MODULAR SELF-RECONFIGURABLE ROBOT

1. Introduction

1.1 Overview

The Modular Self-Reconfigurable Robot (MSRR) is an innovative robotic system designed to adapt, transform, and collaborate for multiple applications. By dynamically rearranging its modules, the system eliminates the need for multiple specialized robots, making automation affordable, efficient, and sustainable.

1.2 Problem Statement

The current robotics industry faces significant challenges:

- High Cost & Single-Purpose Designs – Traditional robots are expensive and limited to specific tasks.
- Complex Usability – Most robots require skilled operators, restricting accessibility.
- E-Waste & Sustainability Issues – The rapid obsolescence of robots leads to increased electronic waste.
- Limited Adaptability – Robots cannot easily adjust to new environments or tasks without significant modifications.

1.3 Project Objectives

- Develop a scalable, multi-functional modular robot.
- Ensure cost-effective automation for various industries.
- Enhance ease of use through a mobile-controlled interface.
- Minimize e-waste by designing a reconfigurable and reusable system.

2. Technical Specifications

2.1 Hardware Components

- 2x N20 Encoder Motors – Provides precise motion control.
- 1x ESP32-CAM – Enables real-time vision processing and wireless communication.

- 1x MPU6050 – Inertial Measurement Unit (IMU) for motion sensing.
- 1x L9110S Motor Driver – Efficiently controls dual-motor operation.
- 7.5V 800mAh LiPo Battery – Ensures long-lasting power supply.
- Custom 3D-Printed or Metallic Chassis – Lightweight and durable design.

2.2 Power System

- Stable 3V Power Supply – Achieved via a buck converter (MP2315) or LDO regulator (AMS1117-3.3V with Schottky diode).
- 2S BMS with Battery Percentage Display – Tracks power consumption in real-time.

3. System Design & Working Mechanism

3.1 Core Functionalities

✅ Independent & Collective Operation – Each module can operate individually or as a swarm.

✅ Self-Reconfiguration – Uses magnetic & mechanical latching for modular attachment.

✅ Smart Wireless Communication – Wi-Fi, & IR-based proximity sensing for real-time interaction.

✅ AI-Based Motion Planning – Predictive AI optimizes task execution and power efficiency.

3.2 Control & User Interface

- Mobile App Interface – Allows users to monitor and control robot formations.
- Cloud Connectivity – Enables remote operation and real-time tracking.
- Battery Monitoring System – Displays charge levels via the cloud.

4. Challenges & Solutions

4.1 Communication in a Fully Sealed Metallic Shell

Solution: Designed antenna slots & insulative breaks to allow uninterrupted wireless transmission.

4.2 Precise Localization & Positioning

✅ Solution**:** Fused data from esp32 CAM, and IMU for centimeter-level accuracy.

4.3 Camera Stability in a Rolling Chassis

✅ Solution**:** Implemented a free-spinning inner frame using bearing with control od Centre of gravity.

5. Future Scope & Scalability

5.1 Short-Term Goals

📌 Refine AI algorithms for better task execution.

📌 Expand modular capabilities (e.g., robotic arms, medical applications).

📌 Enhance multi-module coordination.

5.2 Long-Term Vision

🚀 Defense & Military – Surveillance & autonomous reconnaissance.

🚀 Space Exploration – Self-configurable robots for planetary missions.

🚀 Industrial & Agricultural Robotics – Automating logistics, farming, and manufacturing.

6. Achievements & Recognition

🏆 **Functional Prototype Developed** – Successfully tested autonomous movement and modular attachment.

📄 **Research Paper in Progress** – Investigating self-reconfigurable robotics.

7. Conclusion

The Modular Self-Reconfigurable Robot is a scalable, cost-effective, and sustainable automation solution that redefines robotics. By creating a single system capable of multiple tasks, we eliminate the need for industry-specific robots, reducing cost, complexity, and environmental impact.