Self-delivery Robot with Human Interaction

CONTROL SYSTEMS AND INSTRUMENTATION ENGINEERING PROGRAM

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Abstract

This project introduces automation technology through the implementation of automatic delivery robots. The objectives are as follows : **First** to investigate and develop robots capable of autonomous movement using the **Robot Operating System (ROS)**, **Second** to explore and design robots with interactive capabilities for **human interaction**, **Third** to research and apply **image processing** techniques for obstacle detection and human recognition. The creator has engineered a robot with autonomous mobility, equipped with a Lidar sensor utilizing light reflection principles to detect obstacles and ensure safe navigation. Additionally, the robot integrates object detection through image processing using the **YOLO (You Only Look Once) algorithm**, known for its accuracy and speed in image analysis. This enables the robot to accurately identify objects and seamlessly interact with humans. Testing demonstrated the robot's ability to navigate to designated destinations while effectively avoiding both stationary and **moving obstacles**. Moreover, the robot exhibits social behavior by halting to acknowledge and greet individuals encountered during its operation.

Introduction

Currently, robots are increasingly integrated into people's daily routines, predominantly as service robots dedicated to aiding, serving, and enhancing consumer convenience in terms of efficiency and accuracy, which circumvents errors resulting from human oversight. Consequently, the development of robots capable of autonomous transportation has gained traction, alongside efforts to enhance human-robot interaction for improved user experiences. Integration of AI-driven facial recognition systems further augments these capabilities, enabling robots to discern and authenticate individuals. Project Organizer has expressed a keen interest in researching and advancing automatic delivery robots for practical deployment.

System Overview

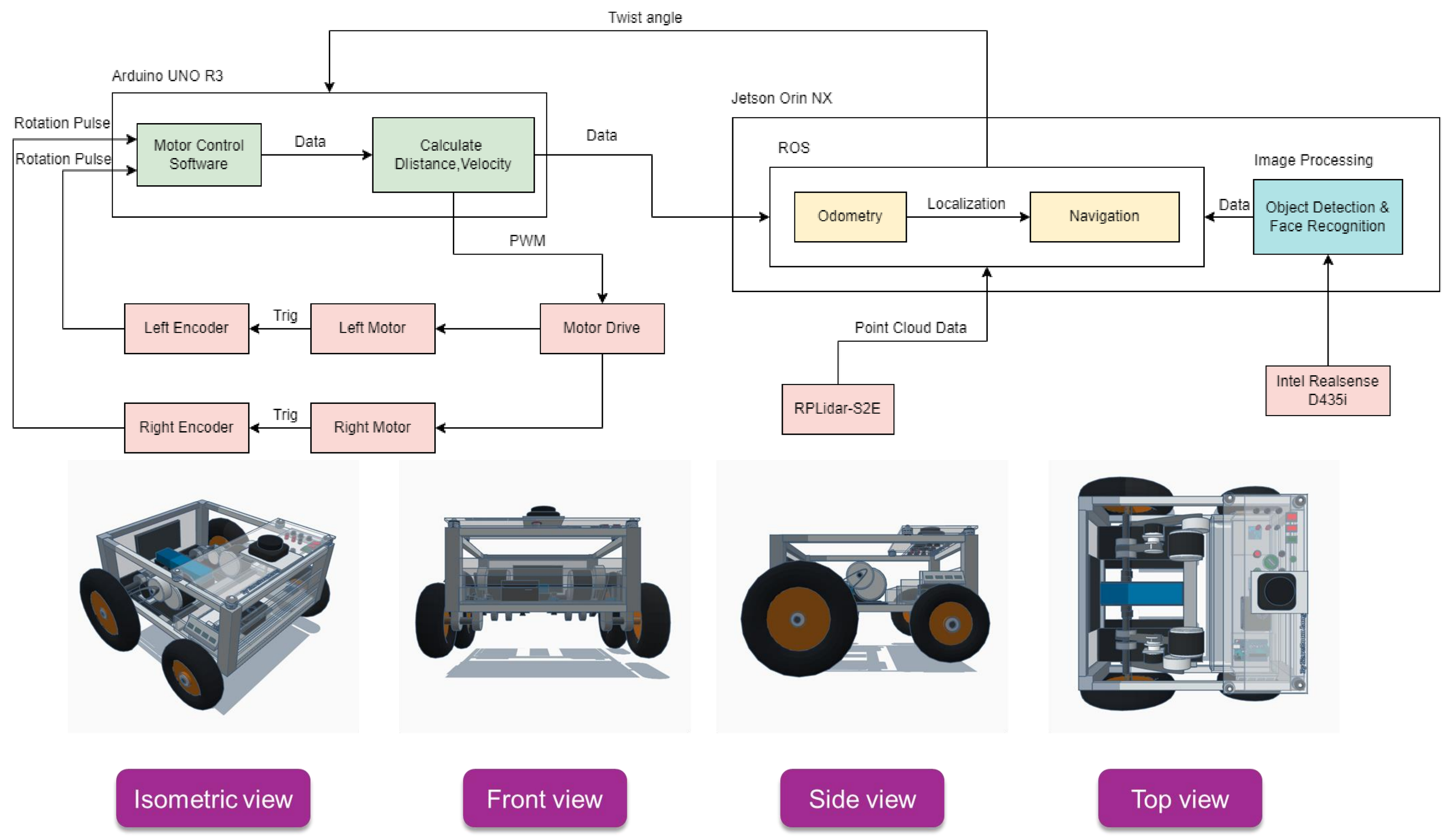

Figure 1 : Overview of Automate Guided Vehicle (AGV)

Results

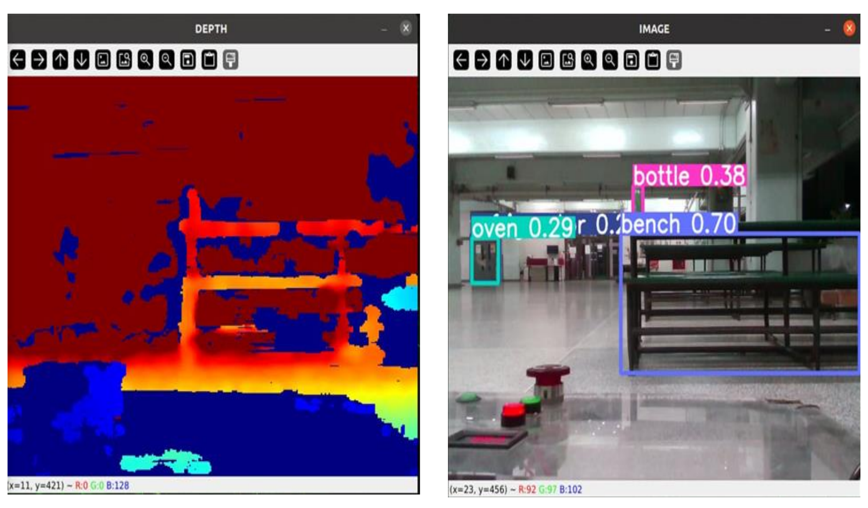

Figure 6 : Distance Estimation and Object Detection with Yolov5s

Range of RPLIDAR Mapping (m^2)	SLAM Mapping Accuracy (%)	Comments
Small (5 m^2)	99	Achieves higher accuracy due to better coverage and detail in smaller areas.
Medium (10 m^2)	97	Accuracy decreases in larger areas due to limited coverage and detail.
Large (20 m^2)	93	Further decrease in accuracy with larger coverage areas.
Extra Large (30 m^2)	87	Maximum coverage leads to the lowest accuracy due to the inability to capture fine details.

Table 1 : AGV with SLAM Mapping accuracy

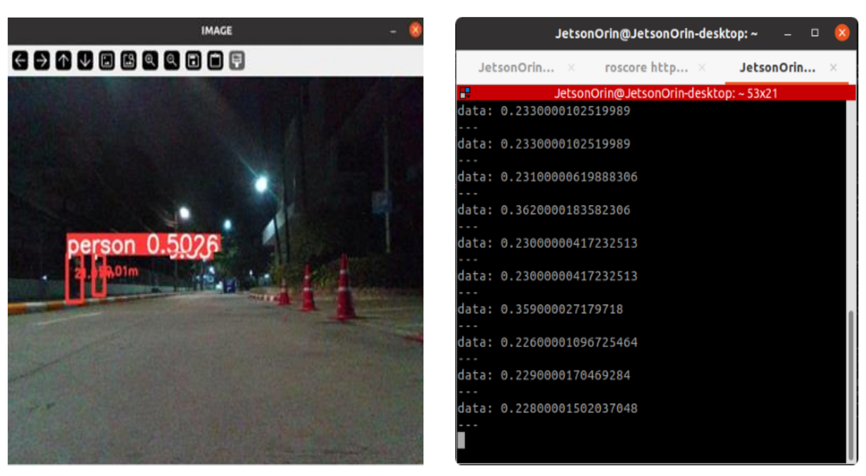

Figure 7 : Person detected and show distance between camera to target

Distance between person to vehicle (m)	Person detection	Distance shown from the algorithm	Car movement
10	Detected	9.82	Moving
5	Detected	5.13	Moving
1.5	Detected	1.41	Speed decrease
0.8	Detected	0.76	Stopped
No person	Can't Detected	N/A	Moving

Table 2 : AGV responds test when detected person

Method

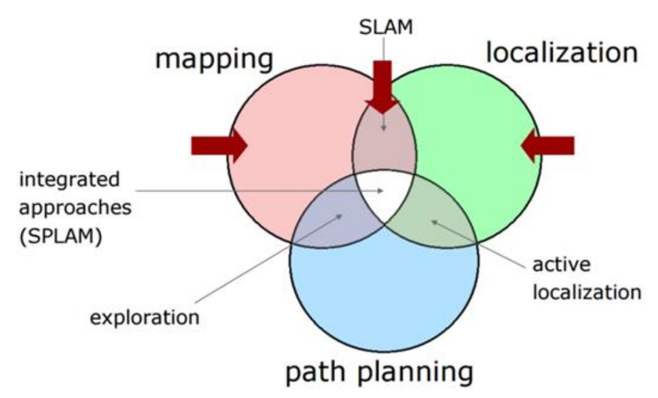

Figure 2 : Elements of Autonomous Navigation

A widely employed technique in autonomous robotics research is **SLAM (Simultaneous Localization and Mapping)**, wherein robots employ sensors like **LiDAR** sensor to construct maps and ascertain their spatial coordinates. As the robot navigates its environment and completes the **mapping process**, it gains the ability to autonomously traverse various locations on the generated map, adeptly avoiding obstacles. At the forefront of robot operating systems is ROS, valued for its open-source nature, facilitating collaboration and integration among diverse software components. Leveraging image processing techniques, ROS aids in **obstacle avoidance and face of person recognition** with navigation core package.

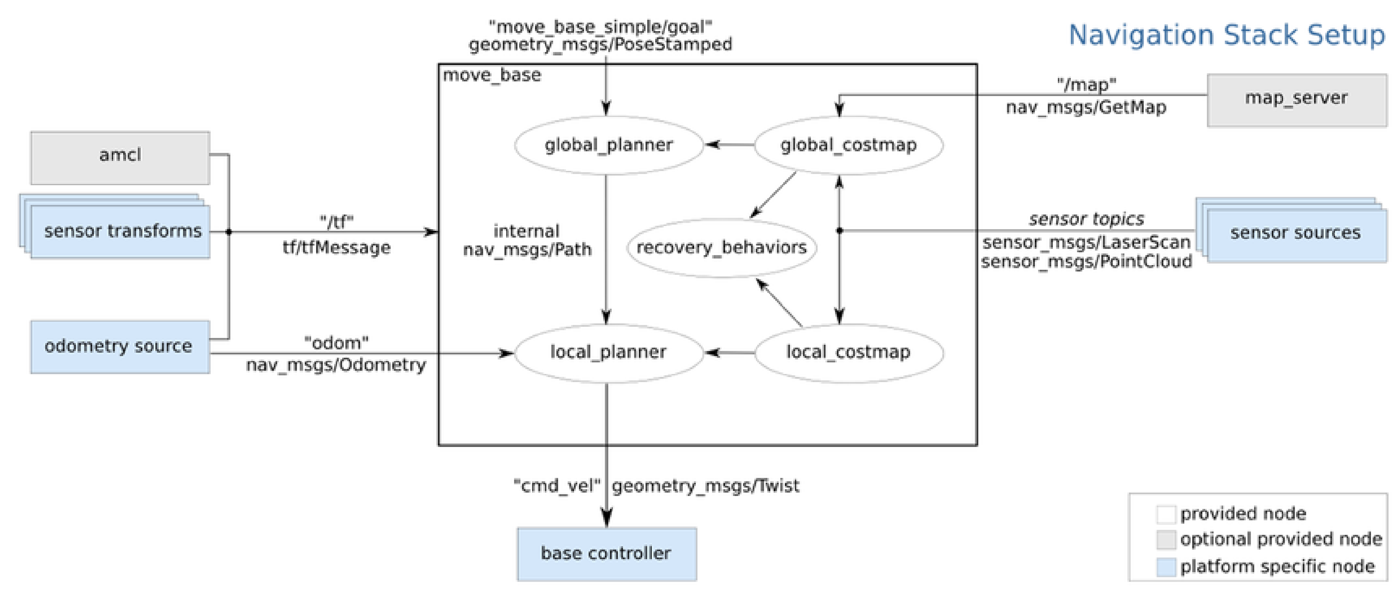

Figure 3 : Navigation stack package

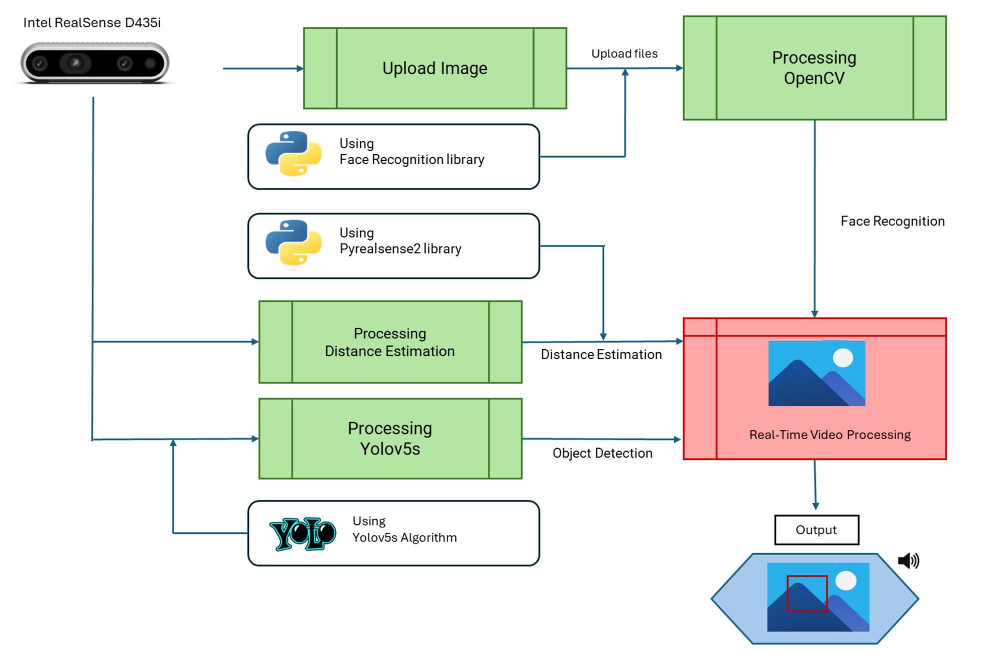

Figure 4 : Flow diagram of AGV Image processing system

This flow diagram illustrates the integration of image processing with AGV functionality. It encompasses a **facial recognition system** implemented through **OpenCV library** in Python, an **object detection** system utilizing **YOLOv5s**, and a **distance estimation** system leveraging the Pyrealsense2 library. The information from each system is then utilized in the **decision-making and response mechanisms** of the AGV robot, facilitated by node creation within the ROS system.

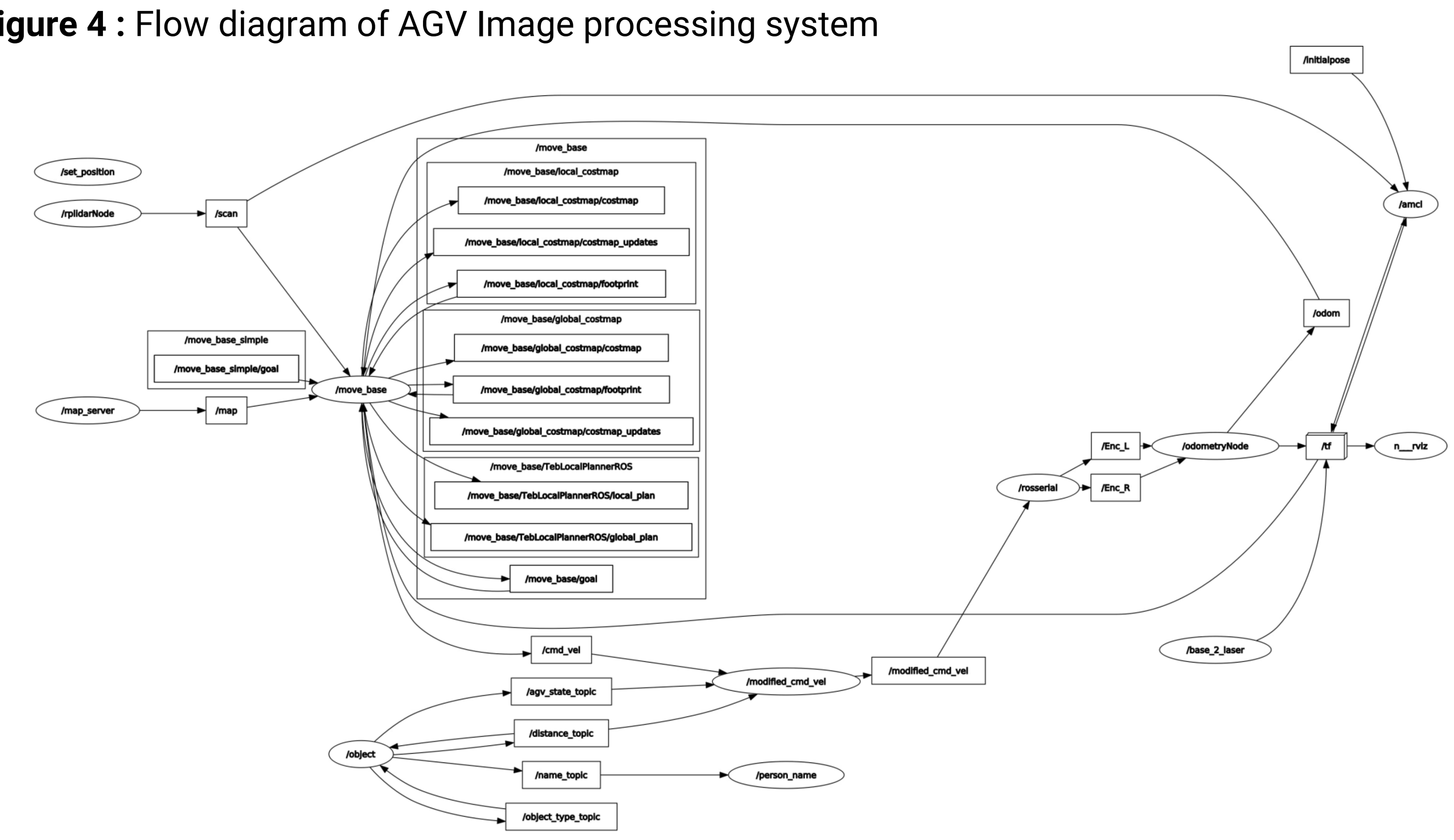

Figure 5 : Rqt graph of ROS navigation

This figure shows **Rqt graph**, which is a diagram of various Nodes and Topics of the AGV robot. It consists of Navigation, Localization, Object Detection and Human Interaction.

Conclusion

From the AGV testing in terms of object detection and distance measurement from the Depth camera, it was found that it was able to correctly classify nearby objects and have accurate distances. But if objects are very far away, they cannot be classified correctly. As for the mapping results using the Lidar sensor using the Hector SLAM method, it clearly shows the details of the map. In indoor navigation, the car can move smoothly to its destination, but in outdoor navigation, Unable to work smoothly Because there are many obstacles that interfere with movement.

References

[1] Y. -X. Wang and C. -L. Chang, **"ROS-base Multi-Sensor Fusion for Accuracy Positioning and SLAM System,"** *2020 International Symposium on Community-centric Systems (CcS)*, Tokyo, Japan

[2] A. A. Abed and A. A. Jallod, **"GPU-Based Multiple Face Recognition Using YOLOv5x,"** *2022 Iraqi International Conference on Communication and Information Technologies (IICCIT)*

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