**CEN 449 Autonomus Robots Project I**

**Report**

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**GITHUB LINK**

[**https://github.com/CaramelMisto/AutonomousRobots/tree/master**](https://github.com/CaramelMisto/AutonomousRobots/tree/master)

**YOUTUBE VIDEO LINK**

[**https://www.youtube.com/watch?v=SWamxFhvKxg**](https://www.youtube.com/watch?v=SWamxFhvKxg)

**Project Title:**

**Autonomous Navigation Mobile Robot Simulation**

**1. Introduction**

**This project is part of the CEN449 Introduction to Autonomous Robots course. It focuses on building an autonomous mobile robot simulation using the Robot Operating System (ROS) and Gazebo. The primary goal of the project is to enable the robot to navigate autonomously to target locations without relying on a pre-saved map. Throughout the project, the team effectively applied theoretical knowledge to practical applications using ROS and Gazebo tools.**

**2. Project Objectives**

**The objectives of this project are as follows:**

* **To understand and apply the fundamental concepts of ROS.**
* **To gain hands-on experience in simulating autonomous robots in the Gazebo environment.**
* **To ensure the robot can navigate dynamically and avoid obstacles.**
* **To enhance teamwork, documentation, and video presentation skills.**

**3. Methodology**

**3.1 Teamwork**

**The project was executed by a team of three members, with tasks divided as follows:**

* **Simulation Setup: Installing and configuring the Gazebo environment and ROS components.**
* **Software Development: Implementing robot navigation algorithms, including AMCL and obstacle avoidance.**
* **Documentation and Presentation: Writing the project report, preparing the video presentation, and managing the GitHub repository.**

**3.2 Training Process**

* **Video Tutorials: The team followed Mecharithm’s 10-lesson YouTube series on ROS, completing practical exercises to gain a solid foundation in the following topics:**
  + **Setting up the ROS environment and configuring nodes.**
  + **Modeling and integrating sensors in Gazebo.**
  + **Processing sensor data using ROS tools.**
  + **Implementing AMCL (Adaptive Monte Carlo Localization) and Move Base algorithms for autonomous navigation.**

**3.3 Simulation Development**

* **Robot Model and Sensors: A robot model was created in Gazebo, and Lidar sensors were integrated for environment perception.**
* **Map-Free Localization: AMCL was utilized to dynamically determine the robot’s position without a pre-saved map.**
* **Navigation Module: Move Base was implemented to enable path planning and goal-reaching functionality.**
* **Software Architecture: ROS's node-based architecture was employed to handle sensor data processing, motion control, and navigation seamlessly.**

**3.4 Testing and Validation**

* **The robot was tested in environments with various obstacles to evaluate its ability to autonomously navigate and reach target locations.**
* **Performance issues, such as noisy Lidar data and transform errors, were identified and resolved to ensure reliable navigation.**

**4. Results**

**4.1 Achievements**

* **The robot successfully navigated to target points without a pre-saved map by leveraging Lidar sensors for real-time environment perception.**
* **The AMCL and Move Base modules were effectively integrated into the simulation.**
* **The robot demonstrated stable navigation performance, avoiding obstacles dynamically in a simulated environment.**

**4.2 Challenges**

* **Transform Errors: Coordination among different reference frames required adjustments and troubleshooting.**
* **Lidar Data Optimization: Noisy sensor data was filtered to improve localization accuracy.**
* **Path Planning Issues: Initial route planning errors were addressed to ensure smooth navigation.**
* **Ubuntu installing: Neither I nor my friends have used such an operating system before. And we had trouble installing it next to Windows.**

**5. Project Contributions**

**This project significantly enhanced the team’s technical and collaborative skills. Key takeaways include:**

* **Proficiency in using ROS and Gazebo for robot simulation.**
* **Practical experience in autonomous navigation and sensor data processing.**
* **Improved problem-solving and performance optimization capabilities.**

**6. Conclusion**

**This project has been a valuable opportunity to gain hands-on experience in autonomous robot navigation using ROS and Gazebo. Through collaborative efforts, we successfully implemented a mobile robot capable of navigating dynamically without relying on a pre-saved map.**

**Simulating TurtleBot 3 autonomous navigation using ROS and Gazebo was genuinely challenging but immensely enjoyable. Despite facing difficulties at every step, we found the process highly rewarding and engaging.**

**The integration of AMCL, Move Base, and Lidar sensors into the robot's system provided deep insights into localization, path planning, and obstacle avoidance. Despite challenges such as optimizing sensor data and addressing transform errors, the team effectively resolved these issues, resulting in a reliable and efficient simulation.**

**Overall, the project enhanced our understanding of robotics concepts, improved our technical skills, and strengthened our ability to work as a team. The knowledge and experience gained during this project will be instrumental in tackling future challenges in the field of autonomous systems.**