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Memory Saving Robotic Arm With 5 Degrees of Freedom

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Abstract: *The paper titled "5 Degree of Freedom Robotic Arm – Save and Play System" aims to design and develop a robotic manipulator capable of performing pick and place operations with high precision and repeatability. The system consists of a robotic arm with five degrees of freedom—base rotation, shoulder, elbow, wrist, and gripper movement—enabling it to perform complex tasks similar to a human arm. The key feature of this paper is the "Save and Play" functionality, which allows the user to record a sequence of movements through wireless control and replay them automatically without the need for reprogramming also demonstrates the concepts of automation, kinematics, motion control, and embedded programming, providing a cost-effective and flexible solution for repetitive industrial tasks. The proposed design finds applications in automated manufacturing, material handling, laboratory automation, and educational robotics. Overall, the system showcases how low-cost robotic automation can be implemented using simple hardware, wireless control techniques, and embedded system design strategies..*

Keywords: 5-DOF Robotic Arm, Bluetooth Control, Internal EEPROM, Arduino, Teach-and-Repeat, Wireless Automation

I. INTRODUCTION

In the era of rapid industrial automation, robotics plays a vital role in increasing productivity, precision, and efficiency. Robotic arms, in particular, are widely used in industries such as manufacturing, assembly, medical, and research, where repetitive and precise operations are required. These systems mimic the movements of a human arm and are capable of performing tasks like lifting, rotating, placing, and positioning objects accurately.

This project presents the design and implementation of a 5-Degree-of-Freedom (5-DOF) Robotic Arm controlled by an Arduino microcontroller. The system is capable of wireless control, position recording, and autonomous playback, demonstrating a foundational concept in industrial automation known as the teach-and-repeat method. A 5-Degree-of-Freedom (5-DOF) Robotic Arm is a type of manipulator that can move in five independent axes, allowing versatile motion and flexibility. Each joint or axis is controlled by a servo motor, which defines the orientation and position of the end effector (gripper or tool). The Arduino UNO microcontroller serves as the brain of the system, controlling all servo movements and user interactions based on programmed logic.

II. LITERATURE REVIEW

Here's a literature review of your project in a table format, summarizing key aspects from the references and literature discussed:

Reference	Focus/Contribution	Relevance to Project
Spong, M. W., Hutchinson, S., & Vidyasagar, M. (2020) -	Provides foundational concepts in robotic control, including kinematics,	Essential for understanding the kinematic modeling (forward and inverse) required for

Robot Modeling and Control (3rd ed.)	forward/inverse modeling, and motion planning.	motion planning in the 5- DOF robotic arm.
Groover, M. P. (2019) - Automation, Production Systems, and Computer Integrated Manufacturing (5th ed.)	Discusses industrial automation systems, including robotic arms and their applications in manufacturing.	Helps to contextualize the industrial use of robotic arms supporting the project's aim to develop a cost-effective robotic arm for education and potential industria applications.
Niku, S. B. (2019) - Introduction to Robotics: Analysis, Control, Applications (3rd ed.)	Analyzes the control and applications of robotic manipulators, focusing on the mechanics and control strategies of robotic arms.	Provides insights into control strategies and mechanical design aspects, supporting the development of the arm's control system.
Kumbhar, P., & Joshi, R. (2022) - “Design and Development of Low-Cost Robotic Arm Using Arduino”	Describes a low-cost robotic arm designed using Arduino, focused on educational and prototype applications.	Directly relevant to the project’s use of Arduino for control and its aim of designing a low-cost robotic arm.

Problem Statement:

In industries and laboratories, tasks like pick-and-place, sorting, and assembly require precision and consistency. Manual execution of these tasks often leads to fatigue and human error, reducing productivity and accuracy. Conventional industrial robotic arms are expensive and complex, making them unsuitable for small-scale applications, education, or prototyping. This Research paper addresses the need for a low-cost, programmable robotic arm that mimics human arm movements and can perform automated tasks with reasonable accuracy and repeatability. The challenge is to design a compact, affordable, and user- friendly system with features such as multiple degrees of freedom, the ability to record and replay motion sequences (teach-and- repeat), and operation using accessible components like Arduino and hobby servos. This Research paper aims to develop a 5-DOF robotic arm that provides both manual control and automatic playback of recorded motions. This solution offers an efficient and cost-effective option for small-scale automation tasks and educational purposes, making robotics more accessible and practical for diverse applications.

Existing System:

Existing robotic arm systems can broadly be classified into two categories: industrial-grade robotic manipulators and low-cost academic or hobby-based robotic arms. Industrial robotic systems are widely used in manufacturing industries for tasks such as welding, assembly, material handling, and packaging. These syst ems offer very high precision, speed, and reliability, and are capable of operating continuously in harsh environments. However, they are expensive, require complex programming, skilled operators, and involve high maintenance costs, making them unsuitable for small-scale industries, educational institutions, and beginner-level projects.

On the other hand, low-cost robotic arms developed using platforms like Arduino are commonly used for educational and prototype purposes. While these systems are affordable and easy to build, they often lack advanced features such as wireless communication, motion memory, and autonomous operation. Most of these systems rely on wired communication or require continuous connection to a computer for control and programming. Additionally, many designs depend on external memory modules (such as EEPROM ICs or SD cards) to store motion sequences, which increases hardware complexity and cost. Due to these limitations, existing low-cost systems are not fully efficient for real-time automation tasks or independent operation.

Therefore, there is a strong need for a robotic arm system that is cost-effective, simple to use, wirelessly controllable, and capable of storing and repeating motion sequences without requiring continuous human intervention or additional hardware components Industrial robotic arms are highly precise but very expensive

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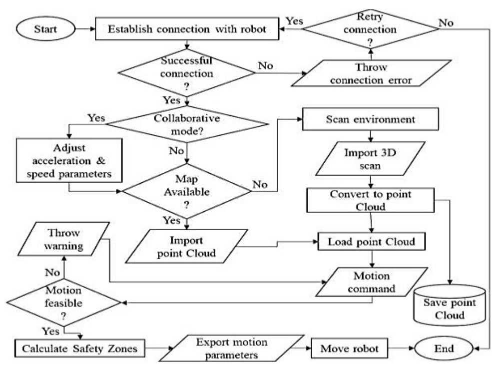
Proposed System:

The proposed system presents the design and implementation of a 5 -Degree-of-Freedom (5-DOF) robotic arm integrated with

Bluetooth-based wireless control and internal memory storage capability. The system is built using the Arduino Uno Rev3 as the main controller, which processes input commands and controls the servo motors responsible for joint movements. An HC-05 Bluetooth module is used to establish wireless communication between the robotic arm and a mobile device, allowing the user to control the arm in real time through a Bluetooth terminal application. One of the key features of this system is the "Save and Play" or teach-and-repeat functionality, which enables the recording of joint angles during manual operation and stores them in the Arduino's internal EEPROM memory. These stored motion sequences can later be executed automatically without requiring continuous user input or reprogramming. This approach eliminates the need for external memory modules, thereby reducing hardware complexity, cost, and system size. The robotic arm is capable of performing basic automation tasks such as pick-and-place operations with acceptable accuracy and repeatability. Overall, the proposed system provides a cost-effective, user-friendly, and scalable solution suitable for educational purposes, prototyping, and small-scale industrial automation, with the potential for future enhancements such as IoT integration, artificial intelligence, and vision-based control systems.

Proposed System flowchart



Result and Implementation

Fig 6.16 - TowerPro_MG995R

Fig 6.17 - SG90

Fig 6.18 - Bolt

Fig 6.19 – Link

Fig 6.20 - Gripper Base

Fig 6.21 – Part

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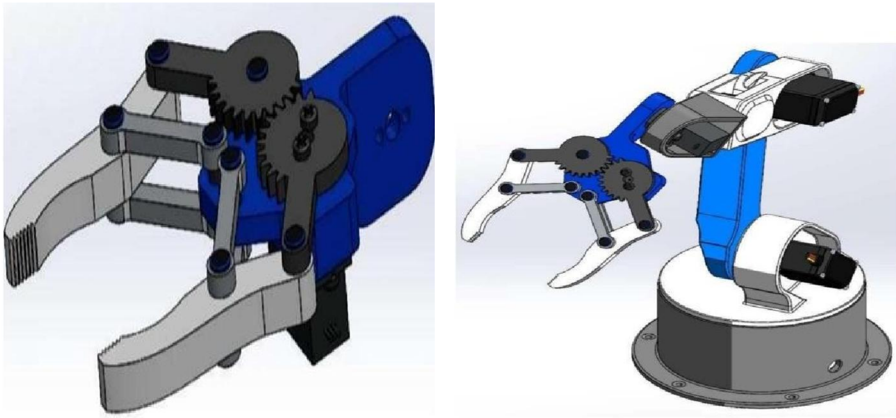
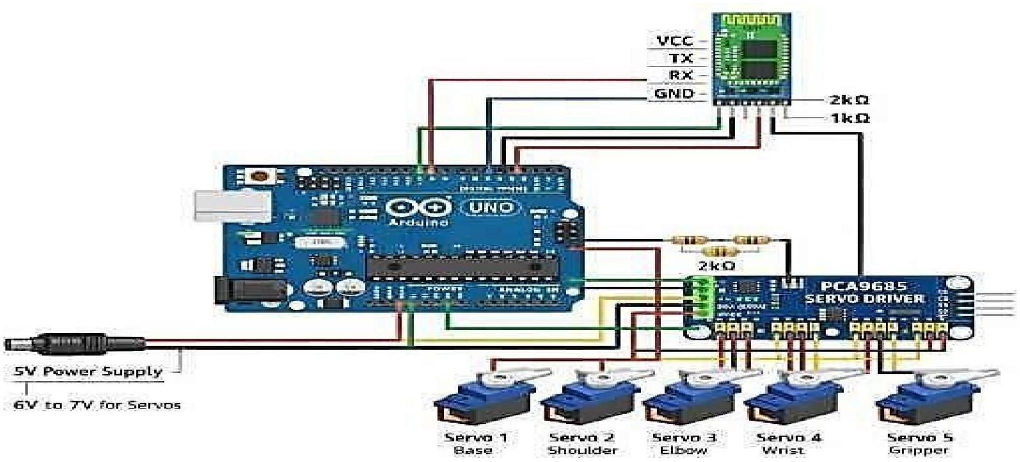
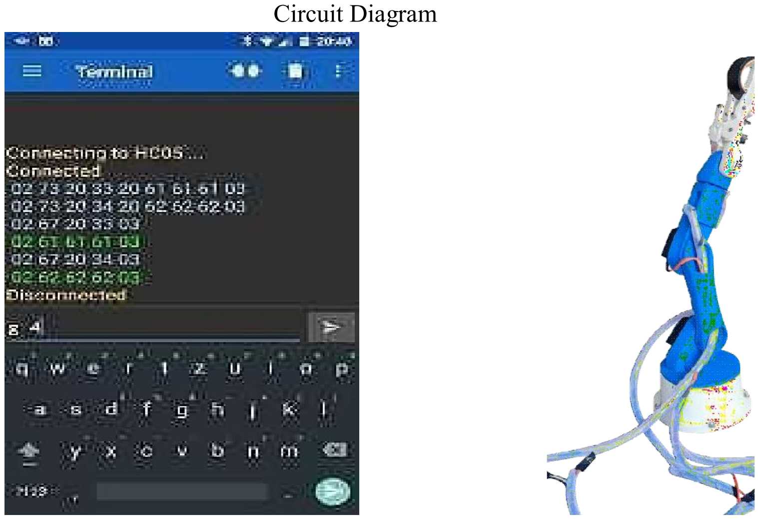


Axis Line Design Using AutCad & Solid Works



Circuit Diagram



GUI Application Actual Implementation

III. CONCLUSION

1. The project "5 Degree of Freedom Robotic Arm – Save and Play System" successfully demonstrates the integration of mechanical design, electronics, and control systems in a single automated setup.
2. The robotic arm was designed to achieve five degrees of freedom, replicating the movements of a human arm with adequate precision and flexibility.
3. The control and implementation of the system were carried out using Arduino, with wireless communication enabled through a Bluetooth module (HC-05) and a mobile application.
4. The Save and Play feature developed in this project enables the robotic arm to record a series of movements received through Bluetooth commands and reproduce them automatically, eliminating the need for physical input devices.
5. This wireless control system makes the robotic arm more flexible, user-friendly, and suitable for remote operation.
6. The project has met its objectives by creating a cost-effective, easy-to-operate, and modular robotic arm capable of performing basic pick-and-place and motion replication tasks.
7. Through this project, the team gained valuable insights into robotic kinematics, motion control, embedded systems, and wireless communication using Bluetooth technology.
8. The combination of software and hardware implementation ensured system stability and provided a practical understanding of modern automation techniques.

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