MULTI-HANDED PICK AND PLACE ROBOT

1. Introduction

The Multi-Handed Pick and Place Robot is an advanced automation system designed to enhance warehouse efficiency through precision object handling and transportation. The robot is engineered to optimize warehouse management by automating the process of picking, placing, and transporting goods with high accuracy and reliability. The prototype demonstrates the feasibility of using a multi-functional robotic system for warehouse operations, reducing human effort and increasing productivity.

2. Objectives

- To develop a robotic system capable of autonomous warehouse management.
- To integrate multi-object handling mechanisms for efficient pick-and-place operations.
- To implement precise navigation using advanced sensing and control techniques.
- To optimize power efficiency and structural stability for prolonged operation.

3. System Architecture

The robot comprises three primary sections:

Ground Floor (Locomotion & Navigation System)

- Two high-torque 24V DC geared motors are mounted in opposite directions for balanced propulsion.
- Four wheels made of durable nylon polymer reinforced with rubber rings for enhanced grip.
- Two ball bearings per wheel to ensure smooth rotation and minimize friction.
- Sensors including IR line-following sensors, junction-counting IR sensors, and ultrasonic sensors to provide real-time environment perception and navigation.
- H-bridge motor driver to control motor movements with precision.
- Cylindrical structure with removable sensor components for easy maintenance.

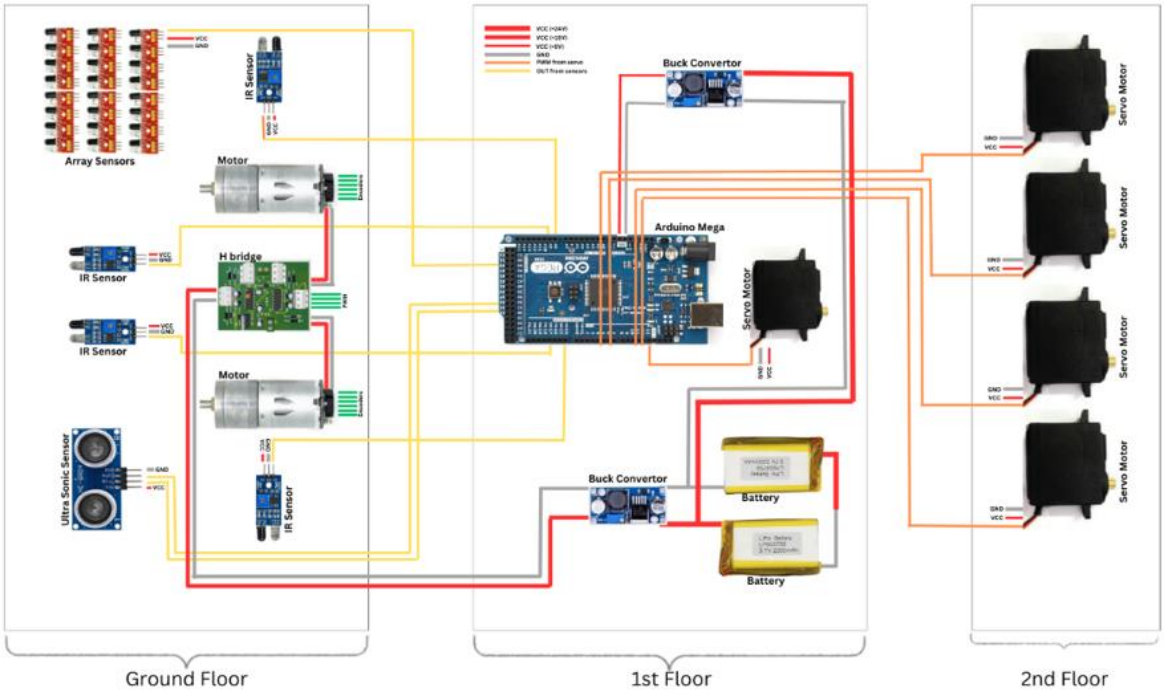
First Floor (Power & Control Unit)

- Two 12V LiPo batteries connected in series to provide a stable 24V power supply.
- Arduino Mega microcontroller for system coordination and motor control.
- Buck converters for stable voltage regulation to different electronic components.
- MG996R continuous servo motor mounted at the central axis to enable rotational movement.
- Mild steel shaft attached to the servo motor, reinforced through welding for added strength.

Second Floor (Object Handling System)

- Four vertical racks resembling spider legs support a forklift system driven by positional servo motors.
- Rack and pinion system ensures smooth vertical movement while restricting unwanted shifts.
- Mechanical locking mechanism to stabilize the forklift when objects are lifted.
- End piece at lifting portions prevents objects from falling during rotation.
- Top cover with decorative lighting elements for aesthetic and functional enclosure.

WIRING DIAGRAM



4. Degrees of Freedom (DOF)

The robot operates with six degrees of freedom (6-DOF):

1. X-axis linear motion - controlled via wheel rotations.
2. Y-axis linear motion - facilitated by bidirectional wheel movement.
3. Z-axis linear motion - achieved through the forklift system.
4. Z-axis rotational movement - controlled by the rotating second floor.
5. X-axis rotation - facilitated by the locking mechanism.
6. Y-axis rotation - additional flexibility via the locking mechanism.

5. Material Selection & Fabrication

- Structural components: Reinforced plastics and metal alloys for durability.
- Wheels, shafts, and chains: Precision-machined to ensure longevity.
- Fasteners (screws, nuts, ball bearings): Made of steel for high load endurance.
- 3D Printing:
    - PLA for smooth and aesthetic parts.
    - PETG (80% infill, gyroid pattern) for high-strength internal components.
- Wiring & insulation: Well-organized to minimize confusion and improve maintenance.

6. Workflow & Algorithm

1. Initialization: System boot-up, sensor calibration, and self-check.
2. Environment Scanning: IR and ultrasonic sensors map surroundings.
3. Object Recognition: Identify objects using sensor feedback.
4. Path Planning: Optimize movement trajectory via A* algorithm.
5. Navigation: Execute path with PID-controlled motor adjustments.
6. Object Manipulation: Pick/place objects using servo-driven arms.
7. Forklift Operation: Raise/lower objects using rack and pinion.
8. Object Placement: Ensure secure and precise positioning.
9. Task Completion: Verify and log successful operations.
10. Standby Mode: Await next command or shutdown.

7. Conclusion

The Multi-Handed Pick and Place Robot successfully integrates advanced mechanical, electrical, and control systems to automate warehouse operations. The prototype validates its ability to efficiently handle and transport objects with minimal human intervention. Future enhancements may include AI-based object recognition, improved battery efficiency, and real-time remote monitoring for enhanced industrial applications.