ENPM808X: Software Development for Robotics

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Final Project Proposal

Project MARIO.COM

Mobile **A**utonomous **R**obot for **I**ndoor and **O**utdoor .
Collection **O**f **M**edical Waste

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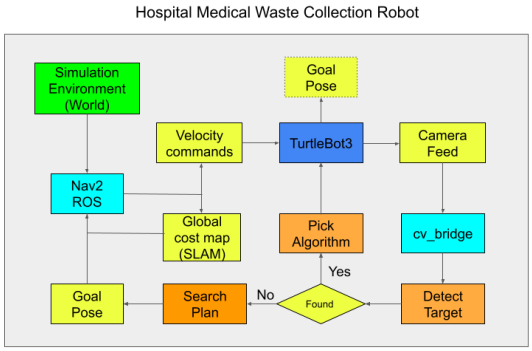

Figure 1: Process

1 Overview

With the successful design and deployment of a robotic manipulator-based software solution for the automation of assembly line production of automobiles, Acme Robotics, Inc. has been able to maximize the efficiency of the automobile plant. As a part of its 5-year roadmap to further expand its expertise areas and leverage robotic solutions to touch human lives, we propose to develop a mobile robot-based medical waste collection and disposal solution to efficiently and safely transport medical waste trash bins from different locations inside a hospital to the disposal zone.

Medical waste is generated at healthcare facilities and may be contaminated by potentially infectious materials. The disease-causing potential of medical waste is greatest at the point of generation and thus, the risk for healthcare workers and the patients in the vicinity of such waste is at a higher level. Janitors and housekeepers often handle medical waste trash bins, and hence our proposed solution attempts to eliminate human contact during the transportation of such waste from its source to the disposal zone in hospitals. [1]

2 Product

The hardware setup of the proposed product shall be the TurtleBot3 Waffle mobile robot with a ROBOTIS OpenMANIPULATOR-X manipulator to pick up the medical waste trash bin. The locations of these trash bins shall be at unknown locations in the hospital. To simultaneously localize its pose and create a map of its surroundings, the bot shall have a LiDAR sensor and an RGB camera onboard. The RGB camera shall be used to identify the medical waste symbol on these bins and the LiDAR shall also be used in collision avoidance. The trash bins are assumed to be of a proportionate size to that of the chosen mobile robot with an appropriate design such that the manipulator may grip them.

3 Process

The software design and development process shall involve adhering to an amalgamation of Agile Iterative Processes and pair-programming techniques over a course of three weeks. The implementation shall be verified using the test-driven development approach. The driver and navigator roles are exchanged during each phase of the project to develop and complete the backlogs effectively. Also, the design keeper shall make sure that the implementation is following the project design along with

good software engineering practices. The various components of the software implementation are listed below:

- **Navigation**: To search for medical waste bins in the unknown environment in the hospital, a grid search algorithm shall be implemented with the Nav2 ROS package that updates the global cost map using SLAM.
- **Perception**: To detect the medical waste bins, a computer vision based algorithm will be implemented.
- **Grasping**: This shall contain kinematics solvers for the OpenManipulator-X to pick up the detected bin.

4 Technology Stack

We shall use C++'s Object Oriented programming capabilities to make the software scalable and adaptable with Visual Studio Code IDE configured with clangd, cppcheck, valgrind and cpplint. Our development team will use ROS2 Humble Hawksbill with RViz and Gazebo to simulate the environment. CMake and colcon shall be used as build systems to provide cross-platform compilation capability for the software. The Apache 2.0 license shall be used for this project.

4.1 Libraries

- NumCpp (MIT License), OpenCV (Apache 2.0), Math (Apache 2.0) & Eigen (MPL 2.0)

4.2 ROS Packages

- Nav2 (Apache 2.0), cv_bridge (Apache 2.0), TurtleBot3 (Apache 2.0), AWS Robotics Hospital Gazebo World (MIT License)

4.3 ROS REPs

- REP 2005: To make use of existing ROS2 packages for simulation, REP 103: To adhere to units and coordinate conventions, REP 2004: To follow package quality guidelines (atleast Level 5)

Other relevant guidelines and practices from the ROS 2 developer guide shall be followed.

5 Risks and Mitigation

The possible risk includes the trade-off between the processing rate of the images captured by the robot to detect the obstacles while moving from the initial pose to the goal pose. Since the environment is unknown to the robot and the search algorithm implements a grid-based search, there is a possibility that the robot may not find the hazardous trash or reach the goal pose generated from the grid search accurately due to dynamic obstacles. Mitigations include the restriction on target object size and its position in the randomized world space. The initial assumption is that the robot should reach the target location and simulate its pickup and reach the disposal zone.

6 Final Deliverables

The deliverables will be a ROS2 software package with appropriate functionalities and visualization for the simulation of the Medical Waste Collection Robot in a hospital world. A functional demo of the robot autonomously detecting medical waste bins and transporting them shall also be submitted.