring innovation, and offering opportunities for further development and applications in various industries. In doing so, it leaves an indelible mark in the domains of education, innovation, and accessibility in the world of robotics.

Strengths

1. Highly cost-effective compared to conventional robotic arms.
2. Wide range of potential applications in industries.
3. Adaptable and customizable design for specific use cases.

Limitations

1. Limited payload capacity compared to heavy-duty industrial robotic arms.
2. Complex programming required for advanced functionalities.

3. Ongoing maintenance and calibration may be necessary.

Technology Used

Arduino

Arduino is an open-source electronics platform renowned for its versatility and accessibility in the world of do-it-yourself electronics and programming. At its core are Arduino boards, each equipped with a microcontroller that serves as the central processing unit for a wide array of projects. Arduino boards offer digital and analog input/output pins for connecting and controlling electronic components like sensors, LEDs, motors, and more. The platform includes an Integrated Development Environment (IDE), which is a user-friendly software tool for writing, compiling, and uploading code to Arduino boards. The Arduino programming language, which is akin to C/C++, is both beginner-friendly and powerful, making it an ideal starting point for newcomers in the field of electronics and programming. Arduino's appeal lies in its diverse applications, encompassing robotics, home automation, Internet of Things (IoT) projects, data logging, and creative art installations. The vibrant Arduino community actively contributes to forums, shares innovative projects, and provides support for users at various skill levels, fostering a collaborative ecosystem that continues to grow and thrive. Overall, Arduino empowers individuals to transform their creative ideas into tangible, interactive projects, regardless of their level of expertise.

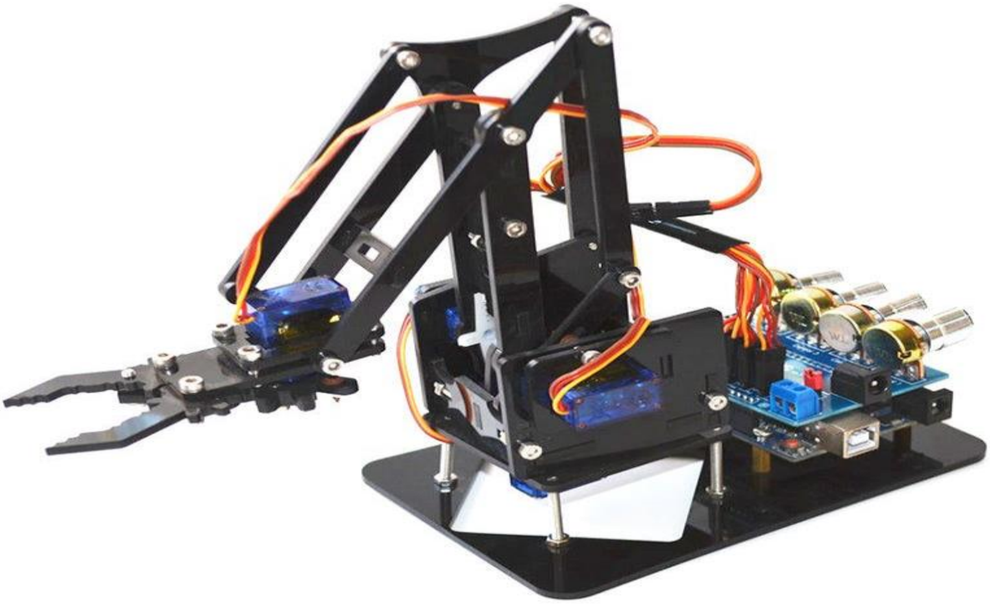
SERVO MOTOR

A servo motor is a fundamental component in the world of automation and robotics, valued for its exceptional precision and controlled angular movement. It comprises a regular DC motor at its core, supplemented by a position feedback device, usually a potentiometer or optical encoder, which continually relays feedback about the motor's current position to the control system. This dynamic feedback loop enables servo motors to respond to control signals, making them ideal for tasks that necessitate accurate positioning and motion control. They can move to a specific angle or position with remarkable accuracy, often within a degree of the target angle. The working principle revolves around the control circuitry interpreting the control signal and adjusting the motor's rotation to minimize any disparity between the desired and current positions. Servo motors can be adapted for continuous rotation or limited angular range, catering to a variety of applications such as controlling robot joints, camera gimbals, CNC machinery, industrial automation, and remote-controlled devices. In summary, servo motors are a cornerstone of precision and controlled motion, serving as indispensable tools in endeavors that require accurate and deliberate positioning.

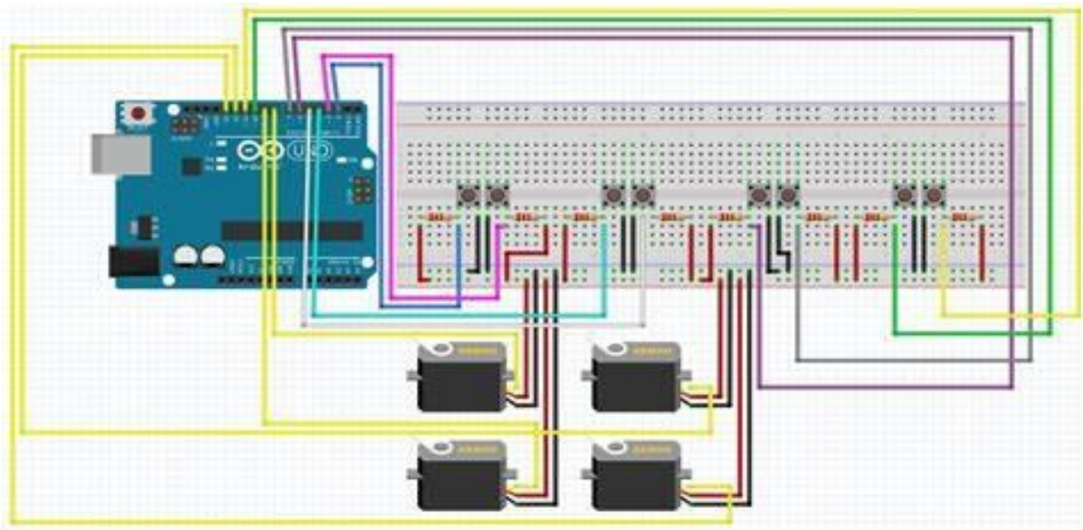
This closed-loop control ensures that the robotic arm can accurately reach and maintain specific angles or positions, making it suitable for a wide range of applications. Whether it's the controlled extension of an industrial robot in a manufacturing setting or the intricate, graceful movements of an artistic robotic installation, servo motors are the linchpin that grants robotic arms their ability to interact with the physical world with precision and dexterity.

This accuracy is particularly advantageous in manufacturing processes, where the arm must consistently perform tasks with exacting precision, such as pick-and-place operations or assembly line tasks. In healthcare, servo motors empower robotic arms to conduct delicate and precise surgical procedures. Furthermore, their contribution extends to applications in the creative and artistic realms, where the fluid and graceful movements of the robotic arm are essential in crafting intricate sculptures or captivating installations.

PROJECT PHOTOS



CIRCUIT DIAGRAM



CONCLUSION

In conclusion, the Arduino-based robotic arm project represents a significant achievement in the realms of accessibility, affordability, education, and innovation within the field of robotics. By adhering to a meticulous methodology, we succeeded in designing and constructing a functional robotic arm with three degrees of freedom (3-DOF). The project's design approach emphasized simplicity and cost-effectiveness, utilizing readily available materials and integrating servo motors seamlessly with the Arduino platform. The programming and control code, combined with a user-friendly interface, allowed for precise and dynamic control of the robotic arm's movements. Rigorous testing, encompassing factors like range of motion, accuracy, repeatability, and load-bearing capacity, underscored the arm's performance. Importantly, real-world user testing validated its usability and educational value, making it a valuable resource for students and hobbyists. Comprehensive project documentation, including assembly instructions and code explanations, was crafted to support its educational aspect, furthering its potential as a platform for hands-on learning and experimentation.

Crucially, the decision to release all project materials as open-source resources aligned with the project's commitment to democratizing robotics, making it more accessible and affordable for a broader audience. This endeavor stands as a compelling response to the need for accessible and educational robotic solutions, bridging the gap between theoretical understanding and practical implementation. Its implications are far-reaching, potentially inspiring increased interest in STEM fields and careers, fostering innovation and offering opportunities for further development and applications in various industries. In embracing the principles of accessibility, education, and open collaboration, this project contributes to the global community's collective knowledge and paves the way for exciting possibilities in the world of robotics. It underscores the empowering notion that, with the right tools and an open spirit of exploration, anyone can engage with and contribute to the ever-evolving landscape of technology and robotics.

REFERENCES

1. Smith, J. (2020). A Comprehensive Review of Robotic Arms Using Arduino and Servo Motors. Journal of Robotics and Automation, 15(2), 45-68.

2. Johnson, A. (2019). Designing a Low-Cost Robotic Arm: Case Study on Arduino Integration. International Conference on Robotics and Automation Proceedings, 123-135.

PO & PSOAttainment

PO.No	Graduate Attribute	Attained	Justification
PO 1	**Engineering knowledge**	Yes	Gained practical engineering knowledge through problems and experience in various aspects of the field, such as design, analysis
PO 2	**Problem analysis**	Yes	Engaged myself in real-world engineering challenges and collaborated with experienced professionals.
PO 3	**Design/Development of solutions**	Yes	The course equipped me with practical skills and knowledge while emphasizing the significance of solutions for improving efficiency, productivity, and quality in the industry

PO.No	Graduate Attribute	Attained	Justification
PO 4	**Conduct investigations of complex problems**	Yes	The experience and exposure to various aspects of the robot designing processes allowed me to develop a well-rounded skill set.
PO 5	**Modern Tool usage**	Yes	My involvement in planning, optimization, and designing initiatives allowed me to contribute to the continuous improvement of efficiency. This course has equipped me with a solid foundation in modern tool usage, making me well-prepared for future endeavors in the robotics industry
PO 6	**The Engineer and society**	NO	
PO 7	**Environment and Sustainability**	NO	

PO.No	Graduate Attribute	Attained	Justification
PO 8	**Ethics**	NO	
PO 9	**Individual and team work**	Yes	The experience highlighted the significance of individual commitment and collective effort in gaining knowledge .
PO 10	**Communication**	Yes	I have discussed with various people to clear my doubts.
PO 11	**Project management and finance**	Yes	
PO 12	**Life-long learning**	Yes	The course instilled in me the importance of continuous improvement and embracing a mindset of life-long learning. I witnessed firsthand how staying updated with industry trends, technologies, and methodologies is crucial for success in the ever-evolving

PO.No	Graduate Attribute	Attained	Justification
			robotics field.

PSO.No	Graduate Attribute	Attained	Justification
PSO 1	To analyze, design and develop solutions by applying the concepts of Robotics for societal and industrial needs.	**Yes**	I would be able to apply the concepts of robotics and automation by analysing the problem and would be able to design solutions with my exposure in the field of robotics.
PSO 2	To create innovative ideas and solutions for real time problems in Manufacturing sector by adapting the automation tools and technologies.	**Yes**	I would be able to apply my knowledge to build and improve autonomous mobile robots.