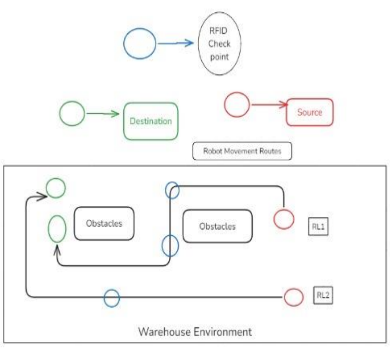
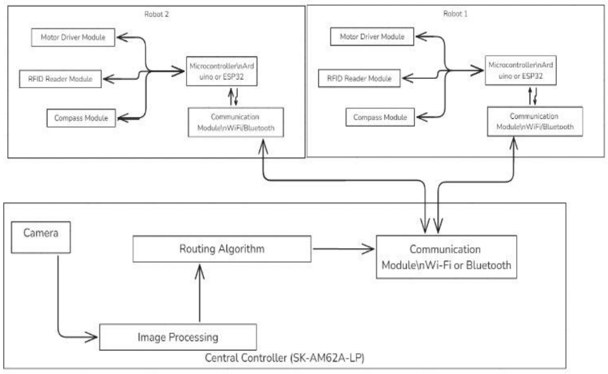
# Warehouse Management System using Autonomous Robots and Centralized Coordinator


- **Abstract**: The proposed system involves a smart warehouse management solution using a centralized coordinator and multiple small autonomous robots. The coordinator, equipped with a 2D map of the warehouse, sends real-time instructions to the robots to transport packages efficiently. It's position tracking of robots is achieved using RFID checkpoints and compass modules, enhancing precision and reducing camera dependency. This solution aims to streamline warehouse operations, reduce human error, and increase overall productivity**.**


- **Problem Statement:** Many companies face operational inefficiencies in warehouses. Order picking is one of the most labor intensive and time intensive processes in internal logistics, accounting for more than 50% of the total warehouse costs.[1] Human errors account for about 80% of process deviations in industries where procedures are well-defined, like warehousing.[2] Research suggests that businesses spend, on average, 20% of their operational budget addressing and rectifying human errors.[2] Traditional systems rely on costly camera-based tracking, which is expensive. We tackle this problem, by using our system, which aims in improving the efficiency, scalability, and eliminating most of the human errors.

- **Explanation of the idea -**




The system consists of a centralized coordinator and several small autonomous robots. The coordinator holds a 2D map of the warehouse and communicates with robots using wireless communication. The robots, designed like small cars, are equipped with motors, an RFID reader, and a compass module for positioning and orientation.

**Overview of the diagram**:

The coordinator sends commands like "move forward," "turn left," and "turn right" to guide the robots to pick up and deliver packages. Positioning is managed by RFID checkpoints, reducing camera monitoring costs and allowing more accurate tracking within the warehouse environment.

- **Hardware Platform Selected for the implementation: Texas Instruments' SK-AM62A-LP**

  We prefer this board for the following reasons:

  ➔ The Sitara processor family, specialise in real time processing, like the quad-core 64-bit ARM Cortex-A53 microprocessor, a single-core ARM Cortex-R5F, over here, can help with high-performance processing and real-time control within the same device.

  ➔ They are supported by the TI Processor SDK, which includes a full Linux distribution, simplifies tasks due to a familiar OS environment. It also minimizes latency in reading and processing RFID tag data and permit scalable detection.

  ➔ The board's image signal processor (ISP) supports up to 5 MP at 60 fps and includes high dynamic range (HDR) encoding and RGB-IR camera support. This ensures high-quality video feeds from cameras in varying lighting conditions.

- **Parts and Implementation:**

| **Parts** | **Implementation** |
|---|---|
| **Texas Instruments' SK-AM62A-LP** | Serves as the Central Controller |
| | ISP module handles video feeds |
| | 2D Mapping Module: Stores/updates warehouse digital map. |
| | Control Software for navigation, decision-making, and task assignments. |
| **Camera System** | Real-time monitoring. |
| | Done with cameras connected via MIPI CSI-2 |
| | Provides feedback with link to the ISP module |
| **Workers Robots** | Microcontrollers for robot control (ESP-32 or Arduino Uno R3/R4) |
| | Compass Module for orientation<br>RFID Reader Module for tracking location via tags |
| | Wireless Communication Modules for communication to the central controller |
| **Warehouse Environment** | Strategically placed RFID tags that serve as landmarks for robot localization. |
| | Predefined routes or dynamic paths that robots follow, marked visually or digitally. |

- **Example of its application:** Besides our main goal, some other applications include:

  **1) Manufacturing Facilities:** The system automates movement of raw materials to assembly lines and transfer finished products to storage, enhancing production efficiency and reducing downtime.

  **2) Retail Environments:** Robots can autonomously restock shelves or transport inventory from storage to the sales floor, ensuring optimal stock levels and minimizing manual labour.

  **3) Hospital Logistics:** In healthcare settings, robots can deliver medical supplies, medications, and meals across different departments, improving delivery times and freeing up staff for patient care.

  **4) Airport Baggage Systems:** The system can be adapted to manage luggage transport from check-in counters to loading areas, optimizing baggage handling and reducing delays.

- **The Benefits and Value Addition:**

  The proposed warehouse management system offers several benefits:

  1) **Enhanced Operational Efficiency**: By deploying autonomous robots, the system minimizes delays and errors, especially during peak seasons, enhancing the speed and accuracy of inventory management.
  2) **Cost-Effective Position Tracking**: Utilizing RFID and compass modules instead of costly camera systems, it provides precise robot navigation at a lower cost.
  3) **Scalable and Flexible System**: The centralized control allows for easy scalability and real-time adaptability, making the system robust and efficient for various logistics challenges.

  In short, unlike any traditional systems that rely on costly camera tracking or manual labor, this solution offers a low-cost, scalable, and adaptable approach, dynamically adjusting to real-time warehouse conditions, making it a unique and highly effective solution for modern logistics challenges. This gives a unique solution to any inefficiencies present in any warehouse.

- **Team and Contacts:**

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- **References:**

[1] Škerlič, Sebastjan, and Robert Muha. "Reducing errors in the company’s warehouse process." Transport problems 12.1 (2017): 83-92

[2] https://weareconker.com/blog/human-error-in-warehousing-a-deeper-dive/