Warehouse Management System using Autonomous Robots and Centralized Coordinator

- **Abstract:** This report has the details about the implementation of a smart warehouse management solution utilizing autonomous robots guided by a centralized coordinator. The solution uses RFID checkpoints, compass modules, and line-follower logic to enable precise navigation and reducing camera dependency. The coordinator sends real-time instructions to the robots to transport packages efficiently A Flask-based website facilitates task assignment and monitoring, while live video streaming and a YOLO-based ML model running on video feed to detect path deviations of the robot.

- **Implementation Overview:**

  The system integrates a centralized coordinator hosted on a Texas Instruments SK-AM62A board, robot equipped with sensors, ESP32, and a web-based user interface. Communication between robots and coordinator is established via a shared Wi-Fi network.

  We have built a website using Flask with the frontend being HTML and the backend being Python. This website is running on the SK-AM62A board. In the website we have functionality to add tasks into a queue, then the coordinator will take care of assigning of tasks to the robot, deleting tasks once the task is done. We can edit the warehouse structure through the website. The website also contains a live video feed, on which we are running YOLO ML model to detect the position of the robot. We use this position tracked from the video to check with the position it is supposed to be in to find any deviations from the path. For robot detection in warehouse, we implemented a YOLO model using PyTorch and fine-tuned it with a custom dataset of images specific to our warehouse setup.

  Communication between robot and coordinator:

  The coordinator and robot are communicating over common Wi-Fi using IP address. We connected the SK-AM62A to the internet via ethernet. The robot is having an ESP32 connected to the same Wi-Fi. Whenever a task is added on the website, the coordinator orders/sends instructions to the ESP on the robot to start doing it, while parallelly processing the video feed.

  The ESP on the robot is always listening while doing its work. In case of any instruction from the coordinator it will be doing that task.

  Warehouse Design:

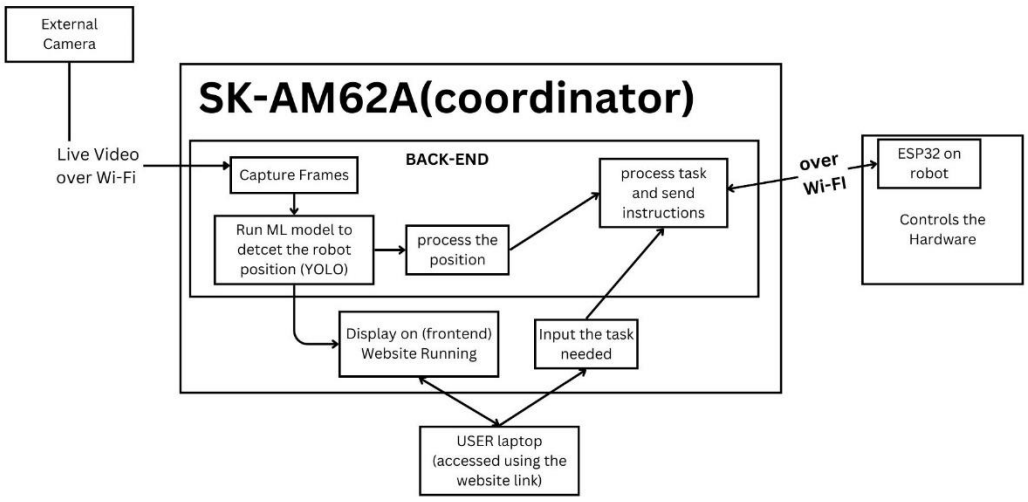
  We have made a warehouse with a few box shsaped items that can be carried by the robot. To help

in tracking the path, black lines were made on the floor to assist the bot. RFIDs cards serve as checkpoints for important areas like sharp turns or intersections..

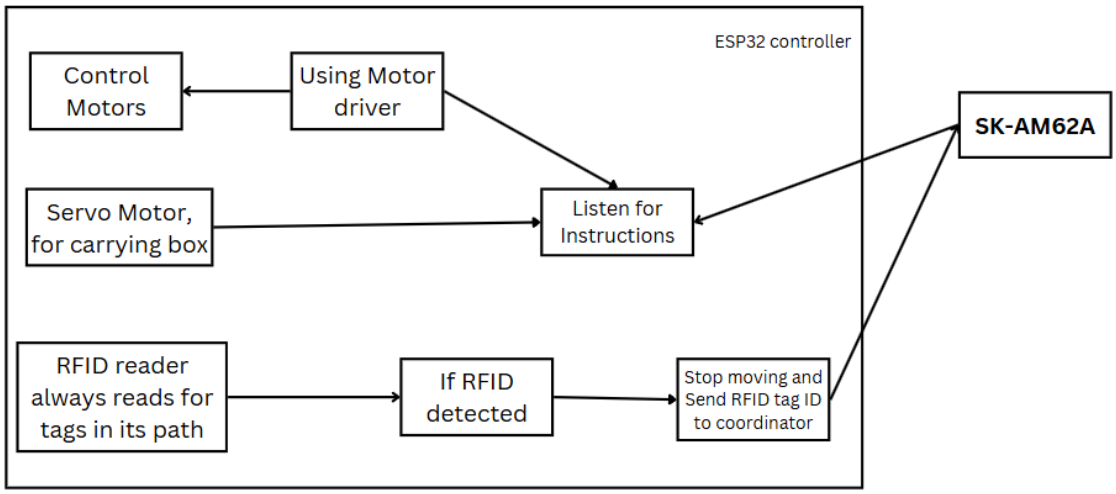
Working of the Robot:

The ESP is the main control unit of robot, controlling motors using motor drivers, we are using compass module to make proper turns like left and right. We have TCRT5000(infrared/ proximity detector) to assist the compass module to make direction/orientation properly, and to align with path in case of slight deviations from the path. While moving in the warehouse the robot always reads the RFID sensor, which we place at the intersections or checkpoints, if the robot detected the RFID's it means the robot has reached one of the checkpoint and asks coordinator regarding the next step to be taken. We use a PID control system, as it will help the robot execute almost every turn, intersection, or sudden interrupt (like a sudden break in the line), execute perfectly.

Block Diagram:



On the Robot



-Team L & R