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International Journal of Electrical, Electronics and Computer Systems

ISSN: 2347-2820

Volume 14 Issue 01, 2025

Arduino Based Packaging Robotic Arm

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Peer Review Information

Submission: 11 Sept 2025

Revision: 10 Oct 2025

Acceptance: 22 Oct 2025

Keywords

Arduino Uno, Robotic Arm, Automation, Servo Motor, Pick-and-Place, Ultrasonic Sensor, Gripper Mechanism, Packaging System, Efficiency, Embedded System

Abstract

Automation plays a vital role in modern industries by improving efficiency, accuracy, and productivity. This project presents the design and development of a Packing Controlled Robotic Arm using Arduino. The system is designed to perform automated pick-and-place operations for packing applications in small-scale industries. The robotic arm is controlled using Arduino Uno, with servo motors providing movement to each joint and a gripper mechanism handling objects. Ultrasonic sensors are used to detect the presence of items for packing, while Arduino coordinates motion control through pre-programmed instructions. The developed system aims to reduce manual labor, minimize errors, and provide a cost-effective automation solution. The prototype demonstrates the potential of using simple, low-cost components for effective packaging automation in educational and industrial setups.

INTRODUCTION

The increasing demand for automation in industrial processes has led to significant advancements in robotic systems. In packaging and material handling industries, repetitive tasks such as picking and placing objects are still widely performed manually, resulting in reduced efficiency and increased labor costs. The

Packing Controlled Robotic Arm addresses this issue by providing an affordable automation solution using Arduino microcontroller technology.

The robotic arm replicates basic human arm movements with multiple degrees of freedom, enabling it to perform simple tasks such as lifting, rotating, and placing objects. The system employs servo motors for precise movement control, ultrasonic sensors for object detection, and an Arduino Uno as the central controller.

The robotic arm is capable of executing pick-and-place operations repeatedly with consistent accuracy.

This project focuses on developing a low-cost, programmable robotic arm suitable for small-scale packaging applications, research laboratories, and educational institutions. It emphasizes the use of easily available electronic components and open-source tools, making it both cost-effective and user-friendly. The proposed system contributes to the advancement of affordable industrial automation and lays the foundation for future improvements using vision and AI technologies.

LITERATURE SURVEY

A review of existing research reveals that robotic arms have been extensively used in industrial automation, with applications ranging from manufacturing to packaging and assembly. Studies show that microcontroller-based robotic arms offer significant flexibility and cost advantages for small-scale implementations. Arduino-based systems, in particular, are popular due to their ease of programming, wide community support, and compatibility with various sensors and actuators.

In their book *Automation, Production Systems, and Computer-Integrated Manufacturing*, Groover et al. highlight the importance of automation in reducing human effort, enhancing accuracy, and improving production consistency. Various projects described in academic papers and online resources demonstrate the use of servo-driven robotic arms controlled via Arduino to perform pick-and-place operations. These systems often rely on ultrasonic or IR sensors for object detection and use servo motors to move joints and control grippers.

Other studies emphasize the use of vision-guided robotic systems for more complex automation, incorporating cameras and image processing algorithms to identify objects. However, such systems are costlier and computationally demanding. Therefore, Arduino-based robotic arms remain an ideal choice for low-cost automation in small enterprises and educational environments.

The literature also identifies limitations such as restricted payload capacity, lower accuracy, and absence of feedback control in basic servo systems. Despite these challenges, the reviewed research confirms that Arduino-controlled robotic arms are highly effective as learning tools and as prototypes for developing cost-efficient industrial automation systems.

METHODOLOGY

The methodology adopted for this project involves a systematic approach that combines mechanical design, electronic integration, and software programming to develop a fully functional packing controlled robotic arm. The main objective of this phase is to design, build, and test a robotic arm capable of performing automated pick-and-place operations efficiently. The methodology follows six key stages:

A. System Overview

The robotic arm is designed to mimic the motion of a human arm, consisting of several joints controlled by servo motors. The system uses an Arduino Uno as the main controller, which interprets programmed instructions and coordinates the movement of the arm based on sensor input. An ultrasonic sensor is employed to detect the presence of an object, triggering the arm to pick and place it into the designated packing area.

B. System Design

The mechanical design of the robotic arm includes a base, shoulder, elbow, wrist, and gripper. Each joint is driven by a servo motor, providing the necessary degrees of freedom (DOF). The gripper mechanism is designed to open and close, enabling the robotic arm to hold or release an object. The frame of the robotic arm can be made of lightweight materials such as acrylic or aluminum for stability and ease of movement.

The control system is centered around the Arduino Uno, which processes sensor input and drives the servos through PWM (Pulse Width Modulation) signals. The overall design ensures that each movement is synchronized to achieve smooth and accurate operation.

C. Hardware Implementation

The hardware setup consists of the following key components:

Arduino Uno: Serves as the microcontroller for controlling servo motors and reading sensor inputs.

Servo Motors: Control the rotation of each joint and the opening/closing of the gripper.

Ultrasonic Sensor (HC-SR04): Detects the presence of an object and signals the Arduino to initiate the packing process.

Gripper Mechanism: A servo-based claw used to grasp and release objects.

Motor Driver (L298N): Controls the DC motor used for the conveyor belt (optional).

Power Supply: Provides sufficient current and voltage to operate all components reliably.

The hardware components are connected on a breadboard for testing and then mounted on the arm assembly. The servo angles are calibrated to define the pickup and drop locations precisely.

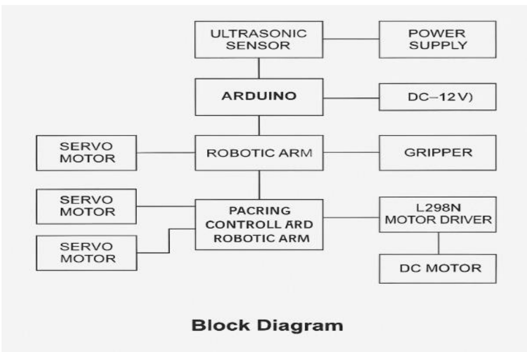

Fig1: Block Diagram

D. Software Development

Programming is carried out using the **Arduino IDE** with Embedded C language. The software defines the movement sequence for the robotic arm and the logic for sensor-based triggering.

Steps in the program logic include:

- Initialize all servo motors and sensor pins.
- Continuously monitor the ultrasonic sensor for object detection.
- When an object is detected, execute the predefined sequence:
- Move the arm to the pickup position.
- Close the gripper to hold the object.
- Lift and rotate the arm to the packing area.
- Release the object by opening the gripper.
- Return to the initial position and repeat the process.

This algorithm allows the robotic arm to operate autonomously in a continuous packing cycle.

E. Testing and Calibration

After the hardware and software integration, the system undergoes a series of tests. Each servo is individually calibrated to ensure correct angular movement. The gripper pressure is adjusted to hold objects securely without damaging them. The ultrasonic sensor's detection range is optimized to ensure accurate triggering. The complete cycle is tested repeatedly to confirm consistent operation and reliability.

F. Performance Evaluation

The performance of the robotic arm is evaluated based on accuracy, speed, consistency, and load capacity. The system successfully demonstrates the capability to perform repetitive packing operations without human intervention. Although the accuracy is limited due to the open-loop control of servo motors, the system provides sufficient precision for small-scale applications.

CONCLUSION

The development of the Packing Controlled Robotic Arm using Arduino demonstrates the potential of integrating low-cost hardware and open-source software to create an effective and reliable automation system. The project successfully achieves automated pick-and-place operations using servo motors, an Arduino controller, and simple sensor-based object detection.

The robotic arm efficiently performs repetitive packing tasks, reducing human intervention and minimizing the chances of error. By utilizing affordable components such as the Arduino Uno, servo motors, and ultrasonic sensors, the system provides a cost-effective alternative to expensive industrial robotic solutions. It also serves as an excellent platform for educational and research purposes, offering hands-on experience in the fields of robotics, embedded systems, and automation.

Although the system's performance is limited to lightweight objects and operates on an open-loop control mechanism, it still demonstrates good accuracy, consistency, and repeatability for small-scale applications. With further advancements, such as incorporating vision systems, feedback control, and IoT-based monitoring, the system can evolve into a more sophisticated and intelligent robotic solution capable of handling complex industrial operations.

In conclusion, the project provides a practical demonstration of automation in the packaging industry, highlighting how simple, programmable, and cost-efficient robotic systems can significantly improve productivity and reduce manual effort. This work lays the groundwork for future enhancements in smart industrial automation using embedded technology and intelligent control systems.

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