HARDWARE DOCUMENT

GROUP 4

30th November 2016
Version 3

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 30th.

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

Quentin Norris: Updated pros and cons for grabbers and collectors. Drew sketches and finalized design plans for main two grabbers, the grabber claw and the motorized grabber. Oct 31st

Jake Zhu: Added pros, cons and optimum solution for the brick 31 Oct

Benjamin Willms: Edited all sub-sections of the identification of possible solutions, sketched the lifters, collectors, and hybrids, edited all sub-sections of the feasibility, edited pros/cons of lifters, hybrids, and locomotion, and edited all the sub-sections of optimum solution(s). 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 Collector/Grabber/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. Not only do the bricks have to communicate with each other, they must be positioned so that there will not be any problems while they are in use.

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 Collector/Grabber/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 slave brick must be able to receive a signal from the master brick.
- Both bricks must work with minimal delay
- The bricks have to be structured on the robot so that there is no interference with the processes

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

See System Document section 8.1

2.3.2 Lifters

See System Document section 8.1

2.3.3 Grabbers

See System Document section 8.1

2.3.4 Collector/Grabber/Lifter Hybrids

See System Document section 8.1

2.3.5 Bricks

We may have to use multiple bricks connected through USB, so the structure of the robot must take this into account.

For a single brick construction:

- the brick could be located in the center of the robot, parallel with the ground
- the brick could be located in the center of the robot, at an angle with the ground

For a dual brick construction:

- the bricks could be located in the center of the robot, stacked on top of each other with enough room between them to allow viewing of the screens
- the bricks could be located on their sides, each above a motor for locomotion, with an empty space in between them

2.3.6 Locomotion

See System Document section 8.1

2.4 SKETCHES

2.4.1 Collectors

Sketches on Dropbox in Hardware Directory

2.4.2 Lifters

Sketches on Dropbox in Hardware Directory

2.4.3 Grabbers

Sketches on Dropbox in Hardware Directory

2.4.4 Collector/Grabber/Lifter Hybrids

Sketches on Dropbox in Hardware Directory

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

All three collectors are feasible (similar designs were observed during lab 5). The sliding collector will be more difficult to implement as it requires the motor to translate its natural motion into two different motions.

2.5.2 Lifters

All three lifter designs will be simple to construct, and will work as intended. The sole feasibility issue for the lifters comes with the tower with a motor driving up and down it. The EV3 kits do not have any gear racks (long flat toothed pieces, allowing gears to roll along them). This means that the motor would need to be connected to a wheel which would clasp the tower to allow the up and down motion. This would likely have some issues with slipping, and causes such a design to be difficult to implement effectively.

2.5.3 Grabbers

The partial platform design, and the motorized design will both be relatively simple to construct. The pinching claw will have issues with getting it to release the blocks at the correct height, and a proper release mechanism may be difficult, or impossible to create with the lego form factor. The partial platform may not work in any case, as it relies on friction levels that are not completely controllable by the design itself, and the balance of the blocks in the contraption may be suspect.

2.5.4 Collector/Grabber/Lifter Hybrids

All three of the Hybrid options have some feasibility issues, namely:

- the cage design is extremely large, and will likely be difficult to get working with the lego blocks in the EV3 kits. It would require a vertical conveyor belt system that wouldn't shift the blocks into improper orientations, and must provide enough friction to lift the blocks, while simultaneously not being so tight that the blocks cannot enter the system. It is unlikely that the precision required to do all of this can be easily attained through lego construction.
- The two-use motor design would require precise use of gears to allow the four clamps to close in the desired manner, and at the proper places with respect to the blocks. This means that it would require significant time to construct, and get working in a consistent manner, and the budget may not allow it.
- The third hybrid design is simply re-purposing collector 4 so that it acts as a collector, and a grabber. It would use one of the tower lifters, and its feasibility is that same as both of them (both in 2.5.1, and 2.5.2).

2.5.5 Bricks

The brick housing structures are all feasible, however the angled single-brick structure may be more difficult to implement than the other designs.

2.5.6 Locomotion

All three designs for the locomotion of the robot are equally feasible (all three were observed during different labs).

2.6 PROS/CONS

2.6.1 Collectors

Collector 1:
Pros:

- Swinging motion of arms allow block to be trapped
- Can be done from on top of the robot or from side, or both
- Flexibility with swinging as well as the software team's ability to generate how strong of a swing gives us a lot of versatility with the positioning of the brick

Cons:

- Swinging motion may destabilize the bricks position
- Swinging motion would utilize one or two EV3 motors which would take up valuable resources for us to use for other designs

Collector 2:
Pros:

- Sliding motion of arms allow block to be trapped
- Lack of swinging motion will reduce the chance of destabilizing the block and moving it away from the robot by accident.

Cons:

- Sliding motion reduces versatility in actually capturing the block.
- Requires more precise orientation from robot in terms of navigating to block. Less versatility means the robot will have to be in a better position to "trap" the block.
- Sliding motion would utilize one or two EV3 motors which would take up valuable resources for us to use for other designs

Collector 3:
Pros:

- No EV3 motors required, allows us to use those ports for a more useful purpose.
- Static prongs and thus a lack of swinging motion will reduce the chance of destabilizing the block and moving it away from the robot by accident.

Cons:

- Will position block entirely upon robot's navigation code and positioning. Places more of the burden on the software team.
- Precision required to actually entrap and rotate the block would require constant use of ultrasonic sensor and light sensor. This draws a lot of energy and power.

2.6.2 Lifters

Tower Climbing Motor
Pros:

- Can provide downward force other than simply using gravity
- Solid design that won't allow for much shifting
- Can easily be updated to change the height

Cons:

- Difficult design to implement
- The wheels used for moving up and down may slip on the tower, throwing the entire system off
- Heavy design focused on one side of the robot (front or back)
- Would require a long cable for the motor, as its position is variable
- The wire and system may hinder the functionality of the robot
- The tower could get in the way of the grabber's necessary motion

Wired Tower
Pros:

- Solid design that won't allow for much shifting
- Can easily be updated to change the height
- Light construction

Cons:

- Slack wires could cause problems
- Wire choice may be imperative to the success of the design
- Room for the wires must be set aside
- Dropping a grabber onto a block may cause the wires to go slack
- The tower could get in the way of the grabber's necessary motion

Crane
Pros:

- The crane would be out of the way of the grabber
- Light Construction
- The motor would have many possible locations
- The wires pass through the structure

Cons:

- Slack wires could cause problems
- Wire Choice may be imperative to the success of the design
- Dropping a grabber onto a block may cause the wires to go slack
- The design would require balancing and extra support
- May allow the grabber to swing

2.6.3 Grabbers

Claw Grabber
Pros:

- Tube design ensures the secure transport of the block post pick up
- Easy on the budget, light construction
- Grabber claw is large enough to fit around most orientations for Styrofoam block

Cons:

- Requires a minimum height to be lifted successfully
- May be impaired by orientation at which EV3 robot lines up with
- If material for cardboard tube isn't strong enough it will not provide enough force to properly clamp the block

Motorized Grabber
Pros:

- Due to motor it will be easy to secure whatever it is holding onto by applying more force.
- Claw is versatile and can rotate itself outwards as far necessary due to motor.
- Design is efficient and will not require many legos to build, however may take some time to assemble

Cons:

- Requires the use of another EV3 motor, thus requiring another cable which may interrupt design.
- Will have to see the best way to implement this with a lifter as a string will not be able to hold it up
- Complexity of endeavor means it will take time to build and perfect

Partial Platform Grabber
Pros:

- Simplicity
- Lack of motors will allow us to use another motor in the design for something else

Cons:

- Lots of room for error as friction coefficients cannot be controlled by us in the lab
- Entirely successful based on block stability whilst being held - would have to design an entire system to stabilize block
- If the EV3 made a sharp turn or sudden change in speed block strong chance the block may fall off.

2.6.4 Collector/Grabber/Lifter Hybrids

Cage
Pros:

- Allows the stacking of blocks before reaching the desired location
- Would ensure the stack is structurally sound
- Would cut down on the time required to create the stack

Cons:

- Nearly impossible to construct
- Extremely heavy design focused on one end of the robot
- The release mechanism would most likely require another motor
- Difficult to initiate the feeding of the blocks into the cage

Two-Use Motor
Pros:

- Would allow for a centered rotating ultrasonic sensor
- Would cut down on the motors/sensors used
- Could cut out the need for a dedicated collector

Cons:

- Specialized gear design
- Low tolerance for error in the block's position
- Can only use the rotating sensor when a block hasn't been picked up

- Heavy design focused on one end of the robot

Hybrid 3
Pros:

- Would re-purpose a collector design
- Wouldn't require a distinct collector and grabber, as it would act as both
- Light design compared to the other hybrids

Cons: See section 2.6.1

- Must use one of the two tower lifter designs

2.6.5 Brick

One Brick
Pros:

- Don't need to take care of a slave brick
- Easier to Debug

Cons:

- May not have enough ports for all the motors and sensors

Two Bricks Stacked:
Pros:

- Simplicity
- Can fit more ports
- Easy to plug in ports

Cons:

- Heavier because the two bricks are on top of each other

Two Bricks on Side:
Pros:

- Can fit more ports
- Bricks on their side will spread the weight

Cons:

- May be hard to take out the battery and ports if necessary

2.6.6 Locomotion

Metal Ball
Pros:

- Smooth motion
- Low friction
- Simple implementation

Cons:

- Difficulty with discontinuities
- Possible issues with balance
- Slipping in forward motion

Gear Wheel
Pros:

- Smooth motion
- Low friction

Cons:

- Possible issues with balance
- Difficulty with discontinuities
- Slipping in forward motion

Treads
Pros:

- Less slipping during forward motion
- No issues with discontinuities
- Good balance

Cons:

- The large contact surface with the ground could cause issues with turning
- High friction during turning could cause flex in the structure

2.7 OPTIMUM SOLUTION(S)

The assessments done in section 2 lead to the identification of solutions that should be constructed and formally tested.

2.7.1 Collectors

As all three collectors are feasible, the optimum solution is either the swinging collector (front orientation) or the sliding collector. This is simply because they wouldn't have as high a likelihood to unintentionally make contact with obstacles.

2.7.2 Lifters

The optimal lifter is the wired tower. This is because it is the simplest structure, and can perform all the necessary functions of the lifter without causing too many problems with balance and weight.

2.7.3 Grabbers

The optimum grabber solution is the motorized grabber. It is the design with the least possible failure points, and can be easily constructed. The partial platform is also simple enough to warrant construction and testing on the off chance that it works as intended.

2.7.4 Collector/Grabber/Lifter Hybrids

The optimum hybrid design is Hybrid 3. Hybrid 3 is the only one that is likely to not cost an obscene amount of time to design and construct. It is also the solution that is most likely to succeed, and can re-use parts from the other constructions when they are complete.

2.7.5 Bricks

We would like to use two bricks just in case it is necessary to use more ports. We would need to figure out which design for the two bricks will work better in terms of weight, balance, and port location.

2.7.6 Locomotion

It is believed that the treads will be the optimum solution, as they will have no trouble with the discontinuities. The discontinuities are a problem that could cause a large amount of error in the odometer, which is to be avoided at nearly any cost. We don't believe that the treads will cause too much of a problem with the navigation, and turning, however this must be tested. It is suggested that all three options are built and tested, as it is imperative that we make the correct choice of locomotion, and all three are easily constructed. Unforeseen circumstances may cause one of the other options to truly be the best.