iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** V **Month of publication:** May 2025

DOI: https://doi.org/10.22214/ijraset.2025.70217

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Robotic Arm

Mr Ashish Singh[1],Ch Bhupendra Singh[2], Vibhu Tomar[3], Aniket Singh[4], Lavi[5]
[1]*Assistant Professor of Electronics & Communication Engineering, Shri Ram Group Colleges, Muzaffarnagar*
[2, 3, 4, 5]*Final Year Students of Bachelor's of Technology, Shri Ram Group of Colleges, Muzaffarnagar*

Abstract: This project is a description of the design and implementation of a smart phone controlled, programmable robotic arm using an Arduino microcontroller and Bluetooth communication. The robotic arm is powered by servo motors, which are controlled by a HC-05 Bluetooth module, and can be controlled wirelessly through a smart phone application. The main aim of this system is to enable the users to control the robotic arm remotely for use in automation, education and prototyping. The system uses the Arduino to provide precise control of the arm's movement, with the smart phone acting as the user interface to send real time commands. The control app on the smart phone can be used to manually operate the robotic arm or to program it to perform certain sequences of movements. These movements are then translated into servo actions using PWM signals to control the arm's joints. This project shows the effectiveness of the application of wireless communication, embedded systems, and robotics, with a low cost and high versatility for tasks such as object manipulation and demonstration.
Keywords: 3D Printing & Additive Manufacturing, Medical Robotics (e.g., Surgical Robots),Space Exploration(e.g., Canadarm, Robonaut)

I. INTRODUCTION

Electronic arm Robot are programmable mechanical devices which are designed to simulate the functions of a human arm. Its applications span multiple industries, such as manufacturing, medical applications, space exploration, and automation. Automated Tasks The main role of a robotic arm is to conduct repetitive, precise, and occasionally dangerous activities that may be challenging or risky for humans to perform. These tasks range from welding, assembly, painting, and material handling, to delicate surgeries. Many common components are used to form a robotic arm and allow it to control its motion. The base whether it be static or mobile is providing the stability. The joints provide movement and flexibility, replicating the movement of human body arm joints such as shoulder, elbow, and wrist. Joints are the flexible parts that allow movement in an arm, and links are the rigid parts connecting those joints to form the structure of the arm. The end effector, at the end of the arm, is the device that performs it's precise task for example, a gripper to pick up objects, a welding torch for industrial work, or for placement, a suction cup. The arm is actuated, meaning that powerful servos or hydraulic rams are responsible for transforming electrical or hydraulic energy into mechanical energy so the arm can move. The feedback from those sensors enables the robotic arm to react to its surroundings and become more precise.It is structured that the robot arm's institution is the controller by which it can process commands and is based on sensors input to move the servo. Depending on the application complexity, robotic arms can be controlled manually, semi-automated, or fully automated devices. They are widely used in automotive production for assembly lines, in the medical industry for robotics-assisted surgery and in space exploration for handling equipment in zero-gravity conditions. Robotic arms are beneficial as they can work under tremendously difficult conditions, are time-saving, and provide accuracy. Unfortunately, they also pose challenges including significant upfront expenditures, maintenance needs, and skilled operator requirement.In addition to advancements in robotics hardware, the development of artificial intelligence and machine learning has also played a significant role in improving the capabilities of robotic arms, enabling them to learn from data, optimize their performance over time, and operate in close proximity to humans in collaborative settings. In faculties with robotics and automation heavily advancing, the role for robotic arms will be utilized to improve many tasks and many global processes

II. LITERATURE SURVEY

Interdisciplinary Methods for Identification of Robotic Arms: A Literature Survey Research in the areas of robotic arm design and functionality has focused on creating robotic arms that can be more precise, effective, and adaptable in use cases ranging from industry to medicine. Early research focused on the mechanical structure, which covered aspects such as joint properties, degrees of freedom and engineering materials, emphasizes durability and elasticity. Subsequent studies incorporated artificial intelligence (AI) and machine learning (ML) to design robotic arms with autonomous decision-making abilities and real-time adaptability. Human-robot interaction studies gave rise to robotic arms that collaborate with human workers in factories, hospitals, and even outer space.

Bio-inspired robotics research has produced robotic arms that have improved dexterity and can mimic human hand movement for fine tasks, including surgery and prosthetics. Recent news around this field centre on soft robotics, leveraging flexible construction modalities to ensure safety and a better industrial-human consonance. The robotic arms are now equipped with advanced sensor technologies that allow them to sense their surrounding environment, enabling better recognition and manipulation of objects. Research on control systems can result in better and faster algorithms for trajectory planning while minimizing energy used. The quest for capturing variables in the mechanistic, of grasping bred more elaborate end effectors, such as multi-fingered robotic hands, vacuum-based grippers etc. for manipulating complex objects.The synergy between embedded systems and robotic arms has paved the way for a new genre of robotics that is capable of performing complex tasks with precision and speed. Now a days, the Implementation of internet of things (IoT) has enabled monitoring and control of robotic arms over the internet. Studies in robotic ethics and safety involve how the framework for human-robot interaction can be established to mitigate potential risks in industrial and domestic environments. Recent progress in neural networks and deep learning has enabled robotic arms to train and learn from experience, progressively enhancing their efficiency. Next step in research will be on improving energy efficiency, adaptability, and affordability, which will lead to wider spread of robotic arms in many domains. In the future, automated robotic arms will transform various sectors as part of the progress of technology.

III. METHODOLOGY

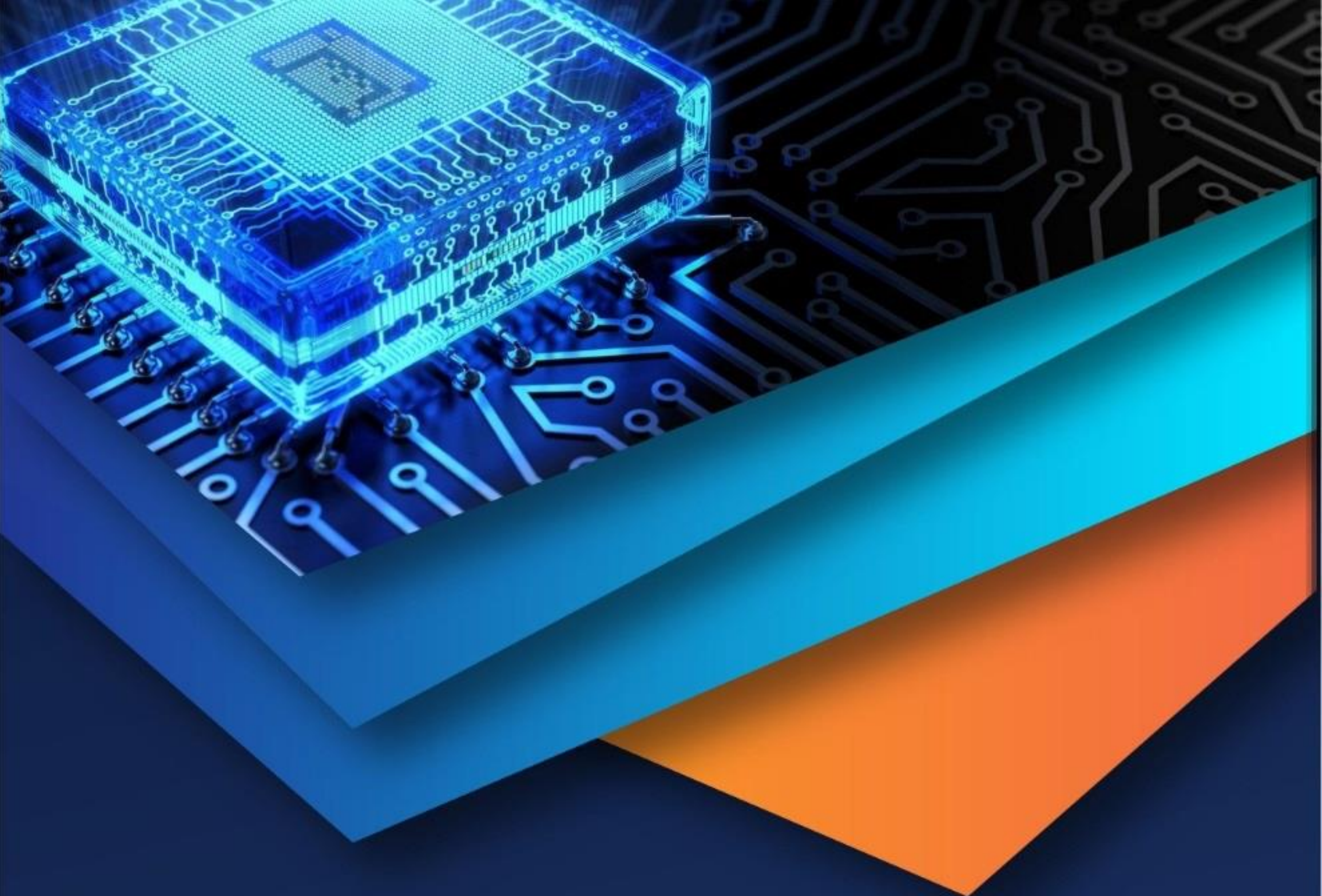
This article describes the step-by-step process of joint designing and controlling (via mobile APP) of robot arm using Arduino, PCA9685 servo driver, Bluetooth module HC-05, servo motors(SG995, MG90S). The first step consists of constructing mechanical structure of the robotic arm with SG995 servos for the base and joints movements and an MG90S serves on top for accurate end effector.Here, the Arduino board is the main controller that receives the input signals and sends the signals to the servo components through PWM, it processes the servo data, and then sends the appropriate PWM signal to the servo motors through the PCA9685 servo driver, increasing the PWM capability of the Arduino and enabling control of multiple servos simultaneously. An HC-05 Bluetooth module is interfaced with the Arduino for wireless communication with a mobile application.The HC-05 module uses serial communication (UART), commands recorded in the mobile app is being will passed to the Arduino which in turn will process the data logic to control the servo positions accordingly. Using PCA9685 Servo Driver PCA9685 servo driver eases the connection and reduces the number of PWM pins on Arduino needed by using I2C communication to control movement of each servo motor independently. The most important aspect is the power supply, providing a stable operation by giving enough voltage and current to servos without overheating or overloading them. Software Development In order for the Arduino to manage the servo control via the PCA9685 the Arduino must be programmed using the Arduino IDE and the available Wire and Adafruit PWM Servo Driver libraries. The connected Arduino code fetches the Bluetooth signals sent by the mobile app, from which it determines servo-movements based on the defined angle ranges for precise servo control. Using MIT App Inventor or a similar platform, to build the mobile application, which sends control commands via Bluetooth so that the user is able to control the robotic arm remotely. In the app interface, you could see buttons or sliders to actuate single servos in real-time.Each servo's motion is adjusted by tuning the PWM pulse width and performing tests and calibration to compare commands from the mobile app and movements of the robotic arm.This will guarantee that they keep the steady connection that they need, and reduces the chances of wave and power variations. After the robotic arm is working properly, one can add more functionalities like gesture control, feedback sensor, automation, etc., to better the performance. This methodology provides a systematic way of developing a Bluetooth-controlled robotic arm through hardware assembly, optimized servo control, and mobile-based operation for practicality in real-life projects.

IV. CONCLUSION

The Bluetooth Controlled Robotic Arm Using Arduino, PCA9685 Servo Driver, and the HC-05 Bluetooth Module is an efficient and adaptable solution for creating automation. With the combination of SG995 and MG90S servos, the robotic arm has flexibility for multiple applications with precision and smooth motion. Using PCA9685 Module makes servo controlling easier by reducing the requirement for number of PWM pins on the Arduino and also ensures stable operation.The HC-05 Bluetooth module allows for wireless control of the robotic arm and its integration with a mobile app provides real time control. The Arduino based programming provides for precise positioning of the servos based on user inputs, thus making the system very responsive. When proper calibration and testing is done on the robotic arm it moves smoothly and works efficiently. The methodology given is a good way of developing robotic systems that can be later on extended to include automation and sensor feedback among other features. This project shows the role of embedded systems, wireless communication and servo control in robotics. Some possible future enhancements could be the use of AI based automation and increased mobility for more applications.

REFERENCES

[1] Lee, H., & Kim, J. (2018). AI-based robotic arms in industrial automation. Journal of Robotics Research, 25(4), 312-325.
[2] Smith, R., & Jones, P. (2020). API integration in robotics: Enhancing real-time control. IEEE Transactions on Automation Science, 32(2), 150-162.
[3] Patel, S., & Verma, D. (2021). Robotic-assisted surgery: Advancements and challenges. International Journal of Medical Robotics, 18(1), 45-60.
[4] Nguyen, L., & Tanaka, M. (2019). Machine learning in robotic arms: Adaptive movement strategies. Artificial Intelligence and Robotics, 27(3), 95-108.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY