AUTONOMOUS ROBOT PROTOTYPE DESIGN

RFP-QC120-12345

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ENGR120

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1 Introduction and Problem Statement

Disposal of materials which pose a hazard for human life is an ever-changing challenge. As outlined in RFP-QC120-12345, Canada Foundation For Innovation seeks designs for robots to dispose of radioactive materials have been requested.

1.1 Background

The aftermath of the Fukushima Daiichi nuclear disaster has presented numerous problems with regards to the cleanup of radioactive materials. With the hazard these materials present to humans, the utilization of robots in hazardous material removal is essential. This project aims to improve the cleanup process by introducing novel designs to the process of radioactive material removal.

1.2 A Need for Safe Cleanup

Radioactive material removal poses a severe health risk for humans. Therefore, a need exists for an autonomous device that can remove radioactive material with little or no human input. In lieu of radioactive materials in a laboratory intended to be safe for student use, a non-radioactive target placed on top of an infrared beacon is to be picked up and removed from an arena of predefined dimensions.

1.2.1 Design Evaluation

The design will be evaluated on several metrics. The design will be judged on

- how quickly it can find the target and subsequently manipulate the target so that it is removed from the arena
- how well the robot moves about the arena; designs which hit the boundaries of the arena will lose points
- the novelty of the design
- build quality, and
- the execution of the design.

1.2.2 Design Constraints

The design will consist of parts found in a vex robotics kit, plus anything procured within a budget of $25. Autonomy will be provided by software embedded in the vex robotics microcontroller. The microcontroller must be programmed using RobotC.

2 Proposed Robot Designs

To obtain the best possible robot, it is prudent to evaluate more than one design concept. Therefore, two candidate designs for autonomous material removal robots have been devised.

2.1 Design Idea 1 - The Catapult

The first proposed design involves a catapult mechanism to remove the target from the arena (see Figure 1). This mechanism will consist of a metal hook attached to a long metal shaft which pivots on a superstructure. This superstructure has a stop bar to ensure the target is thrown clear of the arena.

Potential energy for the mechanism will be provided by stiff elastics connected to the front of the chassis and to the back of the arm. The arm will be held in place by a pin which can be moved using a motor as an actuator.

A microswitch is attached to the end of the hook. The switch protrudes just beyond the edge of the hook such that a target inside the hook will activate the switch. Upon activation of the switch, the motor-actuated release is engaged, and the arm and hook move under elastic power.

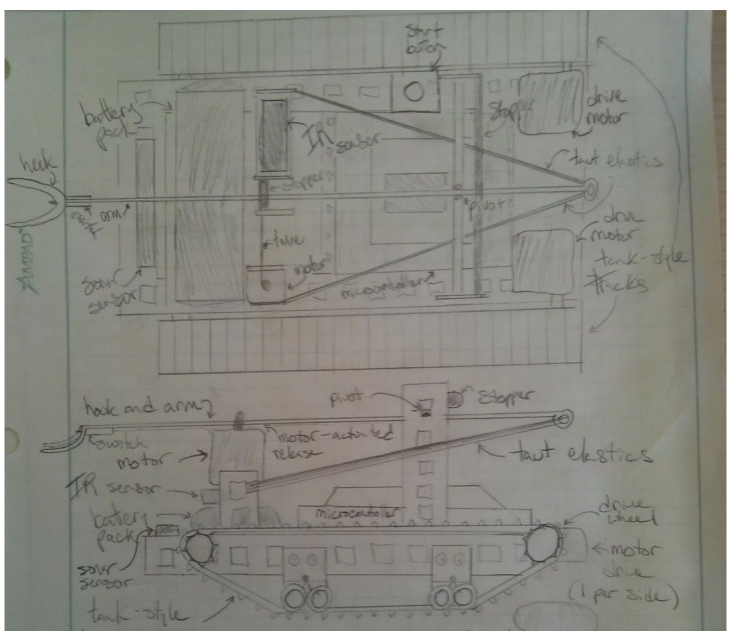

Figure 1 - The Catapult Prototype Design

2.1.1 Materials

Materials for this design will be from the vex kit, with the exception of the hook and arm assembly, microswitch, elastic bands, and tank-style tracks. The hook and arm will be of metal, likely steel or aluminium for rigidity. The microswitch and elastic bands are easily purchasable and inexpensive. Tank-style tracks compatible with the vex robotics kit can be purchased from vex robotics or procured elsewhere. The target will be of a bespoke design in order to mate easily into the hook.

2.1.2 Sensors

The sensors needed for this design consist of

- limit switches for wall detection
- a microswitch for identifying target engagement, and
- two infrared sensors for homing in on the target.

The limit switches and infrared sensors are mounted on the front of the chassis as most movement will be entirely forward or forward with a lateral component.

2.1.3 Motion

Mobility will be provided by two drive motors on the rear of the chassis, connected to tank-style tracks. Tracks will provide the ability for the robot to turn without moving longitudinally or laterally. Tracks will also lend stability over rough terrain, or when the chassis is subjected to uneven forces due to the fast movement of the hook and arm assembly during target projection.

2.2 Design Idea 2 - The Grabber

The second proposed design involves a four-wheel setup that uses a grabbing mechanism in order to pick up the target object. The grabbing mechanism will be a pronged structure that has the ability to move up and down to pick up the target. Once the target object has been acquired, the robot will then move to the dropoff location and deposit the target gently using its grabber arm.

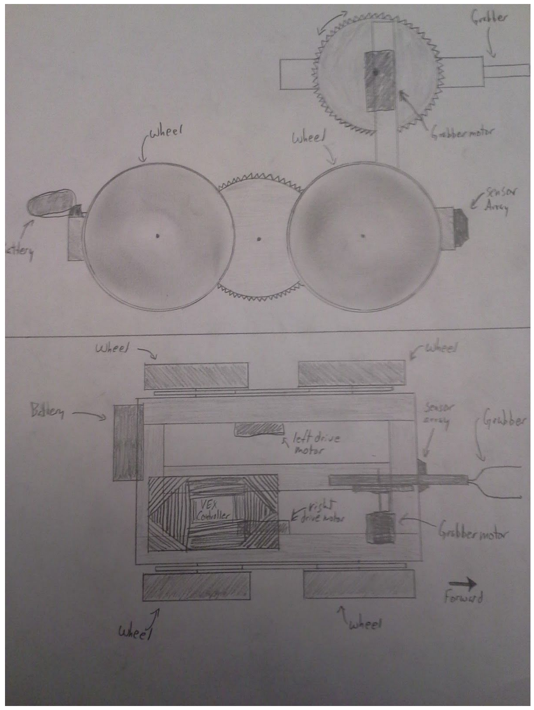

Figure 2 - The Grabber Prototype Design

2.2.1 Materials

The main structure involves a rectangular base frame that is wider than it is long to promote stability. The structure consists of a sub-frame to mount the motors, the VEX controller, and the battery pack. The grabbing mechanism to lift the target object is extruded from the sub-frame to enhance rigidity in order to ensure that the target object does not fall during robot movement.

2.2.2 Sensor

On the front end of the robot is the sensor array which consists of 3 IR sensors that allow the robot to track the IR beacon. By comparing the sensor values from the right and the left side, it will be able to determine the necessary angle correction in it's movement to approach the target object directly.

There will also be two bumper sensors on the front of the robot to detect walls and other various impassable obstacles. When either the left or right bumper is hit, the robot will be able to maneuver around the obstacle and continue towards its target.

2.2.3 Motion

Each pair of right and left side drive wheels are powered by a single motor as seen in Figure 2. Each motor has it's own encoder which when each drive side is compared, a ratio can be taken and wheel speed adjusted in order to ensure that the robot moves in a precisely straight line. By having each side of the robot powered by a separate motor, this allows for the robot to make a turn with a very small radius and it also allows it to make minute corrections in each side's wheel speed.

2.3 Bill Of Materials

Materials common to both designs are found in the vex robotics kit, including

- 2 electric motors
- 2 electric motors with optical encoders
- various sizes of gears
- worm gears
- racks and pinion gears
- a microcontroller module
- a battery pack and charger
- various lengths of metal bars, c-channels, and rails
- a metal plate
- hardware (screws, nuts, standoffs, shaft spacers, ty-wraps)
- wheels of diameter 5", 4" and 2.75"

2.3.1 Non-vex Materials for The Catapult

Materials not found in the vex kit that are required for the Catapult design comprise

- a metal hook and arm assembly
- a microswitch
- elastic bands, and
- tank-style tracks.

2.3.2 Non-vex Materials for The Grabber

The Grabber design concept requires basic parts found in the vex kit. No additional materials are required.

2.4 Materials Budget

The budget for any parts not found in the vex robotics kit is not to exceed $25. Costs associated with the Catapult design are outlined in Tables 1. No extra materials are required for the Grabber design.

Material	Cost
metal for arm and hook	< $10
microswitch	< $2
elastic bands	< $1

tank-style tracks	< $25

Table 1: Costs for the Catapult

2.5 Project Timeline

The project commences on January 14, 2015 and ends on April 1, 2015. Expected progress has been outlined in Figure 3.

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3 Conclusion

The goal of the two designs is to improve the safety and speed of the clean-up process of hazardous radiation sites. Both robot designs offer unique functionality that would help in various situations. The Catapult allows for precise movement over any terrain and quick removal of the radioactive waste from the scene. The Grabber allows for speedy movement over smooth terrain and precise removal of the radioactive waste.

Considering that the clean-up is unsafe and difficult, the two proposed autonomous robot designs are suitable solutions to the problem. Both robots perform optimally under differing conditions. Therefore, the choice of design will come down to the environment in which it is intended to operate.

4 References

[1] Canada Foundation For Innovation , “Autonomous Robot Prototype Design”, RFP-QC120-12345, 7 Apr. 2014.