Autonomous Vehicle Sensor Data Processing to Enable Control of Material Handling Equipment

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***Abstract*— The project detailed below is a multi-sensor system that will attach on to manual warehouse vehicles. The sensor system will collect and process data from the surrounding environment. The data will then be used by the vehicle to navigate the environment. The essential features of the project are how the sensor system will interpret the environment data; how it will parse and pull valuable information out of specific data streams. The motivation behind this project is to see the limits of this new emerging automation technology and the future application of this technology in the material handling field**

I. Introduction

Currently on the market there are a variety of robotic kits that turn manual robots into Autonomous Guided Vehicles. These Autonomous Guided Vehicles or as industry calls them AGVs are the future of warehouse loading/docking and transportation within warehouses and construction environments. UniCarriers' Americas came to the team to get assistance in making their own version of an autonomous robot kit.

The reasoning behind this comes from the lucrative market that AGVs have in the warehouse environment. Since the market is heading towards this direction, and in order to have a step up on other AGV manufacturers, UniCarriers wants to understand the sensor technologies and integration details required for a fully Autonomous Guided Vehicle. After understanding the process of turning a regular robot into an AGV, UniCarriers can more effectively support their Autonomy partners during integration into existing products, while developing platforms customized for AGV/AMR applications.

To accomplish this goal UniCarriers approached our team with various sensors and computer hardware they felt would be vital to the positive outcome of this project. The sensors included were the TopoSens 3 Ultrasonic Sensor and Intel RealSense Visual Sensor. These sensors will send data to their corresponding Raspberry PIs. The data will then be aggregated onto one PI where it will be mapped inside of the program Robot Operating System (ROS). The data points will then be superimposed on top of each other to create a detailed map of the surrounding environment. From there the proposed program would then split up this environment map into specific quadrants, where from there it would use occupancy grid mapping to measure distances between data points in relation to the robot itself. The bulk of the project will be this program and how we get these two sensors to relay data back and forth to each other.

II. Materials and Methods

A. Robot Operating System (ROS)

ROS is not a physical device in the system, but a flexible framework designed specifically for robots and other micro-controllers. ROS was designed to be as thin as possible so that other programming languages could easily implement ROS. ROS is integrated into the system because it acts as the framework that processes all the sensor data collected within the system. That processed sensor data can then be visualized using different existing ROS modules; one of which is called RViz. RViz is a graphical interface that allows the information to be visualized, by using plugins for available topics [4]. Below is an example of ROS plotting ultrasound data from the TopoSens 3 sensor.

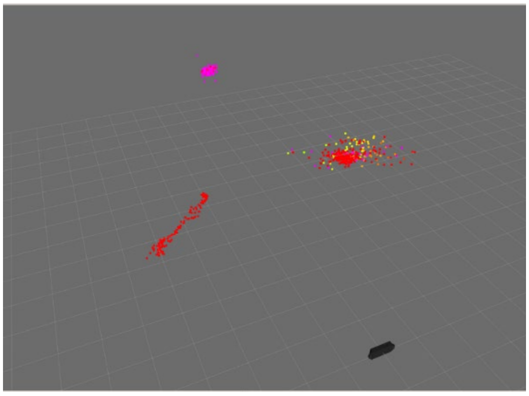

Figure 1: Sensor Data visualized on RViz

B. TopoSens 3 Sensor (TS3)

The TopoSens 3 is a sound-based sensor; meaning it uses ultrasound waves to map the surrounding environment. The form of the sensor is a rectangular shaped object, the dimensions are roughly 9 x 3 x 1 cm. It has a field of view of 140° x 140° and can scan up to five meters with a precision of ± two mm. The TS3 functions by sending ultrasound waves at intermediate points in time, the sound waves rebound and are then picked up by a high-frequency microphone inside the sensor. All this data concerning the ultrasound waves are generated; the time traveled, the distance crossed, and the angle of the wave are all measured and sent into ROS.

Figure 2: TopoSens 3 Ultrasonic Sensor

C. Intel RealSense Camera

A product that has a range of depth and tracking technologies designed to give machines and devices depth perceptions capabilities and much more[5]. The Intel RealSense Depth Camera uses an RGB sensor and infrared projector to create a view of the environment surrounding it. The unit also contains an inertial measuring unit (IMU) that can detect rotations and movement in six degrees of freedom. This IMU uses a gyroscope to detect rotation and movement in three axes. The Active IR Stereo projector has a field of view of 87° x 58° x 95°. The function of the RealSense camera is to provide a secondary data type that ROS can parse through. The parsed sensor data then can parse through. The parsed sensor data then can be integrated with the sensor data from TopoSens 3 and then combined sensor data can be visualized inside of Rviz

Figure 3: Intel RealSense Camera

III. Results and Discussion

The final iteration of this project includes a custom-made sensor module to house the multiple sensors. The sensor module was then mounted on top of a prebuilt robotic testing unit. This testing unit was used to collect data and simulate a standard manual vehicle that would be found in most common warehouses. The findings for each sensor are as detailed below.

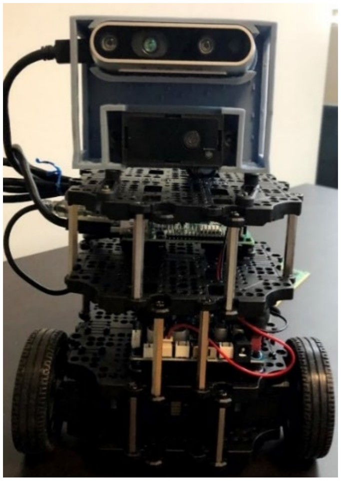

Figure 4: Integrated Sensor Module + Testing

TopoSens 3 Sensor

Initial results from the TS3 were promising; however, the data points gathered revealed several flaws. External high frequencies caused false data points to appear within the ultrasound map created by the TS3. As such, this specific sensor would be hard to implement within a warehouse context because most machinery emit high frequency waves; these ultrasound waves will cause false positives to appear in the environment which will lead to the AGV trying to navigate past objects that may not actually exist in the given environment.

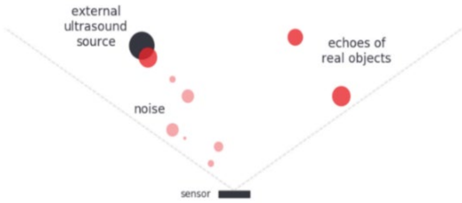

Figure 5: Location of false echoes resulting from external sources of ultrasound waves.

Intel RealSense Camera

Documentation for this sensor describes the maximum depth range to be up to ten meters with a slight variation depending on lighting. However internal testing revealed that a realistic range for this sensor was around five meters; with any practical data being only generated when the sensor was within two to three meters away.

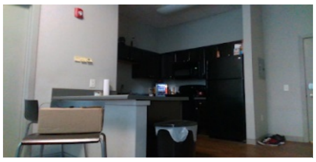

Figure 6: RBG Data Stream

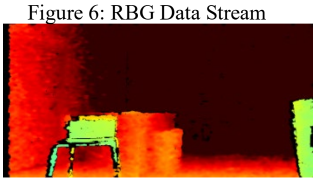

Figure 7: Depth Data Stream

IV. Conclusions

The initial project scope detailed a system that supported a fusion of different sensor types. The fused sensor data theoretically would give a more accurate representation of the surrounding environment. The practical data gathered from these specific sensors however has led to be less insightful than initially thought. The current completed system follows a modular approach, which in the future will allow for easier implementation of new sensors. A combination of new sensors in conjunction with the existing sensors may lead to a successful project goal of a fully operational AGV kit.

Acknowledgment

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