

Wrocław University of Science and Technology

Faculty of Electronics, Photonics and Microsystems

Intermediate Project

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Localization of mobile robot based on histogram and particle filter

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1 Project description

The project entails the development of software that realizes localization of a mobile robot within a simulated environment. To accomplish this objective, methods such as the histogram filter and particle filter will be employed. These algorithms will utilize input data derived from measurements obtained through the LIDAR sensor installed on the mobile robot.

2 Measurable Outcome

The measurable outcome of this project will be the correct operation and adequate accuracy of the methods used to localize the mobile robot. In order to verify these factors, tests will be performed to compare the estimated position of the robot with the actual position depending on the parameters of the used algorithms.

3 Project Goals

No.	Must do Goals	Description
1.	Configure ROS2 Humble Project	Set up the ROS2 Humble project for seamless integration and functionality.
2.	Integrate TurtleBot3 Model in Simulation	Import TurtleBot3 model into Gazebo and RViz. Prepare the simulation environment for the implementation or usage of localization methods.
3.	Implement Histogram and Particle Filter	Develop or use already prepared histogram and particle filter algorithms for robot localization within the simulated environment.
4.	Test Algorithms in Simple Environments	Perform tests in controlled simulations to validate algorithms accuracy.

Table 1: Must do Goals

No.	Hope to do Goals	Description
1.	Test Algorithms in Complex Environments	Extend the testing phase to more complex simulation. Evaluate the performance of the localization algorithms in new environments.
2.	Create Fusion Between Implemented Filters	Explore the possibility of creating a fusion or hybrid approach between the implemented histogram and particle filter within the simulated environment.
3.	Create Docker Container for ROS2 Humble (<i>Technical functionality</i>)	Create a Docker container for ROS2 Humble packages and project code to ensure portability and compatibility across various operating systems.

Table 2: Hope to do Goals

4 Tools and Technologies

- ROS2 Humble
- TurtleBot3 Model
- Gazebo and RViz
- Docker
- Python

5 Main difficulties that will need to be solved

This project has several challenges. First of all, working in a developing framework like ROS2 can be a source of many problems due to insufficient documentation of individual aspects of the system. An additional challenge is the implementation of the algorithms selected for this task, which must be incorporated into the created environment. This problem also applies to the use of ready-made algorithms, as they will need to be adapted to the simulation. Ultimately, the simulation environment itself does not provide ideal working conditions, which may affect the results of robot position estimation.

References

- [1] Bogdan Kwolek. Finding location using a particle filter and histogram matching. In Leszek Rutkowski, Jörg H. Siekmann, Ryszard Tadeusiewicz, and Lotfi A. Zadeh, editors, *Artificial Intelligence and Soft Computing - ICAISC 2004*, pages 786–791, Berlin, Heidelberg, 2004. Springer Berlin Heidelberg.
[URL:https://link.springer.com/content/pdf/10.1007/978-3-540-24844-6_121.pdf](https://link.springer.com/content/pdf/10.1007/978-3-540-24844-6_121.pdf)
This paper considers the problem of mobile robot localization. The localization is done using a particle and a histogram based representation of sensor readings. The paper describes localization methods that will be used in the project.
- [2] Nataliya Boyko and Yaroslav Hladun. Histogram filter for robot localization. In *2021 IEEE 16th International Conference on Computer Sciences and Information Technologies (CSIT)*, volume 1, pages 38–43, Sep. 2021.
[URL:https://ieeexplore.ieee.org/abstract/document/9648585](https://ieeexplore.ieee.org/abstract/document/9648585)
The paper describes experimental application of the histogram filter algorithm on a mobile robotic platform. The paper presents particle filter and histogram filter, that will be used in the project.
- [3] Kacper Szczepanowski. Comparison of selected methods for locating a mobile robot. Master's thesis, Wrocław University of Science and Technology, 2023.
[URL:https://edu.domski.pl/wp-content/uploads/praca-dyplomowa/2023-mgr-Szczepanowski.pdf](https://edu.domski.pl/wp-content/uploads/praca-dyplomowa/2023-mgr-Szczepanowski.pdf)
Thesis describes a method that uses a histogram to represent map of the robot environment. This paper was the main inspiration for this project.
- [4] Open Robotics. ROS 2 Documentation: Humble, 2023.
[URL:https://docs.ros.org/en/humble/index.html](https://docs.ros.org/en/humble/index.html)
Official documentation of the ROS2 distribution that will be used to develop a simulation environment.
- [5] ROBOTIS-GIT. TurtleBot3 Repository, 2022.
[URL:https://github.com/ROBOTIS-GIT/turtlebot3](https://github.com/ROBOTIS-GIT/turtlebot3)
Official repository for TurtleBot3 and ROS integration.