ARTPARK Robotics Challenge 2021

2nd stage (Simulation stage) - Project report

General Instruction

- All fields are mandatory.
- Please do not try to alter the section headings.
- Please use a font size of twelve (12) for filling up the project report.
- Once done filling the project report, please convert the document to PDF format and save the PDF using the following convention: your-name_your-group-name.
- The project report should not exceed 5 pages.

Name and affiliation of the team:	**RoboJyothianz from JEC Thrissur**

A brief description of overall architecture of the proposed system/solution

We designed our solution right from the first principles to create the **simplest, effective and the most elegant design** possible. Right from day 1, we designed it keeping in mind the **ultimate goal**- to create a robot that can be deployed in **real life bathrooms**. Therefore, some design aspects (like the ability to climb a step, reach tight spaces as mentioned in the readme) are designed beyond the scope of stage 2 and 3. We have 3 different designs ready in case we discover a fatal flaw in our design. All of the designs have a common mobile base with different 4 DOF manipulators. The best design will be selected for the final.

Mobile base: Driven by **mecanum wheels** and measuring around 420x420x200, it combines the outer body, water-tank with slosh baffles, pipes, ducts, motor mounts, etc into a **single 3D printed piece.** Most of the heavy parts are integrated inside the base, keeping the **centre of gravity low**.

Design details of the robot, the manipulator/end effector, spraying and cleaning mechanisms

Moppy: Moppy has a PRPR manipulator that moves like how humans use a mop. We plan to use a custom **non-backdrivable worm gear** driven by 5kg/cm Nema 17 stepper motors for the vertical post slider and the first revolute joint; other joints use servos. The mopping is done by the rotating brush and nozzles that spray the liquid and other nozzles that blow it dry. On the other end of the mop stick, Moppy has a suction gripper which can also be used for blow drying and a sprayer nozzle which can be used to spray the sink.

Stretchy: Stretchy is designed after the Hello Robot Stretch RE1 - an open source robot that actually exists. I adapted the design for our use case by adding a dock to place the same mopping brush used in moppy, the robot can pick it up to use and place it back. There can be an additional dock to hold a spraying and vacuum blowing tool, which can be used in a similar manner.

Scoopy: Scoopy is a derivative of Stretchy with a different end effector. It uniquely scoops up the trash items and drops it into the bin by reversing the lid. The mopping part is done by a mopping pad on bottom of the end effector, where the sanitizing liquid drips into the mop through veins inside the 3D printed end effector. The end effector also has a spraying nozzle for cleaning the sink and vacuum blowing nozzles on the sides and bottom.
Scooping mechanism working demo

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Description of the approach to mapping, localization and navigation

The current stack uses Gmapping, AMCL and TEB for mapping localisation and navigation. The robot has a RPLidar A1 and Realsense D435i for object detection. We are planning to use the point cloud data from that for 3D navigation.

For the robot to **reach the door** from a completely unknown starting point in that world, we created an algorithm that uses odometry and LaserScan data to do the task. When the robot reaches the door, the python script launches the navigation stack with a predefined position in front of the door as the 2D pose estimate / initialpose for localisation.

Description of the method used for detecting and localizing trash items, markings, wash basin and the dustbin.

We are currently using simple CV thresholding to detect the cans, cups and dustbins and the depth data from the Realsense camera and some trigonometry to get the location of the objects. We are not detecting the sink as of now because it's a fixed object and the problem description doesn't specifically ask to detect the sink.

For deployment in real life bathrooms to do all the tasks done by a janitor, the current plan is to start the robot from a dock that charges the battery, refills the water tank and conditions the mop. The robot will use a mopping and spraying plan verified (not manually created) by the operator during the initial mapping phase (somewhat similar to how its done in somatic, the only commercially available bathroom cleaning robot). Just like a Janitor, It'll take the dustbins with collected trash out of the bathroom and mop the entire floor (because the entire floor will be dirty).

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General comments/remarks

During the 2 weeks deadline extension, we did the following changes based on the feedback we received:

- Until the evaluation meeting, our understanding was that the starting location should be anywhere 2 metres away from the door, not 2 metres around the bathroom. We **created an algorithm for the robot to reach the door** from any starting location using /odom and /scan data.
- Changed the world to correctly orient the sink and commode
- Made the vision stack detect cups, dustbins and markings as well.
- Improved the countertop and sink cleaning coverage.
- Picking algorithm isn't ready for deployment yet

FAQ

Q: Won't Moppy's joints require powerful motors that drain the battery?
A: No, We're using a non-backdrivable worm gear mechanism to drive the joint, the motor only needs to be powered to change position, not hold the position. The position only needs to be changed a few times. The biggest battery hogs will be the pump motors and wheel drive motors

Q: Won't the 3D printed parts- especially the gears- fail quickly?
A: I can make it out of proper engineering materials using my tool-changer with a heated chamber. Multi material gears last as long as metal ones when printed with the right materials.

Q: The robot seems to be oscillating in the simulation. Is it that unstable?
A: Gazebo's physics is far from perfect, I don't think the robot will oscillate nearly as much in reality. For reference, the Stretch robot is fairly stable despite having a much smaller, triangular base of support; also, their mobile base won't weigh nearly as much as the ~30 Kg ours will likely weigh with the tank filled.

for more questions, please contact me: prdevadathk3@gmail.com

References

Please click the embedded links for references and refer the submission readme for more info.