Robotic Metallic Debris Collection Manipulator

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Introduction

The goal of the project is to create a robotic platform for autonomously collecting metallic debris from the ground. The robot must be able to sense the metallic objects on the ground and have the capability to move these objects to a static or dynamic drop zone. To achieve this endeavor, some type of manipulator is needed on the robot to physically manipulate its surrounding environment. Performance, efficiency and cost are the three important factors in choosing the right manipulator. This technical paper will review two different types of feasible on-board manipulators for the robotic platform and outline the advantages and disadvantages of each one while providing a brief method of implementation with modern microcontrollers.

Robotic Arm

Robot arm is the first choice that will be examined as a viable on-board manipulator. Also known as articulated robot, a robot arm has revolute joints with three fixed axes connected to two revolute bases. Both widely manufactured and extensively used in today's industry, an optimal robot arm can operate with high rotation speed and flexibility to carry out any precise physical manipulation within a static or dynamic environment [4]. Educational robotic arm offers five to six degree of freedom and are priced less than $600 dollars with the lowest priced arm being around $300 dollars. These robotic arms are made using aluminum or PVC and run on DC servo motors. Affordable and easy to program, most educational robotic arms interface with a microcontroller through serial communication (via RS232 or USB) [3]. Using serial communication also saves I/O pins on the board which seems to be advantageous if the robotic platform needs to have many on board sensors for navigation through an environment. Another leeway that robotic arm could provide is through real time collision detection system during the process of debris collection. A book published by Shaffer and Herb described a unique data structure that decompose three-dimensional space into eight equal cubic octant that continuously update as the robot arm moves around the given degree of freedom. When the robot arm comes too close to an object, the octree gets updated and report the imminent collision [1]. The integration of collision detection and physical manipulation can be the key in making efficient and well optimized robotic platform for debris collection.

Electromagnet

The second choice of on-board manipulator for the robotic platform can potentially be an electromagnet. Since the debris that needs to be transported is solely metallic, electromagnet seems to be an appropriate choice for the given task. Industrial use of lifting magnets for moving metallic junk and scrap metals have been a staple in the industry since the early 1900s with the world largest magnet capable of lifting as much as 50,000 pounds of scrap metals [5]. The need to move metallic debris on a smaller scale can be translated over with a smaller electro magnet that can be easily interface and control via a microcontroller. An electromagnet is a solenoid coil of wire wrapped around a ferromagnetic core that generated a magnetic field when currents runs through the wire [6]. The strength of the magnetic field can be control by increasing or decreasing the current through the wire or the number of coils around the metal. Electromagnets are easy to make by conventional means and they are cheaply available online. Uxcell 12v DC electric lifting magnet with a suction force of 500 newtons cost around $20 dollars and there is also the 24 volts version with 400 newtons suction force costing several dollars less than the latter. If more surface area is needed to collect the maximum amount of metallic debris in an area, MPI rectangle electromagnet can be use which offer up to 12.25 square inch of magnetic surface with the input of 24 voltage of direct current.

Direct Comparison

Both the robotic arm and the electromagnet are viable manipulators for the robotic platform but when comparing the cost, performance and efficiency between the two options, there are some discrepancies Due to its robustness and wide range of applicable option available for the robotic arm, the cost of using such device is nearly five times the amount of using a simple electromagnet for debris collection. However, the robot arm provides a precise debris collection compare to wide area collection offered by the electromagnet. Programming the arm to have precise physical manipulation can be a challenge but by utilizing inverse and forward kinematics with the microcontroller to calculate the exact angle needed to move the arm in the x, y, z coordinate space will be one of the aspects that will determine the efficiency of the robotic arm compare to the electromagnet [2].

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[6] *Electricity and Magnetism*. Films Media Group, 2008.