Team #4

Project #28: Electronic Parts Picker

Stephen Coombes
Ryan Hart
David Tyler

Capstone Proposal

March 3, 2014

Requirements and Solution Report

Introduction

This document describes the objectives of the capstone project being done by Team #4. Our project is an electronic parts picker for Professor Darish of the University of Massachusetts Lowell. Professor Darish is currently running all of the labs and is looking to change up how the labs are run. Professor Darish is looking to have all of the students receive a box of parts at the beginning of the semester with upwards of a couple hundred parts. With the current situation in the parts room, this would be impossible. We started to research how others have built electronic parts pickers in the past and found that there really isn't anything like this. We found a device that would give a specific number of screws and a lego sorting machine. We also found a couple of "robotic hand" ideas that we will look further into. After taking all of these ideas and breaking them down into separate solutions and giving them all pros and cons, they will be run through a metric to decide which would be the best solution. The solution that was decided upon was the Lego Sorter with a Wall of Bins.

Client Background

The client is Professor Michael Darish of University of Massachusetts Lowell's Electrical and Computer Engineering department. Professor Darish orchestrates the four essential ECE laboratory courses, encompassing two hundred students or more each semester. The laboratory experiments that he utilizes in these courses necessitate parts being supplied, and with the number of students involved, it is a time-consuming process to acquire parts sufficient for all students. Currently, the stockroom organizes parts by dividing them into sections and looking up the row and column of each part in a specific section. This involves having a human cross-reference the section, row, and column number. Prof. Darish has now expressed interest in being able to provide the students with all parts needed for the entire semester during the first class meeting. This would prove exceedingly time-consuming and troublesome for the current method to fulfill the order, so there is a use available for an automated parts picker.

Problem Statement

The parts room has selected hours of operation and due to the current set up gathering parts for each class and project takes too long and is too labor intensive. Professor Darish is looking to have all of the students receive a box of parts at the beginning of the semester with upwards of a couple hundred parts. With the current situation in the parts room, this would be impossible. Our project will resolve this situation.

Project Objectives

The goal is to create a programmable system that can pick out the correct parts in the desired quantities, and separate them for distribution in desired configuration. The goal for our project is do be able to pick up 10 different parts with 100% accuracy.

Research Summary

In brief, no evidence can be found of this sort of a system being implemented anywhere else. However, the parts picking robots have been implemented in similar domains successfully so we will explore a couple of those systems.

One of the major concerns for this design is how to pick up loose parts from a drawer, and to do so accurately, i.e. picking up a known quantity without error. The simplest solution appears to be to pick up a single part at a time, and repeat as many times as necessary to obtain further quantities of a part. A combination of people from Cornell University, University of Chicago, and iRobot created a robotic gripper hand with a balloon of coffee grounds and a vacuum pump [1]. This gripper was able to deform to any object, and demonstrated the ability to lift 650 grams in a single pull, pour water from a glass, write with a pen, and lift a raw egg. It was also able to pick up an LED, which would indicate it has the fine control to pick up other electronic parts. Another way we found this being done was in a screw dispenser robot from Design Tool Inc. Their robot basically vibrates and augers screws and other fasteners from an open bowel into a jig that feeds into a pneumatic delivery system [2]. The system seems to have perfect accuracy based on demonstrations and provides timely, bulk dispensing. The drawback seems to be the power required to run it and the noise it generates from the vibrating bowel and compressed air. It also looks like it has to be reconfigured each time the type of part it is dispensing changes.

The closest machine we found to what we want to do was actually a Lego sorting machine made out of Legos. The machine has a vibrating hopper that angles towards a lift that lifts one piece at a time into a channel. The channel then uses a kind of airlock system to separate individual pieces out since they are all in a line[3].

We also found a couple sources that discussed how best to pick up electronic parts. One source advocates using a small diameter rubber tube that can be used to pickup parts with suction via a vacuum pump [4]. The idea specifically applied to a human-controlled tool but could possibly be extended for use in an automatic system. This doesn't seem to apply to resistors, but looks like it might be the best way to pickup integrated circuits. Another method was simply using tweezers to pickup the parts. Not sure how applicable this is for our project, but it is something to keep in mind.

Requirements

The device shall:

- Be able to accurately locate up to 10 different parts
- Be able to acquire the correct quantity of parts 100% of the time
- Be able to place the collected parts into container without dropping any parts
- Include a user interface which you can specify parts to be collected (no limits accept for container size)
- Be able to match or exceed a human‘s pace (Speed to be determined)
- Include an emergency shut off that kills the system within 1 second
- Be able to update an inventory of 10 different parts
- Reduce human involvement in the parts room by 40%

The device shall not:

- In any way represent a hazard to persons in the room
- Be able to reload the supplies on its own

Potential Solutions

Our final project will be the combination of three separate projects that are combined at the end. The first part of our project is the grabbing mechanism. This will be the device that actually grabs the parts from the storage bins and is responsible for the accuracy of our system. The second part of the project will be the storage of the parts. The third aspect of our project is the control of the two above systems and the software that will allow our system to actually function. This currently doesn't have a metric or ideas since the mechanical design of the system significantly impacts this part of the project.

Grabber

There are several ideas for the grabber device. These include a vacuum grabber, a mechanical grabber, a system similar to the one shown in [3], Cornell's balloon hand [1], a conveyer belt system, and one that cuts the parts off of a roll. These systems all have pros and cons which are described below.

Vacuum Grabber

The vacuum grabber would use a very small head which would pick up components one at a time and store them. The grabber would move on a 3 axis system similar to that of a 3-D printer.

Pros

- Can be completely autonomous, assuming there are parts in the bin
- There are no extra safely concerns because the air pressure would be so small

Cons

- Picks parts one at a time
- May not be able to grab a single part consistently
- Pneumatic systems can leak, decreasing the reliability of the system

Mechanical Grabber

The mechanical grabber would be a pair of finger that would grab components. It would use an optical check to make sure that there was only one part held. The grabber would move on a 3 axis system similar to that of a 3-D printer.

Pros

- Can be completely autonomous, assuming there are parts in the bin
- There are no extra safely concerns because the squeezing power of the grabber would be minimal

Cons

- May not be able to grab a single part consistently
- Could damage part while picking it up
- Picks parts one at a time

Lego System

The lego sorter show in [3] would move all the parts in the bin into a line and then have a mechanism that would allow for one to be dispensed at a time once they were organized This grabber would also move on a 3 axis system that would allow it to travel from bin to bin.

Pros

- Can be completely autonomous, assuming there are parts in the bin
- There are no extra safely concerns because it would be a contained unit
- Allows for very fast one at a time dispensing

Cons

- Could jam
- Could damage part while organizing them into a line
- Must organize parts first before sorting

Balloon Hand

Cornell's Ballon hand would allow us to conform to the shape of any part allowing us to pick up items very easily. This grabber would also move on a 3 axis system that would allow it to travel from bin to bin.

Pros

- Can be completely autonomous, assuming there are parts in the bin
- There are no extra safely concerns because the ballon hand is not sharp or could cause damage in anyway
- Extremely easy to pick up different shaped parts

Cons

- May not be able to grab a single part consistently or at all
- Picks parts one at a time

Pre-Organized Storage

The idea of pre-organized storage is that when parts come into the parts room, they are organized so that they are in a nice line and then the grabber would come over and extract the specified amount of parts. This grabber would also move on a 3 axis system that would allow it to travel from bin to bin.

Pros

- Still one part at a time, but very quickly dispensing.
- Less jamming would occur because a human would stock the bins and confirm they were organized correctly

- There are no extra safely concerns.

Cons

- Not completely autonomous, requires more intense human interaction by the human to fill the bins
- Requires specialized bins for storage

Roll Cutter

The roll cutter would cut the roll of parts after every part. This grabber would also move on a 3 axis system that would allow it to travel from bin to bin.

Pros

- Can be completely autonomous, assuming there are parts in the bin.
- Wouldn't have to deal with the problems of getting 1 part at a time since the parts would be on a roll.

Cons

- The device has a set of sharp sheers which could potentially be dangerous
- Could damage part while cutting it off the roll
- Cuts one part at a time, but would have reasonable speed.
- Would most likely jam often

Storage

Wall of Bins

The wall of bins would be a wall (or series of walls) that would have bins hanging on it.

Pros

- Allows for easy scalability of just adding more walls which wouldn't take up much room horizontally.
- Could potentially use off the shelf bins

Cons

- Could be difficult to restock depending on how close walls are together

Spooling Printer Style

This would be similar to the design of a printer. There would be a series of rolls of parts that would be hanging on horizontal polls. T

Pros

- Could potentially store a lot of parts in little area due to the nature of rolls of parts

Cons

- Only works if parts are on a roll

Spinning Columns of Bins

The mechanical grabber would be a pair of finger that would grab components. It would use an optical check to make sure that there was only one part held. The grabber would move on a 3 axis system similar to that of a 3-D printer.

Pros

- Could use current set up with slight modification
- Could potentially use off the shelf parts for the whole thing

Cons

- Very space inefficient
- Not scalable easily
- To implement off the shelf solutions would need to open drawer, which could prove difficult.

Table of Bins

The table of bins would be a table (or stack of horizontal surfaces) that would have bins hanging on it.

Pros

- Allows for easy scalability of just adding more levels of the table which wouldn't take up much room vertically.
- Could potentially use off the shelf bins

Cons

- Could be difficult to restock depending on how big the tables are and how close they are together

Chosen Solution

Grabber

For the grabber portion of the project, we decided to go with the Lego System. After running all of our designs through the metric you see below, it had the highest score and seemed to meet all of our requirements well.

Table 1: Grabber Mechanism Metric

	Accuracy	Safety	Speed	Cost	Autonomy	Reliability	Total
Vacuum	2	4	2	2	4	3	2.7
Mechanical Grabber	4	4	2	2	4	3.5	3.35
Lego System	4.5	4	4	3	4	3.5	3.875
Balloon Hand	1	5	1	5	4	3	2.65
Pre-Organized Storage	4.5	4	5	0	2	4	3.575
Roll Cutter	5	4	4	4	4	2	3.65
Weights	0.25	0.05	0.15	0.1	0.15	0.3	1

Storage

For the storage portion of the project, we decided to go with the Wall of Bins. After running all of our designs through the metric you see below, it had the highest score and seemed to meet all of our requirements well.

Table 2: Storage Mechanism Metric

	Size	Cost	Scalability	Reliability	Total
Wall of Bins	4	4	4	5	4.2
Spooling Printer Style	4	1	4	2	3.3
Spinning Column of Bins	2	2	1	4	2
Table of Bins	1	4	3	5	2.9
Weights	0.3	0.1	0.4	0.2	1

Hazard Assessment

The main hazard is that with the grabber mechanism that was chosen, there will be the system that moves it around to each bin which could potentially hurt someone in the room. We plan to mitigate this hazard by having an emergency stop button mounted near the door so that at anytime a human can stop our device.

Conclusion

This document has presented the overall progress for our electronic parts picker for the client, Professor Darish, of Massachusetts Lowell. Professor Darish was looking for a way to give

out parts that would allow him to be able to give each student a box full of all the parts they would need for the semester. We are building an electronic parts picker that will allow him to have this become a reality. From our research we are pioneering the idea of an electronic parts picker since we found almost nothing during our research. We only found devices people had built that do part of what we are attempting, either sorting or dispensing, but nothing that was able to do both and non with electronic components. After taking all of these ideas and our own and breaking them down into separate solutions and giving them all pros and cons, they were run through a metric to decide which would be the best solution. The solution that was decided upon was the Lego Sorter with a Wall of Bins.

Bibliography

[1] M. Z. Eric Brown, John Amend, "Universal robotic gripper based on the jamming of granular material." http://creativemachines.cornell.edu/jamming_gripper, Feb. 2014.

[2] D. T. Inc., "Screw dispensers." http://www.designtoolinc.com/automatic-fastener-presenting/screw_dispensers/index.php, Feb. 2014.

[3] Itchy4000, "Lego pin sorting machine." http://www.youtube.com/watch?v=kYhE0Yhv7qM, Feb. 2014.

[4] J. Chandler, "A diy vacuum pick & place tool." http://digital-diy.com/forum/electronics-projects/a-diy-vacuum-pick-place-tool-t2862.html#p16895, Feb. 2014.