AUTONOMOUS ARUCO MARKER BASED MULTI-TERRAIN EQUIPMENT SERVICE BOT

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Section : 03 Group : 04

Introduction

This project develops a low-cost, autonomous indoor service robot for labs, workshops, and hospital corridors. It handles lightweight objects, navigates with ArUco markers, avoids obstacles with ultrasonic sensor and uses an ESP32 to control movement and a robotic arm.

Functionalities

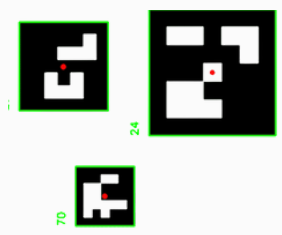
Functionality 1:
6-DOF Pose Estimation

Functionality 2:
Visual Servoing without Kinematics

Functionality 3:
Hierarchical Control

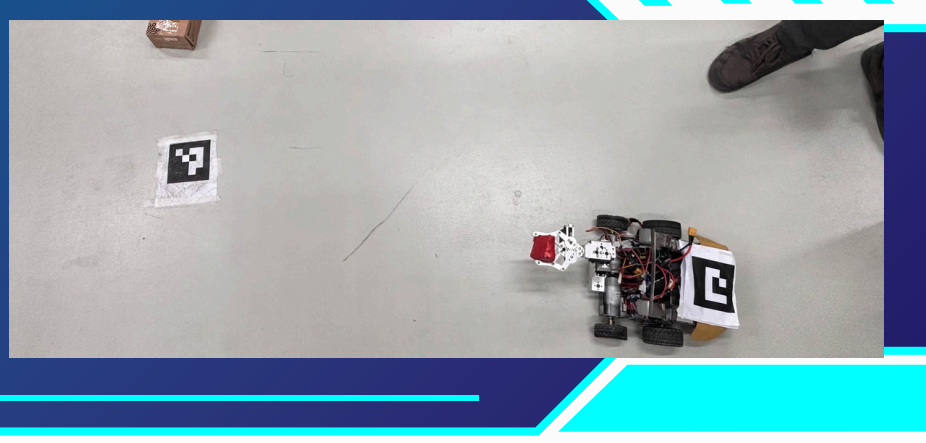
Functionality 4:
Distributed Modular Architecture

Functionality 5:
State Machine Visual Servoing

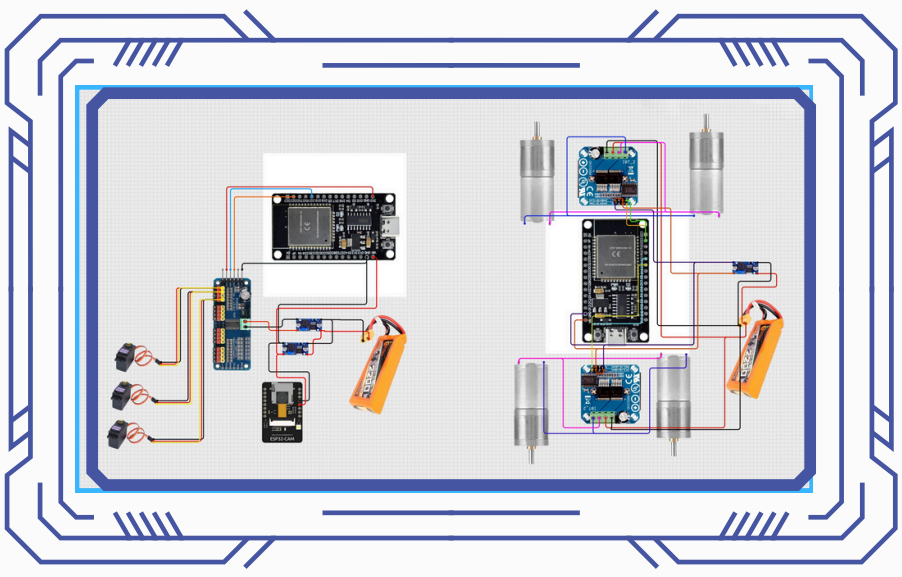


Abstract

Autonomous robot integrating vision-based navigation and manipulation. Distributed control: separate ESP32s for navigation and arm. ArUco marker localization for autonomous point-to-point navigation. Position-Based Visual Servoing (PBVS) for object manipulation using calibration-based pixel-to-joint mapping. Supports manual teleoperation and autonomous operation modes. 5kg stainless steel chassis, differential wheel configuration (65mm front, 85mm rear) for terrain adaptation. Real-time vision processing via USB camera. WiFi TCP/IP communication at 40Hz (navigation) and 30Hz (arm). Applications: warehouse logistics, manufacturing automation, research platforms.



Schematic Diagram

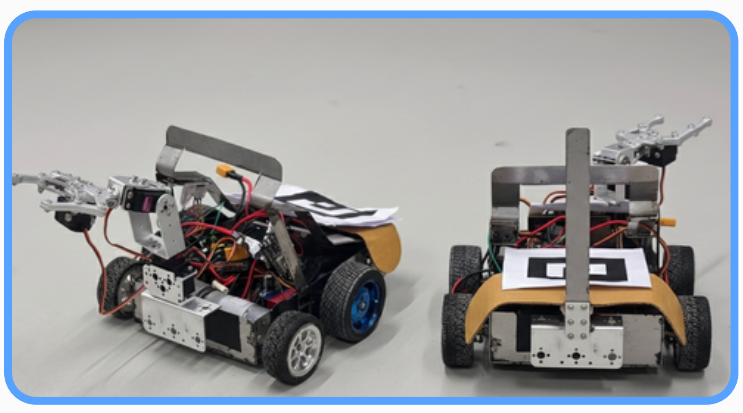


Components Used

Category	Component	Description
Microcontroller	ESP32	Main control unit responsible for motor control, robotic arm actuation, sensor data processing, and wireless communication (Wi-Fi/Bluetooth).
Sensors	Camera	Used for visual perception and detection of ArUco markers for navigation, alignment, and localization.
Actuators	DC Gear Motors (2×)	Provide torque for the differential drive and movement over various terrains.
	Motor Driver (2)	Controls motor speed and direction by interfacing the ESP32 with DC motors using PWM signals.
	Servo Motors (3)	Control the robotic arm joints and gripper for precise manipulation of objects.
Body / Chassis	Multi-Terrain Robot Chassis	Mechanical base with large rubber wheels and SSS mounting plates for stability and payload support.
Additional Parts	Li-ion / LiPo Battery + Buck Converters	Power source for the system with voltage regulation for different components.
	Power Switch, Wiring, Connectors	Ensure safe power control and reliable electrical connections.
	ArUco Marker	Printed fiducial markers are used by the vision system for detection and localization.

Application and Relevance:

in environments such as laboratories, workshops, hospital corridors, and even in Mars exploration missions. It handles lightweight objects to improve efficiency and reduce manual labor. By minimizing human involvement in routine tasks, it enhances workplace safety while also serving as an educational platform for learning robotics, embedded systems, and autonomous navigation.



Conclusion

Modular autonomous robot with distributed control. ArUco-based navigation and calibration-driven PBVS manipulation. Manual and autonomous operation modes.

Key Achievements:

- ±5cm navigation accuracy
- Calibration-based arm control (no explicit kinematics)
- Real-time performance (40Hz nav, 30Hz arm)
- Weather-resistant, impact-tolerant design
- Modular, maintainable architecture