Turtlebot Robotic Arm - Project Proposal

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Introduction

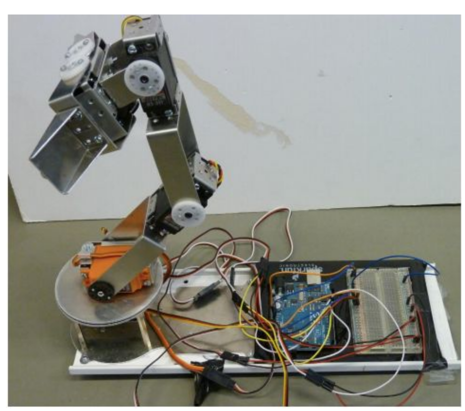
The purpose of designing a mechanical robotic arm is to simulate the actions and movement capabilities of a human arm. Robotic arms are constructed with multiple beams connected by special types of hinges. For a mechanism to be classified as a mechanical arm, it must be able to grab and hold an object, and transfer it to a new location.

Initially, robotic arms were specifically designed for the intent of performing actions that could be harmful to humans. Pioneering projects that utilized robotic arms included designs by General Motors for molding molten metal, and a project at MIT designed for naval research, specifically for underwater exploration. As time passed, development in robotic arms began to branch into specific fields, being utilized by companies for specific purposes. Automotive companies began research into robotic arms that could be used for assembly line manufacturing, while medical specialists explored designs for intelligent prosthetic arms. Robotic arms have also been vital for spacecraft reparation and exploration. NASA designed Mars rover that are able to pickup and analyze ground samples from the red planet.

Robotic arms expand the usefulness of robots, allowing them to be more useful in everyday society. Combined with innovations such as machine learning and computer vision, robots are able to automate an increasing number of mundane or dangerous human actions. Our project focuses on the optimal design of a functional robotic arm, with the future intention of creating a turtlebot with the ability to identify and pick up pieces of trash strewn about Halligan Hall. The turtlebot design is optimal for precise movements that are needed to navigate the obstacles in Halligan, and our robotic arm design will be constructed to be agile enough to reach demanding locations while being strong enough to carry a variety of objects.

Related Work

Researchers at the University of Zaragoza, Spain produced a project proposal and outline for building a low-cost, custom-built robotic arm for the Turtlebot platform. Their robotic arm is controlled from an arduino board. They use a kinect sensor for object detection, and use ROS nodes to command the robot and define the objects to be grasped. Their model uses a kinect sensor in order to move objects out of the way of the turtlebot.



Their turtlebot design uses 4 kinds of servos, with torques of 3, 3.2, and 9 kg/cm. The intensity of the servos ranges from 120mA to 350 mA. The servo maintains the positioning of a joint by using an integrated feedback controller. They compared the options of custom building the links of the arm, or purchasing a standard kit that was pre designed. The prices of each were about the same, and they chose the standard kit option because of the time saved from having to calculate variables such as center of gravity and equivalent mass. This is what their final design looked like

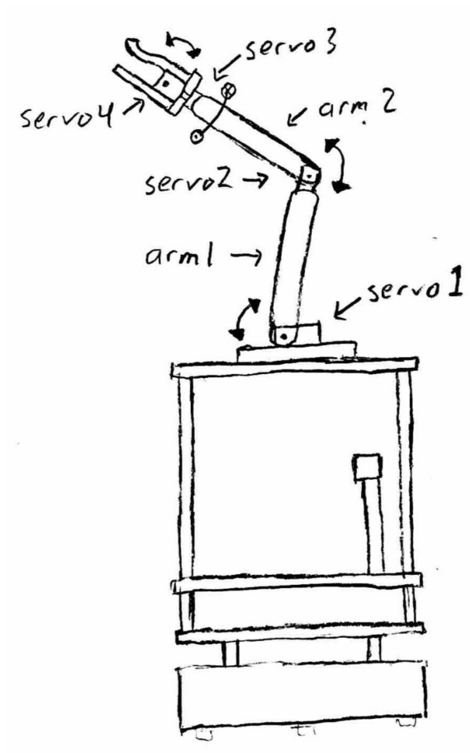
The researchers needed to design a contraption to find the linear proportion between pulse duration and angular position. They designed a grid to measure the results. They discovered that errors in the Z axis were on average larger than the other axes. This was caused by the influence of gravity on the arm. They also observed how the larger the distance was to be travelled, the larger the error. Another calculation they had to perform was finding the positioning error between the input position command and the final position of the arm.

Problem Formulation / Technical Approach

For this project a mechanical arm will be built for the turtlebot which it can use to interact with the environment. This arm will have to extend beyond the body of the turtlebot, have multiple axis of rotation, and have a gripper on the end which it can use to interface with the surroundings.

To accomplish this three standard servos will be used, each with a range of 180 degrees. As shown below in Figure 1, the first servo will be used to rotate the first arm. The second servo will be used to rotate the second arm. Both of these servos will rotate about the turtlebots y-axis, allowing it to reach directly in front and behind it. The turtlebot will rely on its base motors to rotate about the z-axis. The third servo will rotate the gripper about the length of the second arm. This will allow the robot to pick up objects oriented in different directions. The fourth servo will supply the clamping force for the gripper.

Figure 1. Robotic Arm Sketch



To power the servos the serial port connectivity in the base unit will be used. The serial output has everything necessary to run the servos, two 5V pins, manys GNDs, and most importantly four digital output pins which will be used to control the servos with PWM. A breadboard mounted on the top of the turtlebot will interface between the Serial Port and the actuators.

Evaluation Plan / Criteria for Success

Positive Outcomes and Impacts:

The main positive outlook of implementing a robot arm include adding an extra level of functionality to the TurtleBot. A versatile arm greatly increases the functionality and variety of tasks the TurtleBot can go tackle.

The work that follows the robot arm will more thoroughly judge the success of this project. If the arm is functional enough to be used in future projects and applications, the arm was a success in how it was built.

We hope to implement a function for the arm, whether just a demonstration of the arm picking up and dropping off the object, or something a bit more complicated or intelligent.

Negative Outcomes and Impacts:

The only real negatives that could result from this project is that the robot arm created is very limited and not very functionable. No terrible consequences, but the money and time will have been put to waste. Then hopefully the servos' would be able to be reused in another application.

Distribution of costs and benefits:

The main part of our budget is going to go towards purchasing the different servos to create the moving arm. The arm pieces will hopefully be metal that is purchased, but if not, just made out of acrylic at Bray using the laser cutter. The most basic servos will be our baseline, but with our plan, we believe the project may warrant some more heavy duty servos that can handle heavier weights to perform a wider variety of tasks. The more money put into the project will directly correlate to its usefulness in the future.

Resources and Timing

Our deadline is Friday, May 4th, but we hope to meet certain other deadlines along the way. Before the servos and other physical supplies arrive, we hope to have our simulations complete and have our ROS program finished since the physical creation of the arm will take consider time taking measurements for dimensions and figuring out physical restrictions like stress and forces. Ideally, the first deadline of the programming and simulation of our arm will be complete by mid-April (the 18th).

Standards

The standard we hope to create with our arm correlates directly to the budget we expect for this project. Ideally, the arm will be fully controllable by program with a 360 degree of motion and ability to grab anything from the ground up to 3 feet in the air. With roughly a ~$50 budget, we'd expect the arm to be able to pick up anything up to a few ounces (like cans or wrappers for a trash robot or a piece of candy for a candy delivery robot). This is due to the strength of the servos' that are around $10-15. The more expensive servos can handle much greater weights and more stable of devices.

The way we will test the standards of our arm will involve various tasks of picking up items for the robot. There will be:

- Strength test that tests the heaviest item the arm can lift off the ground and move effectively
- Range test that will test the range of motion of the arm