Final Project Proposal
Robotic Recycling Using Vision, Manipulation, and Sorting Algorithms

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Executive Summary

In today's world, many tasks require object identification, task completion, and motion such as filtering trash from recycling, manufacturing and tool selection, and library cataloguing. The system we are designing will be an abstracted robotics system that allows a ROS compatible robot to integrate object identification and object manipulation and task completion, with our proof of concept focusing on object sorting, specifically sorting out trash from piles of recycling.

Automating tasks such as recycling sorting can have large-scale real world impacts. Currently in the USA, 80% of what Americans throw away is recyclable, but America's recycling rate is only 28% [1]. One of the largest reasons for such a low recycling rate in the United States is the overabundance of contamination in piles of recyclables. Automating a process that will sort out recycling contaminants will pave the path for increased recycling rates, reducing the cost associated with recycling and raising the profit incentive for recycling. Increased recycling rates would help reduce the amount of waste sent to landfills and incinerators, conserve natural resources such as timber, water and minerals, and save energy [2].

Our group aims to solve this recycling problem and many other similar real world tasks by implementing a generic system that combines computer vision, object manipulation, robot motion, and task completion. For our proof of concept, we aim to implement such a system on the "Nvidia Jetson NANO Lidar Moveit Robotic Arm ROS Cart Robot Slam Autonomous Navigation" robot. The tasks for this robot will be sorting simple items in a designated area, and then extending this task to the sorting of recyclables to show real life applications of our system. This generic system can then be implemented on other ROS compatible robots such that other users can give robotic systems high-level tasks that require the integration of computer vision, object identification, robot motion, and physical manipulation.

Alternative Approaches

There are multiple alternative approaches to sorting recyclable material. One alternative is to have a robot arm that is stationary, and only able to reach an area around the base of the arm. Another approach is to have the robot arm on a bar or a pulley similar to the cart and pole problem, where the arm can move from side to side along the specified path of the bar or pulley system. Both of these approaches are valid and viable approaches to sort recyclable material. We believe that the best option is to use a skid steer with an arm that can collect materials from any location that is accessible. Though our final goal with this project is to have the software run on any ROS compatible robot with an arm to pick up and move objects.

Bibliographic Information

Possible articles that could help:
Canvas posted articles
Concept for Automated Sorting Robotic Arm
Real Time Color Based Sorting
Sorting Of Objects by Color
ROS Docker Image

Methodology

The robot that meets the systematic requirements that are needed for the project is the Nvidia Jetson NANO Lidar Moveit Robotic Arm ROS Cart Robot Slam Autonomous Navigation Robot. Our system requires the ability to both understand the context of the world around it and to manipulate its surroundings. To achieve this, we need an arm manipulator robot to achieve the task of manipulating its surroundings, and an optical sensor such that the robot can understand it's surroundings, identify items that tasks are to be performed on, and gain real time data of the changes around it and the results of it's manipulation. As our primary proof of concept task will be object manipulation in the real world, we will need "tactile" feedback from the robot's claw to ensure that we are able to pick up the item while making sure the object is not damaged in the process. As our system will be the integration of multiple low level tasks to perform high-level tasks, robot motion will be a required consideration in designing our generalized system. We require a robot arm manipulator mounted upon a skid steer such that the robot can move on the ground as it performs our proof of concept tasks.

The implications of such a robot can stretch far and wide. The task of sorting items is a simple task that is prevalent in many larger tasks. The most straightforward implications of our proof of concept implementation could be employed as a recycling sorter. When given an area filled with recyclables, our robot can path it's way through said area, identifying all non-recyclable goods and sorting them out of the area. This can have a direct impact on the world around us and potentially automate and speed up the tasks given to humans in garbage and recycling facilities where they aim to remove non-recyclable goods from recyclable goods. This is but one example of a real life application of our minimally viable product. As our core task is creating an abstracted system allowing others to easily task robots with high-level tasks, there are many other ways this system could be employed to have a real world impact. Allowing the easy automation of high level tasks can reduce the reliance upon humans in tedious and/or dangerous tasks, such that recycling operations and other high-level automatable tasks can be done quickly, efficiently, and at low cost.

Timeline of Work

The timeline will be broken up into three separate sections:

- Section 1: This section will be broken into two parts and will take approximately 3-4 weeks to complete.
    A) Part A consists of implementing skid-steer movement and kinematics to have the robot effectively move without hitting objects or people.
    B) Part B consists of implementing the kinematics and motion of the robot's arm. The primary function of the arm is to pick things up and drop them.

- Section 2: This section includes implementing the machine learning algorithm to recognize and identify objects. This section will take approximately 2-3 weeks to complete.

- Section 3: This section includes training the robot and wrapping up all the loose ends. This section will take approximately 1-2 weeks.

Conclusion

Our goal is to create a system that can identify and sort objects, the implementation being a robot capable of sorting recyclables. The long term benefits of designing this system is creating a base for other people to take the system we've created and modify to solve other problems.

Automating recycling as much as possible is the key to making large-scale change. Most recyclables are thrown out with non-recyclables, so the goal of the robot will be to sort those recyclables from non-recyclables. This also lays the foundation for similar sorting tasks that could be automated.

The robot will require an arm to manipulate objects around it, optical sensors to identify the objects to be sorted, and a skid steer system so the robot is not limited to a limited space. The system will be built in ROS and visual identification algorithms.

References

[1] https://www.sccmo.org/863/Recycling-Facts
[2] https://www.epa.gov/recycle/recycling-basics