HARDWARE DOCUMENT

GROUP 4

30th November 2016
Version 2

Contents

1 BACKGROUND

1.1 Edit History

Jake Zhu: Initial set up 28 Oct

Kareem Halabi and Jake Zhu: Updated information for the brick 29 Oct

Quentin Norris: Updated problem statements, requirements, possible solutions, sketches, and feasibility for collectors, crane, and grabbers October 31st.

Benjamin Willms: Changed the section structure, edited terms, and edited problem statements and requirements for all pieces (lifters (formerly cranes), grabbers, collectors, etc.) 31 Oct

2 Assessments

2.1 PROBLEM STATEMENTS

2.1.1 Collectors

The collector ensures that the block to be manipulated is in a position that allows the proper functioning of the grabber. It is imperative that the collector functions properly, and consistently, otherwise the grabber may fail.

The goal of this assessment is to determine the feasibility, and the pros and cons of the collector ideas currently brainstormed. In the end, this assessment will recommend one or two collector models to be built and tested.

2.1.2 Lifters

An extremely important function of the robot is the lifter. The lifter is what lifts the blocks so as to enable stacking. The lifter must be robust, light, and use a motor to provide the lifting. It is also closely related to the grabber (as they are attached together), and must provide enough space for the proper functioning of said grabber.

The goal of this assessment is to determine the feasibility, and the pros and cons of the crane ideas currently brainstormed. In the end, this assessment will recommend one or two lifter models to be built and tested.

2.1.3 Grabbers

The grabber is the device which latches on to the block to be lifted. It is imperative that the grabber functions properly, and consistently, otherwise blocks will be dropped, and an error may shift the robot, throwing off the odometer.

The goal of this assessment is to determine the feasibility, and the pros and cons of the grabber ideas currently brainstormed. In the end, this assessment will recommend one or two grabber models to be built and tested.

2.1.4 Lifter Hybrids

In certain cases, the grabber, collector, and crane may be combined into one or two devices, simplifying the entire system. This is an important possibility, as it would allow for the use of fewer motors in the design. Such ideas are discussed here.

The goal of this assessment is to determine the feasibility, and the pros and cons of the hybrid ideas currently brainstormed. In the end, this assessment will recommend one or two hybrid models to be built and tested.

2.1.5 Bricks

The brick is one of the most important parts, if not the most important part, of the robot. The software team will upload code to the brick that will make it run based of the sensors and motors plugged into it. Our issue with the brick is that there may not be enough ports in order to supply all the sensors and motors that are necessary. This means that the possibility of using two bricks must be considered in the hardware design.

2.1.6 Locomotion

The issue with the locomotion is that there are discontinuities where boards meet. This may cause the robot to get stuck in the discontinuities and offset the odometer by a large margin. Due to this, alternative locomotion designs must be considered and assessed.

2.2 REQUIREMENTS

2.2.1 Collectors

- must orient the block to allow the grabber to latch on
- must set the block at the proper distance from the robot for the grabber to function properly
- must not cause issues in navigation or odometry (size/orientation issues causing collisions)
- should not exceed the use of 1 motor

2.2.2 Lifters

- must allow lifting high enough to create a stack of 3-5 blocks
- must not exceed the use of 1 motor
- must provide stability for the grabber
- must not flex to the point of throwing off the stacking process

2.2.3 Grabbers

- must grab the blocks with enough force so as to not let go accidentally
- must be able to grab blocks with the amount of error in their position and orientation that the collector leaves
- must be able to let go of the blocks at the proper heights for stacking

- must not exceed the use of 1 motor

2.2.4 Lifter Hybrids

See sections 2.2.1, 2.2.2, and 2.2.3 for the requirements (as the hybrids combine the 3 sections)

- must not exceed the use of 3 motors

2.2.5 Bricks

The bricks must communicate with minimal delay and minimal interference between the bricks.

2.2.6 Locomotion

- must limit the chance of catching on the discontinuities
- must be able to turn without too much friction causing problems with the navigator and odometer
- must keep the robot balanced and stable

2.3 IDENTIFICATION OF POSSIBLE SOLUTIONS

2.3.1 Collectors

One possible solution is a skeletal tower constructed on the back of the EV3 brick(s). This tower will be tall enough to contain four or five of the blue Styrofoam blocks and will include a mechanism to transport it from the grabber to the tower. The tower will have a release system to drop off all the blocks in their stacked form once the tower is filled. The release system will be done through a motorized door hinge which will empty the tower.

Solution 1: After grabbing the Styrofoam block the crane will rotate over and place it on another EV3 motor with treads. Once placed on the tread the motor will activate and send the block up to the skeleton tower for the collector. The Styrofoam block will fall into the skeleton tower and will be the first block in the stack. After a certain amount of blocks picked up (dependent on the height of the collector) the mechanism for releasing the blocks will activate and empty the skeleton tower.

Solution 2: Use of two EV3 motors on opposite sides which will pick up the blocks and hold them there. Each time a block needs to be put up the two EV3 motors will accelerate the block being entered to the top of the lift and will hold it there. When the blocks need to be released the acceleration will stop and will remove the hold on the blocks.

2.3.2 Lifters

Our main solution for a crane, or "lifter," is a design stemming from an EV3 motor attached to one of the brick's ports. The motor will have a piece of string attached to a wheel that will be threaded through a stabilized group of blocks as it increases in height (preferably to that of our designated collector height). The string will hang down attached to the grabber. As the motor activates it will pull the string up, including the grabber to a designated height. It can move the block down by activating the motor once again to lower the string and thus the grabber.

Another add on to the crane to make it more mobile would be to add another EV3 motor on which it is constructed, to allow it to rotate itself. This would simplify the process of putting the bricks in the collector.

2.3.3 Grabbers

Solution 1: One possible solution for the grabber is two prongs long enough to wrap themselves around the Styrofoam block. They will settle themselves around the block after the EV3 has positioned itself in front of it. The cardboard paper tube will serve as closing mechanism around the block. It will hover over the block and once the EV3 motor pulls the string up, the cardboard tube will force the prongs to close and clamp themselves over the block. The block will then be pulled up through the tube and will stay there until the EV3 motor from the crane releases the string in which the block will fall.

Solution 2: Another possible solution for a grabber is similar to the one proposed. This one would utilize the lifter structure originally proposed, but only to change the height of whatever it is grabbing. This grabber would be an offset of the lifter, utilizing another EV3 motor. It would be made up of two-three long horizontal legos, with the orange spike pieces attached so they are facing the ground. The grabber would work by activating the EV3 motor once the grabber is placed over the block it is attached to. This would launch the grabber directly into the Styrofoam block.

2.3.4 Lifter Hybrids

2.3.5 Bricks

We may have to use multiple bricks connected through USB.

2.3.6 Locomotion

We will have to use a third rubber wheel, the metal ball bearing, a third gear or use four wheels with treads.

2.4 SKETCHES/IMPLEMENTATION

2.4.1 Collectors

2.4.2 Lifters

2.4.3 Grabbers

2.4.4 Collector-Grabber-Crane Hybrid

2.4.5 Bricks

Video on Dropbox in Testing Directory

2.4.6 Locomotion

Video on Dropbox in Testing Directory

2.5 FEASIBILITY

2.5.1 Collectors

The feasibility of this is going to be quite challenging, but would save the software team a lot of time. The time saved would be from the alternate process of picking up a block, bringing it to a known location and stacking it on top of another one. For that process, the software team would have to code the robot to not only pick up, but release the block from the grabber onto another one at a specific location. The precision of this would be extremely challenging.

The challenge in building the collector would not be its actual lego construction, although it would utilize many legos to construct and would be very large and may cause small mobility issues. The main issue with the collector is the release mechanism. This mechanism must be designed so that when the tower is released it is done so in a smooth manner in which the blocks that have been stacked will not fall over. In addition, the release mechanism must reset in order for the EV3 robot to continue picking up and stacking blocks.

2.5.2 Lifters

The solution is very feasible. We can adjust the height the motor pulls the string in to bring the block up by changing its length of rotation.

2.5.3 Grabbers

The feasibility of this grabber is very practical, easy to construct and does not take up much of our budget.

2.5.4 Lifter Hybrids

2.5.5 Bricks

This solution is feasible. We are able to connect multiple bricks to each other and run them from a master brick.

2.5.6 Locomotion

In any case in order to overcome discontinuities, we are going to lose some accuracy with the odometer.

2.6 PROS/CONS

2.6.1 Collectors

Pros: Save software team a lot of time, but in addition would save a lot of time in the demo as the robot wouldn't have to relocate to an exact location to stack the blocks it picks up. If developed correctly would perfectly stack the blocks with no issues, therefore the software side would mainly have to focus on picking up and finding blocks.

Cons: Release mechanism will be difficult to design to release blocks without them falling over. The tower's size may also cause mobility issues due to balance and or hitting other blocks as the robot moves around. An easy fix would be to program the robots final width and length into its navigation.

2.6.2 Lifters

Pros: Ability to pickup and rotate blocks specific distances. Cons: None

2.6.3 Grabbers

Pros: Picks up block fairly easily and once the block is in the cardboard tube it is secured to stay there.

Cons: If the EV3 robot lines up so the grabber is awkwardly over the block it may not successfully pick it up. This may be a problem for the software team as they will have to determine a way to check and see if the grabber has successfully picked up a block.

2.6.4 Lifter Hybrids

2.6.5 Brick

The pros of this system is the fact that multiple bricks can be used to run from one brick. The disadvantage is to make sure there is no interference. As stated in Section 4.1 of the MULTIPLE BRICKS TEST document, there was some interference when separate motors were running and they did not close. We will have to make sure that they are closed after each use.

2.6.6 Locomotion

As stated in Section 4 of the WHEELS TEST Document, there are pros and cons to every solution tested so far.

2.7 OPTIMUM SOLUTION(S)

2.7.1 Collectors

Currently the optimal solution we have chosen to implement in our final robot is solution 1: the construction of a skeletal tower to hold the blocks after they have been grabbed and lifted. They will be placed on a conveyor belt formed by an EV3 motor and treads which will carry the blocks into the tower. A release mechanism will release the blocks out of the tower.

2.7.2 Lifters

The optimal solution for the lifter is the only one suggested, due to its simplicity and low budget It will require a piece of string, an EV3 motor and an arranged set of blocks to guide and attach the string to forming a crane like structure. To make the lifter effective, we will be attaching the string to the EV3 motor and the grabber.

2.7.3 Grabbers

Solution 1 for the grabber is the optimal solution. This is because solution 2 does not have a consistent way to release the block and that may cause problems. Nor is its methodology efficient in picking up the block as the block may not stick to the orange prongs. Although solution 1 utilizes a little more of a budget requiring material that was not initially given to us, it will be much more effective and consistent in the long run.

2.7.4 Collector-Grabber-Crane Hybrid