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# Autonomous PSAS Parcel Robot compliant ROS

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**Abstract:** As the world technology keep revolving, the industries of unmanned vehicles also keep advancing very fast. Start from zero level of autonomous to four and fifth level of autonomous. This article introduce an autonomous PSAS Parcel Robot compliant ROS that is capable of delivering parcels with the load between 0 to 50kg. The development of the autonomous PSAS Parcel Robot compliant ROS would be divided into two major parts including hardware and software. The hardware such as lidar, IMU, and different type of sensors, encoder and different type of motor were used to enable system decision making autonomously. While the system functionality was enabled using open source software ROS (Robot Operating System) and operated under ubuntu operating system. The developed system were successfully tested and enable mapping, localization and navigation autonomously to the targeted route

**Keywords:** *Parcel robot, autonomous, vehicle, ROS*

## 1. Introduction

In our daily life, simple tasks such as sweeping the floor or sending a parcel from one station to another is not a big deal as its needed to be done once a week or once a while. However, in a busy working environment, an autonomous parcel or delivery robot might be a good solution and profitable. In addition, save many workers time and help in completing any delivery task without human supervision.

Traditionally, parcel delivery provider focused on Business to Business marketplace area. However, with the explosive boom of e-commerce, Business to Consumers and Consumers to Consumers marketplace area additionally began to expand rapidly [1]. As a result, courier provider companies rapidly enlarge their community and put in force a gadget to facilitate the logistical issues among the terminals/warehouses [3]. Although the service providers invest heavily in expanding the network, the parcel delivery service, however, suffers from low service quality. This is due to the parcel delivery service still following the the old B-to-B methods where low-frequency big logistics are the norm. In B-to-C and C-to C market, the parcels are often high-frequency and small logistics [3].

In improving the parcel delivery service, an automatic

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parcel delivery system was discussed in [6]. Future more, In 2019, Moritz Poeting et al [4] mention that, the parcel industry is seeking for a new innovation concept such as drones, autonomous vehicles, deliveries to the truck of a car and parcel robots to overcome the issue of parcel delivery service.

## 2. Literature Review

Developing and implementing an autonomous parcel robot need a lot of effort and is a really challenging task. The development process starts with designing the mechanical system, employing different types of sensing device, electrical and electronic set up, programming and strategy for an autonomous delivery system [2]. Future more, programming require everything in the developed system to be connected to one another, so that it able to be fully operated as desired.

As introduced more than a decade, the Robot Operating System has become one of the most powerful operating systems for robot development [5]. It consists of different types of packages that enable any system and or device to be available, connected integrated on any robotic system.

Based on the review work made by Wonsick and Padir [8] in 2020 and Tselegkaridis and Sapounidis [7] in 2021, it was found that ROS provide different type of packages that enable all in one application. Therefore, in this study, a simulation and real implementation of PSAS parcel robot is introduced. This work also integrated a new type of microcontroller that is available with IMU. Odom commonly produce position errors, therefore IMU is integrated with Odom information to enable position correction.

## 3. Research Methodology

PSAS Parcel Robot development could be divided into two major parts, hardware and software. The hardware parts includes of two different types of Lidar, IMU, different types of sensors, different types of motor and 2 types of microcontroller. While the software part were developed using open source software ROS (Robot Operating System) under ubuntu operating system. The software architecture were developed by the integration of four layers and developed for two cases that are autonomous simulation and autonomous on real robot. Detail explanation hardware and software architecture were explained next.

### 3.1 PSAS Parcel Robot Hardware

PSAS Parcel Robot developed hardware is illustrated as in Figure 1. The hardware parts includes of two different types of Lidar that is 2D lidar and 3D Lidar for object detection and to study and mapping environment respectively. The 2D Lidar enable detecting objects in 180 degrees. The 3D Lidar enable to study and map the environment for 360 degrees. GPS RTK and IMU enable to detect the position of the robot. As robot position unable to be detected using GPS RTK because of network deficiency, the information of the robot position was backed up by using IMU. Besides tracking the position of the robot, IMU is used to detect the heading of the robot. Future more, the PSAS parcel robot also equipped with touching sensor. Touching sensor enable to stop the robot immediately as the robot colloids with any hard object. BLDC Motor Driver is used to drive the motor, DC Brush Motor Driver for steering drive and DC Motor Driver for break motor. Two types of controllers will be utilized in the PSAS Parcel robot that are Intel NUC and MRC1. Intel NUC is a high level controller, while MRC1 is a low level controller.

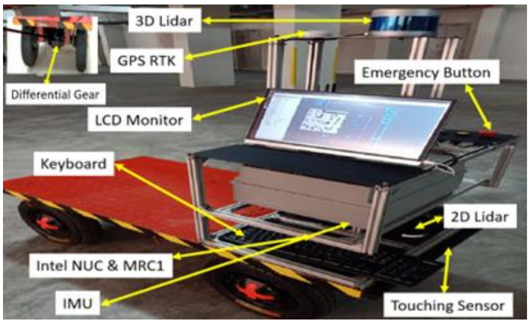


Figure 1: PSAS Parcel Robot Hardware

### 3.2 PSAS Parcel Robot Software Architecture

This study presented a complete software architecture of PSAS parcel robot which was developed by the integration of four levels including Perception layer, Communication layer, Data Processing layer and Application layer. Figure 2 shows the PSAS Parcel Robot architecture structure. This architecture can be modified and added-on with various sensors to get more efficient results. The first layer is called a perception layer which consists of different types of sensors that sense information from environment and send data to the third layer called Data Processing layer through communication layer in second layer. In the data processing layer, information is processed into valuable information via two type of controller that are low level controller and high level high level controller. Finally, the information from both the controllers is fused in high level controller using ROS based packages. In ROS, suitable packages will be utilized to enable robot movement autonomously in simulation and real application.

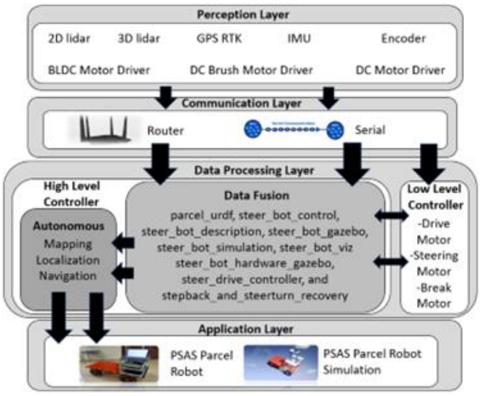


Figure 2: PSAS Parcel Robot Software Architecture

In this study, the PSAS Parcel Robot ROS Packages description architecture was developed by considering the former description of the architecture and according to the previous related work. The proposed architecture was implemented based on Robotic Operating System. The PSAS Parcel Robot based on ROS software architecture was developed for two applications that are PSAS Parcel Robot Simulation and PSAS Parcel Robot in real as shown in Figure 3. PSAS Parcel Robot Simulation was developed prior before real PSAS Parcel Robot for verification.

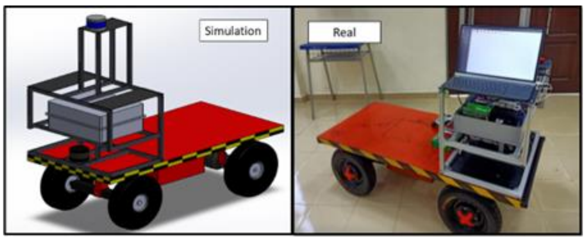


Figure 3: PSAS Parcel Robot in Simulation and Real

The PSAS parcel robot simulation consist of a total of two main packages that are Steer Bot and Steer Drive Ros. Steer Bot package enable a simple Ackermann steering vehicle simulation in Gazebo using ros control. It includes six sub packages that are parcel_urdf, steer_bot_control, steer_bot_description, steer_bot_gazebo, steer_bot_simulation and steer_bot_viz as shown in Figure 4. Steer_bot_discription is a sub-package that consists of the urdf file. Urdf is called Unified Robot Description Format (URDF). It could be found in XML format and it is used to represent a PSAS parcel robot model. Steer_bot gazebo is a gazebo plugin that enable to create robotic simulation environments. Gazebo create virtual worlds that can simulate and load simulated versions of robot into it, simulated sensors that can detect environment and published same rostopic data as real sensors. This plugin made testing algorithm work easy. Steer_bot_control is a sub-package that is used to control the robot steering mechanism(joystick). Figure 4 shows the node and topic involved in PSAS parcel robot simulation. Steer bot simulation is used to do slam_gmapping. Here a 3D (point_cloud) mapping could be map to 2D(laserscan) mapping. Finally, steer bot viz is ROS visualization that is used to visualize the message data in an understandable view not only visualizing many values.


Figure 4: Steer bot and Sub Steer bot package

While Steer Drive Ros is a package that control wheel systems with steering mechanism. Control is in the form of a velocity command, that is split then sent on the single rear wheel and the single front steer of a steering drive wheelbase. Odometry is then computed from the feedback from the hardware and published. Steer Drive Ros consists of three sub packages that are steer_bot_hardware_gazebo, steer_drive_controller and stepback_and_steerturn_recovery as shown in Figure 5. Steer bot hardware gazebo provides 4-wheel car-like robot model with steer mechanism for Gazebo simulation, by using gazebo_ros_control plugin. Steer_bot_hardware_gazebo inherits gazebo_ros_control. Steer bot hardware gazebo is a Gazebo plugin version of RobotHW and called RobotHWSim. This plugin assumed that the steer_drive_controller is selected as the driving controller. steer_drive_controller is designed to have two joint interfaces, one is velocity_joint_interface for the single rear wheel joint and the other is position_joint_interface for the single front steer joint. The stepback_and_steerturn_recovery package is designed for a robot with a car-like steering mechanism. It adheres to the nav_core. Recovery Behavior interface found in the nav_core package and can be used as a recovery behavior plugin for the move_base node. The plugin frequently check if there is a obstacle in the proceeding direction during recovery for protection of a robot. Detecting an obstacle at a close point to the robot make it brake and invoke local planning at the brake point.

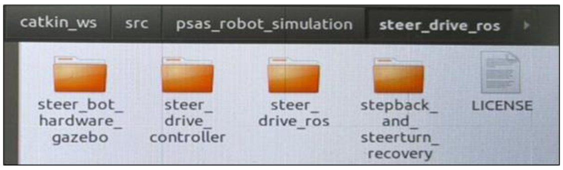


Figure 5: Steer Drive Ros and Sub steer drive ros package

The packages involved in PSAS Parcel Robot in real is as mapped in Table 1. By referring to Table 1for example, PSAS URDF packages is the package for PSAS parcel robot in simulation while Hector_model packages is the package for PSAS parcel robot in real. Each package in simulation is mapped with each package in real PSAS Parcel Robot.

Table 1: Mapping of PSAS Parcel Robot Packages for Simulation and Real

| PSAS Parcel Robot Simulation Packages | Real PSAS Parcel Robot Packages |
|---|---|
| Parcel URDF | Hector_models |
| steer_bot_discription | Hector_components_description |
| steer_bot_gazebo | psas_robot, lslidar_n301(2D), rslidar_sdk(3D), pointcloud_to_laserscan, lslidar__n301_driver, lslidar_n301_decoder, iralaser tools, laser_filters, robot_state_publisher, rviz,rqt_gui |
| steer_bot_control | Joy_node, teleop_twist_joy,twist_mux |
| steer_bot_simulation | gmapping |
| steer_bot_viz | rviz |
| steer_bot_hardware_gazebo | moverobotic_hardware |
| steer_drive_controller | mbl1330 |
| stepback_and_steerturn_recovery | move_base, amcl, moverobotic_mission, map_server, moverobotic_simple_navigation |

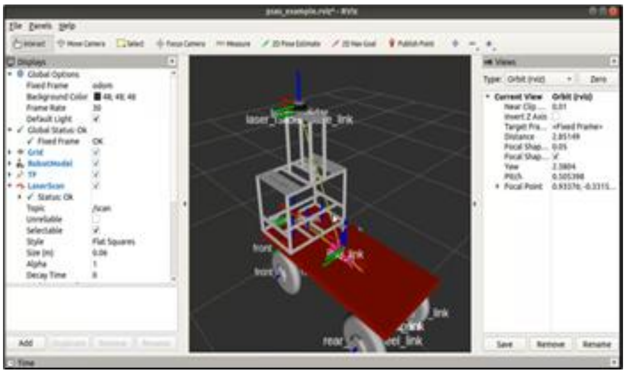

Figure 6: PSAS Parcel Robot in Simulation

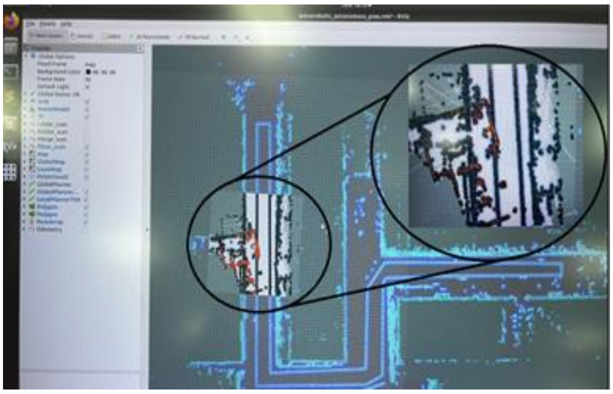

Figure 7: PSAS Parcel Robot in real

Figure 8: RQT Node and topic for PSAS Parcel Robot Simulation

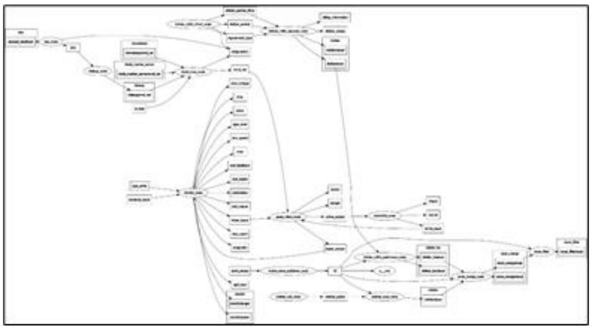

Figure 9: RQT Node and topic for PSAS Parcel Robot in Real

After installing all the packages discuss above, finally, all the packages is run using roslaunch command and the result of a PSAS parcel robot simulation and real PSAS Parcel robot in rviz is as shown in Figure 6 and Figure 7 respectively. Together with PSAS parcel robot simulation, the user can check the node and topic published and subscribed by running rqt on the terminal. Figure 8 and Figure 9 illustrate the node and topic published and subscribed in PSAS parcel robot simulation and PSAS parcel robot in real respectively.

## 4. Conclusion

This article presented an autonomous PSAS Parcel Robot compliant ROS that can deliver parcel with the load between 0 to 50kg. The development of the autonomous PSAS Parcel Robot compliant ROS is divided into two major parts including hardware and software. Hardware such as lidar, IMU, and touching sensor were included to enable system decision making autonomously. Two types of Lidar were utilized that is 2D lidar and 3D Lidar. 2D Lidar were used for object detection while the 3D lidar were used to study the environment. IMU was utilized to detect robot localization under the map and touching sensor was used to stop the robot from moving and touching any object. Besides hardware part, software system was developed under ROS (Robot Operating System) to enable complete system functionality of the robot in simulation and in real.

Under the ROS development environment, there are a total of 2 main packages that were integrated to enable smooth hardware and system functionality. The developed PSAS Parcel Robot system were successfully tested in simulation and real and enable mapping, localization and navigation autonomously to the targeted route.

## 5. Acknowledgements

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## 6. References

[1] Aranko, J. (2013). Developing the last mile of a parcel delivery service concept for consumers

[2] Cañas, J. M., Perdices, E., García-Pérez, L., & Fernández-Conde, J. (2020). A ROS-based open tool for intelligent robotics education. Applied Sciences (Switzerland), 10(21), 1–20. https://doi.org/10.3390/app10217419.

[3] Mohd, A., Rashid, R. A., Abdul Hamid, A. H. F., Sarijari, M. A., Rahim, M. R. B. A., Sayuti, H., & Abdul Rashid, M. R. (2019). Development of android-based apps for courier service management. Indonesian Journal of Electrical Engineering and Computer Science, 15(2), 1027–1036. https://doi.org/10.11591/ijeecs.v15.i2.pp1027-1036

[4] Moritz Poeting, Stefan Schaudt, & Uwe Clausen. (2019). A COMPREHENSIVE CASE STUDY IN LAST-MILE DELIVERY CONCEPTS FOR PARCEL ROBOTS. Proceedings of the 2019 Winter Simulation Conference, 1779–1788.

[5] Pagination, & Cover. (2019). Robot Operating System-The Complete Reference (Volume 4) Several authors. www.cister-labs.pt

[6] Tomoki Kobata, Yukio Tada, & Takao Muromaki. (2016). Development of Automatic Parcel Delivery System using Image Processing Techniques. Proceeding of International Symposium on Flexible Automation, 292–295.

[7] Tselegkaridis, S., & Sapounidis, T. (2021). Simulators in educational robotics: A review. In Education Sciences (Vol. 11, Issue 1, pp. 1–12). MDPI AG. https://doi.org/10.3390/educsci11010011

[8] Wonsick, M., & Padir, T. (2020). A systematic review of virtual reality interfaces for controlling and interacting with robots. In Applied Sciences (Switzerland) (Vol. 10, Issue 24, pp. 1–17). MDPI AG. https://doi.org/10.3390/app10249051