# "Autofocusing in Ophthalmic Imaging for Enhancing the Clarity in Fundus Diagnostics with Robotic Arm System"

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**Abstract:** This paper describes the design and implementation of a robotic arm system using an ESP32 Dev Module and Arduino UNO for efficient control and coordination. The robotic arm is actuated using SG90 servo motors, providing precise angular positioning. A 16-channel PWM servo driver is employed to control multiple servos simultaneously, ensuring smooth and stable motion. The ESP32 utilizes GPIO 32 and GPIO 33 for communication with the servo driver, while the Arduino UNO assists in motor control and peripheral interfacing. The proposed system offers a low-cost, flexible, and scalable solution suitable for automation, educational, and human–machine interaction applications.

***Keywords: Robotic Arm, ESP32 Dev Module, Arduino UNO, SG90 Servo Motor, PWM Servo Driver, Automation, Embedded C .***

## I. INTRODUCTION

Robotic arms are widely used in automation due to their ability to perform repetitive and precise tasks with high accuracy and consistency. With advancements in embedded systems and wireless communication, robotic control systems have evolved from wired interfaces to flexible web-based platforms. These developments improve usability while maintaining reliable and autonomous operation. This paper presents a robotic arm system that is controlled through a web application over a local Wi-Fi network without any internet intervention. The embedded controller hosts a local web server, allowing the operator to connect directly to the system using a smartphone, tablet, or computer. Through this interface, the operator can control the robotic arm in real time and monitor its movements without relying on cloud services or external networks. In addition to manual control, the system is capable of recording the movements performed by the operator and storing them as sequential motion data. These recorded actions can later be replayed accurately by the robotic arm. Once programmed, the robotic arm can execute the recorded sequence continuously without any human intervention, enabling autonomous operation for repetitive tasks. By eliminating internet dependency, the proposed system ensures low latency, enhanced security, and high reliability, making it suitable for industrial training, automation, and educational applications. The use of a local Wi-Fi–based web interface provides an intuitive human–machine interaction, reducing the need for specialized control hardware or software. This approach enhances system adaptability and makes it suitable for small-scale industrial automation, laboratory experimentation, and educational demonstrations where reliable offline operation and repeatable motion control are essential.

## II. METHODOLOGY

The robotic arm system is designed using an ESP32 Dev Module as the main controller to enable web-based control and autonomous operation. The ESP32 creates a local Wi-Fi network and hosts a web application that allows the operator to control the robotic arm in real time using any Wi-Fi-enabled device, without requiring internet connectivity. The arm is actuated using SG90 servo motors, driven through a 16-channel PWM servo driver interfaced with the ESP32 via GPIO 32 and GPIO 33, providing precise and synchronized control of multiple motors. During manual operation through the web interface, the servo positions corresponding to the operator's movements are continuously recorded and stored in the ESP32 memory. Once recorded, these motion sequences can be replayed accurately, allowing the robotic arm to operate continuously without human intervention, ensuring low latency, high reliability, and secure offline operation.

The system features a modular design, allowing easy expansion of servo motors or integration of additional sensors in the future. The local web application provides a graphical interface for monitoring real-time positions, adjusting speed, and controlling multiple motion sequences. Data storage for recorded movements is managed within the ESP32, enabling multiple sequences to be saved and executed sequentially. This methodology ensures that the robotic arm can perform complex tasks autonomously, while maintaining flexibility, scalability, and cost-effectiveness, making it suitable for industrial, educational, and automation applications.

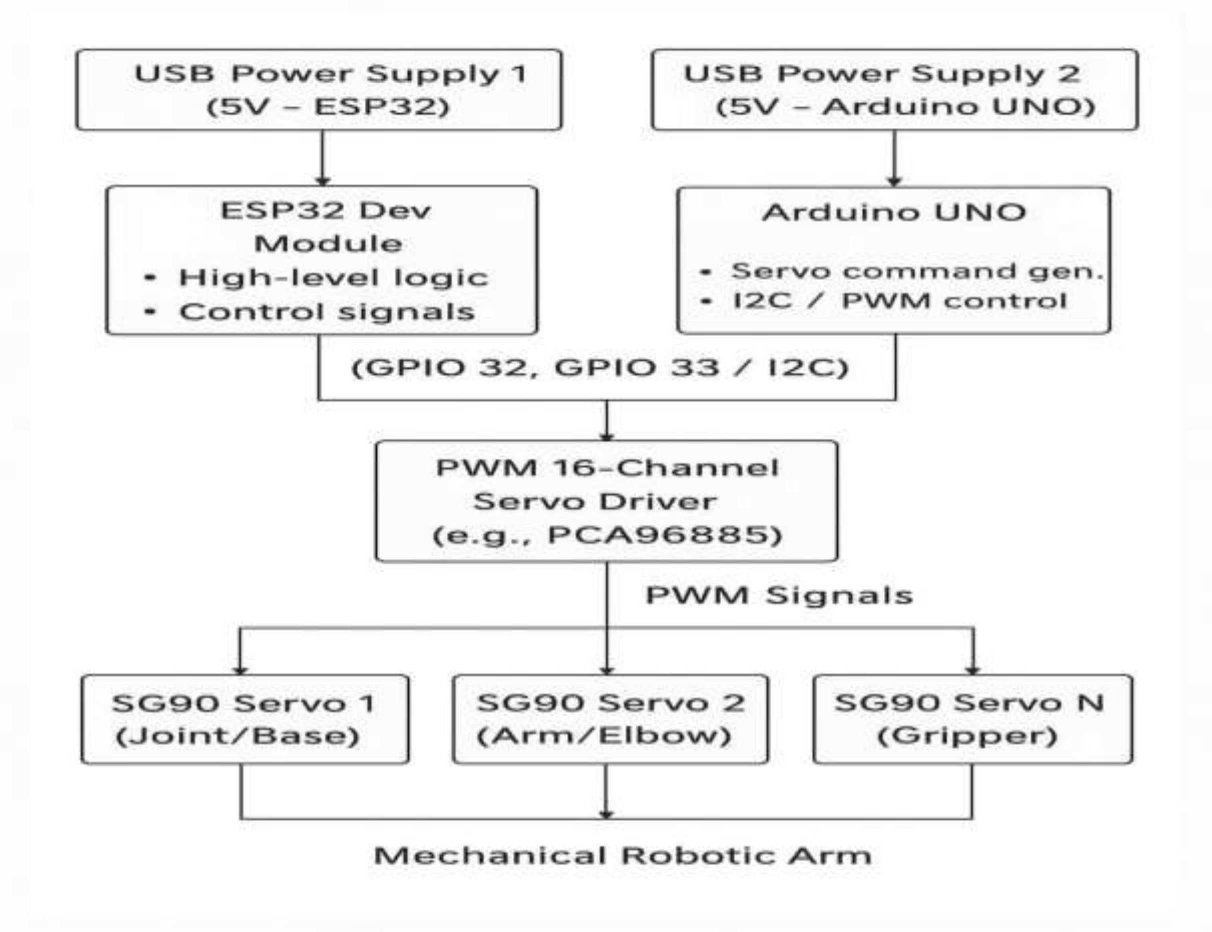


Figure 1: System Architecture

## III. IMPLEMENTATION

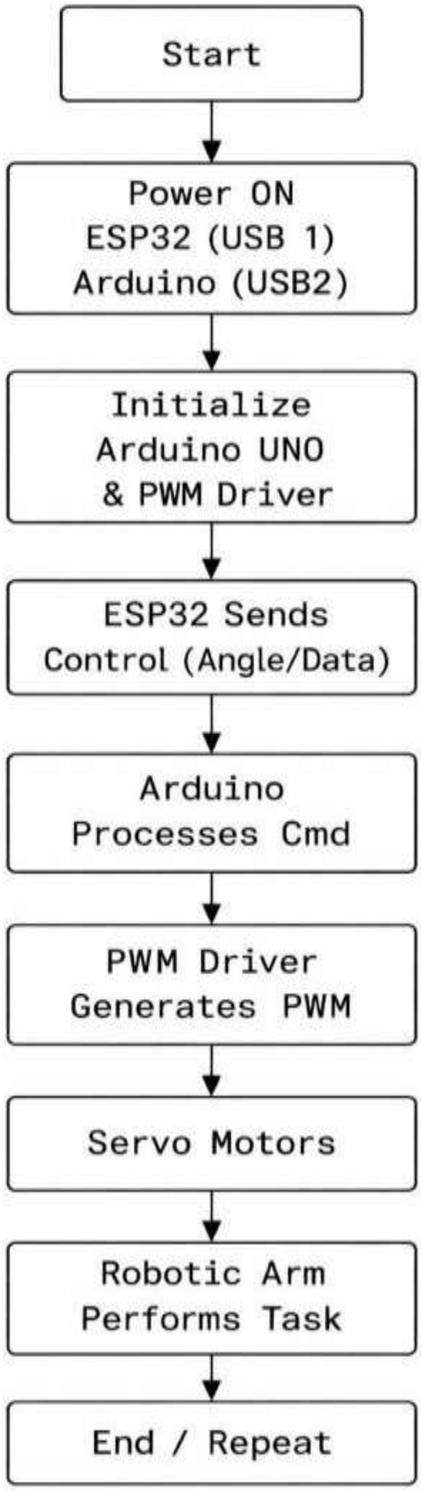


Figure 2: Implementation Steps

## RESULT

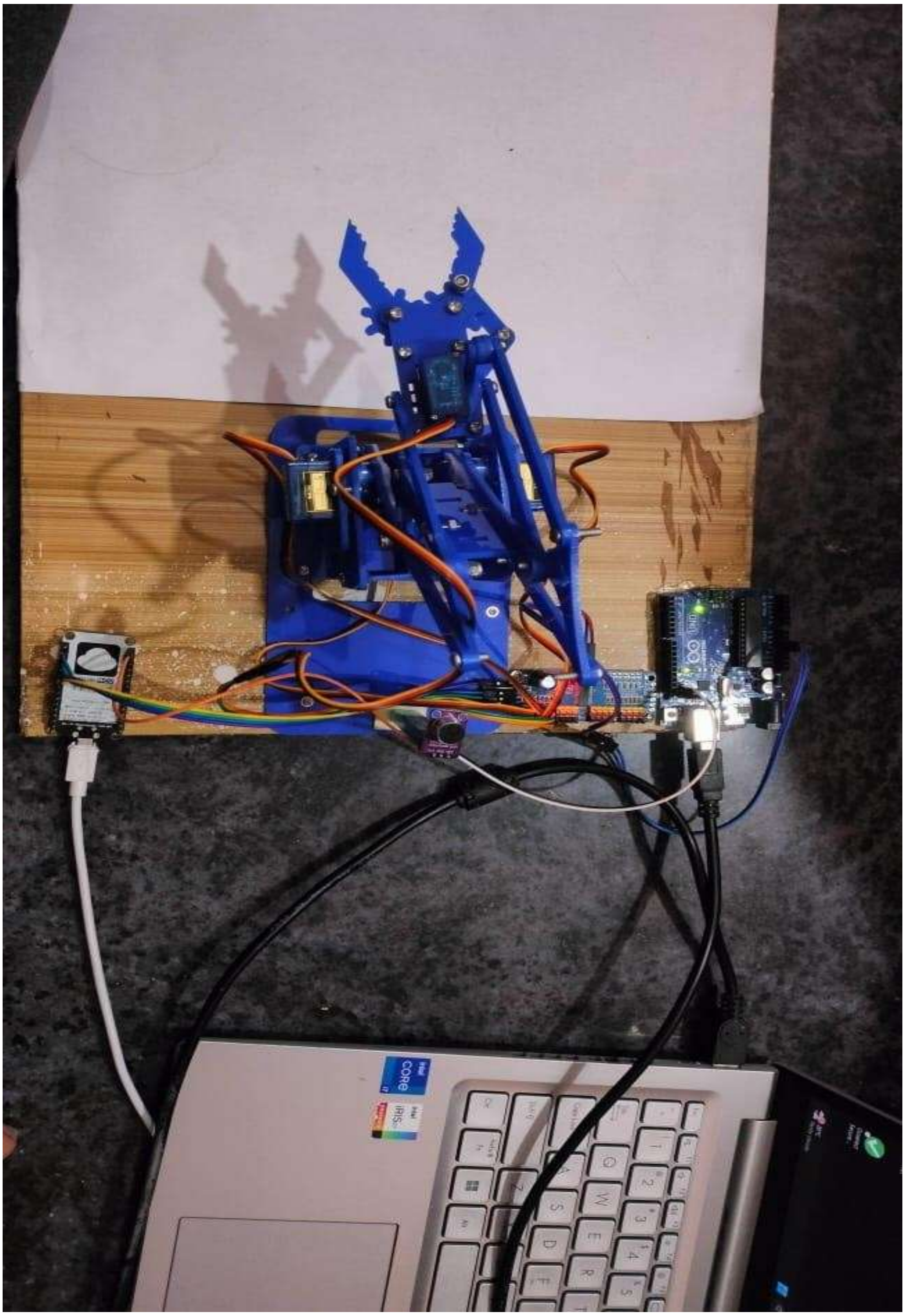

Fig: Experimental Setup

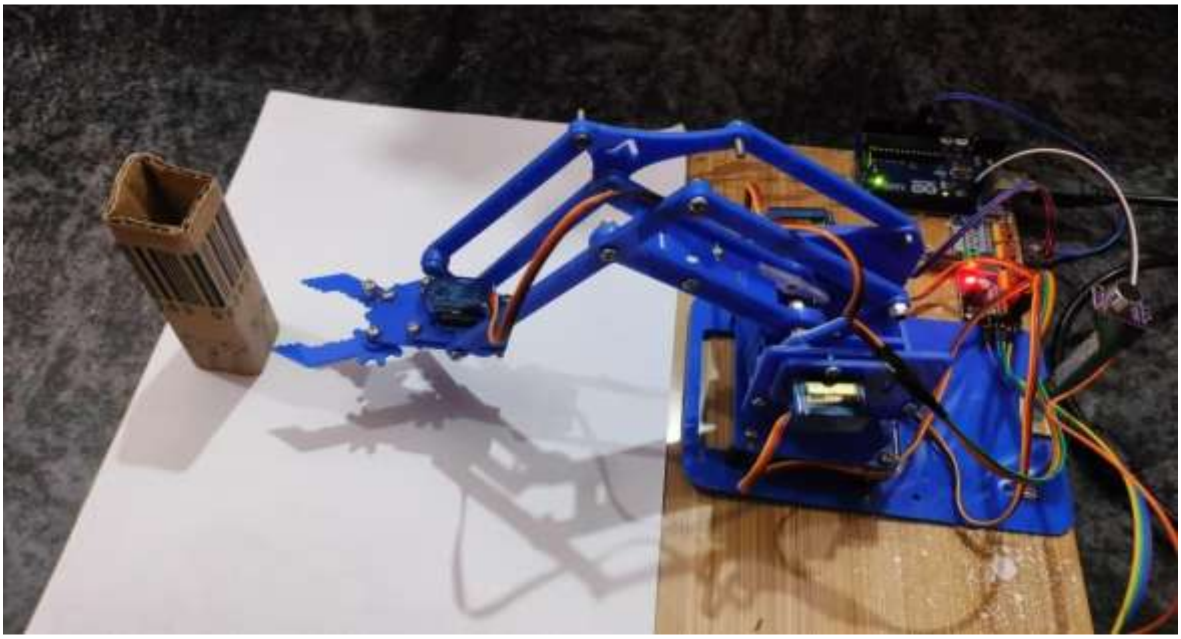

**Fig: Initial Position**

**Fig: Sample Output**

## IV. CONCLUSION

This project successfully demonstrates the design and implementation of a low-cost and flexible robotic arm system using an ESP32 Dev Module and Arduino UNO. The integration of SG90 servo motors with a 16channel PWM servo driver enables precise and smooth control of multiple joints. A local Wi-Fi–based web interface allows real-time control and monitoring of the robotic arm without internet dependency, ensuring low latency, improved security, and reliable operation. An important feature of the system is its ability to record and replay motion sequences, enabling autonomous operation for repetitive tasks with high accuracy. This reduces human effort and improves efficiency, making the system suitable for automation and training applications. The modular architecture supports easy expansion with additional motors or sensors, enhancing scalability and adaptability.

Overall, the developed robotic arm provides an intuitive human–machine interaction platform and is well suited for educational demonstrations, laboratory experimentation, and small-scale industrial automation. Its costeffectiveness, offline operation, and flexibility make it a promising solution for future embedded robotic systems.

**ACKNOWLEDGMENT**

I would like to express my heartfelt gratitude to everyone who has supported, guided, and encouraged me throughout the duration of this project.

First and foremost, I extend my sincere thanks to my project guide and faculty members for their valuable advice, continuous assistance, and unwavering support. Their expertise, motivation, and constructive feedback played a crucial role in the successful completion of this work.

I am also deeply thankful to the laboratory staff and technical team for their help with hardware configuration, debugging, and system integration. Their cooperation, timely suggestions, and hands-on assistance were instrumental in overcoming various challenges encountered during the development phase.

A heartfelt appreciation goes to my family and friends for their constant encouragement, patience, and belief in me. Their support kept me motivated and focused throughout the entire project journey.

Lastly, I express my gratitude to the institution for providing the necessary facilities, resources, and learning environment, as well as to various online platforms that enhanced my understanding and contributed significantly to the completion of this project.

This project would not have been possible without the collective support of all these individuals, and I am genuinely thankful for their contributions.

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