Client: Dr. Don Petkau

November 14, 2017 November 14, 2017

AUTOMATED MAGNETIC CUBE SORTER

ENG 1440 – DESIGN IN ENGINEERING

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AUTOMATED MAGNETIC CUBE SORTER

PROBLEM STATEMENT:

To design and assemble a mechanism that can sort 3 wooden cubes (4cm x 4cm x 4cm) labeled by 2 magnetic markers starting in random side by side positions by utilizing an Arduino, Hall effect sensors, motors, and an RGB sensor, without the help of external interference.

FUNCTIONAL REQUIREMENTS:

- The design must be able to move the wooden blocks.
- The design must be able to recognize which block is which.
- The design must be able to rearrange the blocks into their final sorted positions.

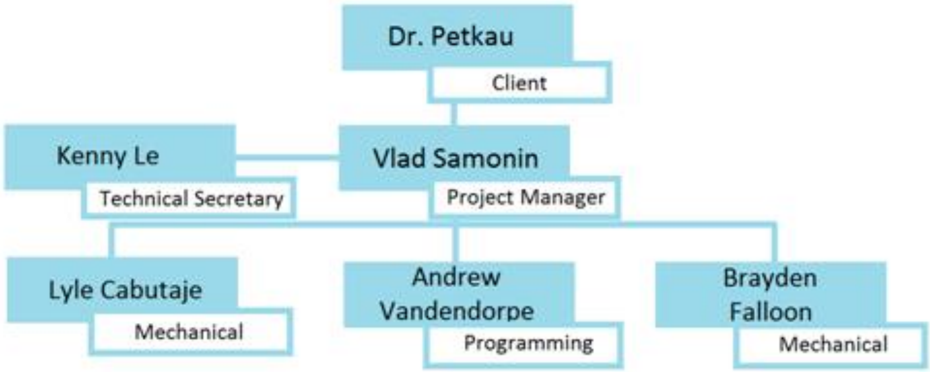
CONSTRAINTS:

- The design must be fully automatic. Once the mechanism starts, there cannot be any interactions with it in any way.
- The design must provide a 12cm x 4 cm area to receive the cubes.
- The design must fit on a table 5ft. in diameter.
- The design must be made of only pre-approved material and not be made of wood, metal, or LEGO components unless stated otherwise by the instructors.
- The design must utilize the Arduino, motors, and the Hall effect sensors.

DESIGN GOALS (OBJECTIVES):

OBJECTIVE	GOAL
Minimal movements	The design can only make a max of 11 “moves”.
Finish quickly	The design must finish in less than 30 seconds.
Size	The design must be at most 2ft. x 2ft. in area.
Looks aesthetically pleasing	The design must contain at least one sticker, where our logo is attached.

PROJECT TEAM ORGANIZATION CHART:



WORK BREAKDOWN STRUCTURE AND GANTT CHART:

Work Breakdown Structure: Lab 6, Automated Cube Sorter					
Task List	**Task #**	**Duration (days)**	**Predecessor**	**Start Date**	**End Date**
Appoint Project Manager	1	1	-	31-Oct-17	1-Nov-17
Form a Problem Statement	2	1	-	31-Oct-17	1-Nov-17
Identify Functional Requirements	3	1	-	31-Oct-17	1-Nov-17
Review and list the problem Constraints	4	1	-	31-Oct-17	1-Nov-17
List Objectives and Design Goals	5	1	-	31-Oct-17	1-Nov-17
Establish Meeting Schedule and Assign Responsibilities	6	1	1	1-Nov-17	2-Nov-17
Define the Design Parameters	7	1	2,3,4,5	1-Nov-17	2-Nov-17
Identify alternatives for the Design Parameters (brainstorm)	8	2	7	2-Nov-17	4-Nov-17
Evaluate alternatives for each design parameter identified	9	1	8	4-Nov-17	5-Nov-17
Select an alternative (Decisions)	10	1	9	5-Nov-17	6-Nov-17
Collect materials needed to build the prototype	11	1	10	6-Nov-17	7-Nov-17
Build the prototype	12	2	11	7-Nov-17	9-Nov-17
Test the prototype	13	1	12	9-Nov-17	10-Nov-17
Revise and refine the prototype	14	2	13	10-Nov-17	12-Nov-17
Finalize and present design	15	1	14	12-Nov-17	13-Nov-17

GANTT Chart: Lab 6, Automated Cube Sorter																
			October-November, 2017													
Task #	**Duration(days)**	**Predecessor**	31	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1	-	■													
2	1	-	■													
3	1	-	■													
4	1	-	■													
5	1	-	■													
6	1	1		■												
7	1	2,3,4,5		■												
8	2	7			■	■										
9	1	8					■									
10	1	9						■								
11	1	10							■							
12	2	11								■	■					
13	1	12										■				
14	2	13											■	■		
15	1	14													■	

DESIGN PARAMETERS:

BLOCK DETECTION:

Alternatives	Pros	Cons
Using the Hall effect sensor to check for (1,1), (0,1), (1,0) or (0,0) and “label” each block in an array. The sensors will check each block moving through a conveyor belt with set slots for each block.	This idea is efficient as it does not utilize another sensor. Because the blocks are moving via the conveyor belt in their set slots, as long as the motors do not skip any steps there will be no deviation from the programmed pathway.	There may be trouble detecting the (0,0) block as that is the same value as air.
Using the Hall effect sensor with the above method along with the RGB sensor. Each block will be checked over the same conveyor belt system as above.	With this method, we cannot miss the (0,0) block. Because the blocks are moving via the conveyor belt in their set slots, if the motors do not skip any steps there will be no deviation from the programmed pathway.	There are more sensors and more lines of codes allowing for more potential bugs.
A vehicle moving along the boxes while utilizing the RGB and Hall effect sensor.	This method won’t miss the (0,0) block if the initial set up is correct.	With the vehicle (and attached sensors) being the moving part of the system and not the blocks, there are chances for the vehicle to deviate from its path and miss the blocks.

CHOICE OF ACTION:

Alternatives	Pros	Cons
Picking the Blocks up and placing them down.	The blocks will be accurately moved around.	There are too many movements involved that can cause deviations from the programmed pathway. This idea takes more time to finish moving.
Having a moving vehicle push the blocks around.	A smaller number of movements involved for less inaccuracies.	There is a moderate amount of movement allowing for deviations from the programmed pathway. This idea takes more time to finish moving.
Conveyor belt and piston complex to move and push the blocks into required order.	This idea contains the least amount of movements which decreases failure rate. Time to finish movement is also minimal.	Required production of tracks to match the gears. The increases time of production.

SORTING THE BLOCKS:

Alternatives	Pros	Cons
Scanning each block and storing their positions in an array in the program. Depending on the blocks position in the array.	This method is efficient.	This method is code heavy and increases production time.
Scanning each block then moving the first block, rescanning the initial set up and moving the next block, etc.	This is a simple and easily made algorithm.	This method is less efficient than the first alternative.
Hit the blocks in a random order and hope it is the correct final order.	The simplest of algorithms.	Will only work about 33% of the time.

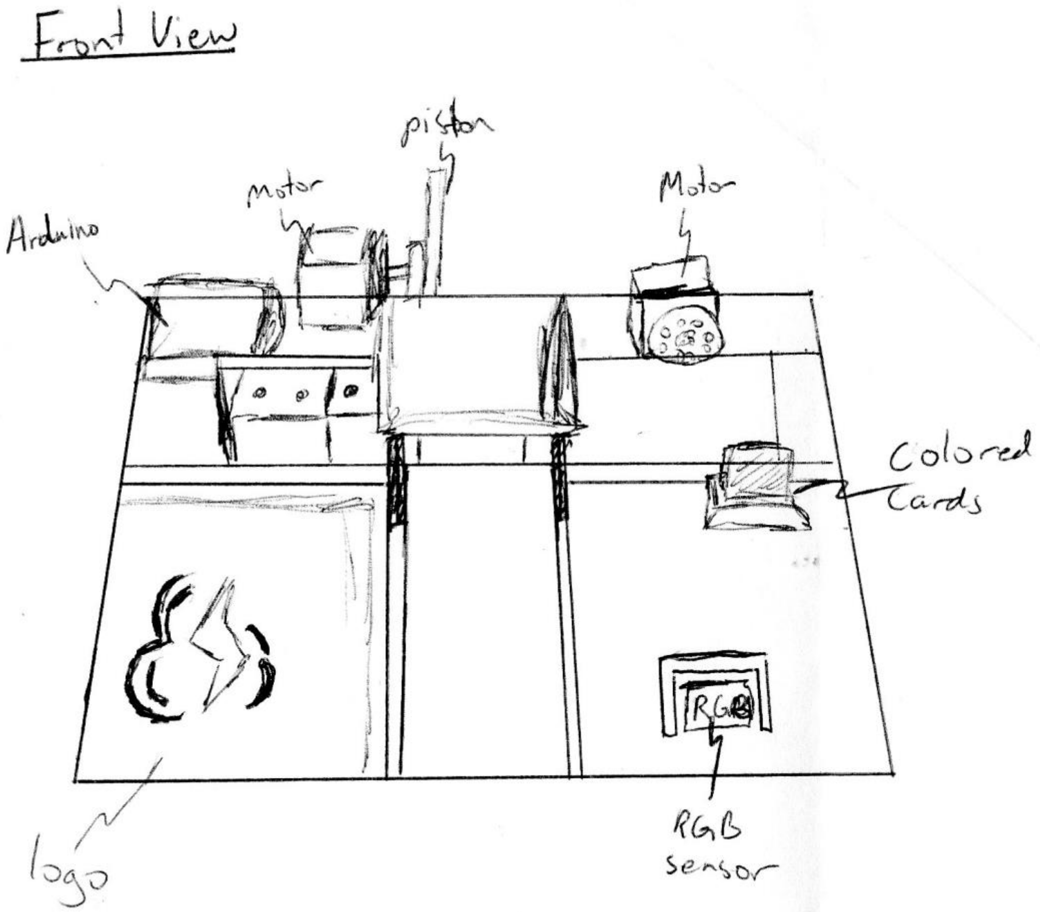
FINAL PLACEMENT:

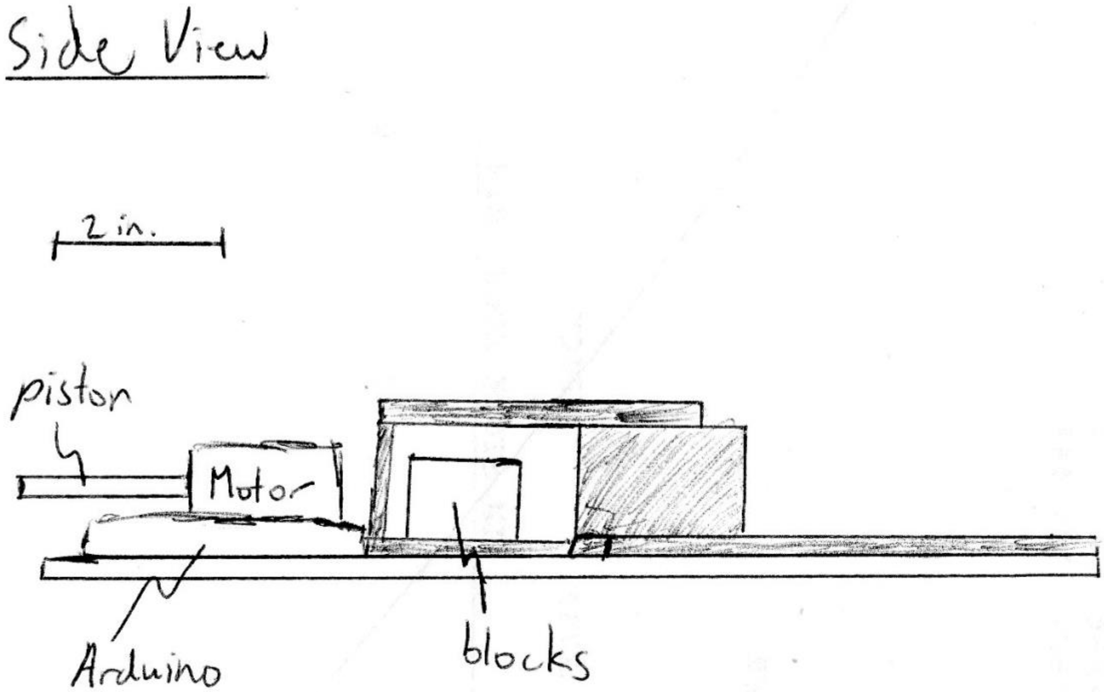
Alternatives	Pros	Cons
A conveyor belt and piston complex to push the blocks into place.	This idea is simple and efficient.	This idea is more difficult to manufacture.
Robotics arms that pick up and move the blocks to the desired positions.	This idea has high precision.	This idea is near impossible for us to produce with the amount of time and resources given.
A conveyor belt and chimney system. The blocks move across a trap door which only opens for the correct block.	This idea is simple and can be easily implemented and manufactured.	The blocks may get caught on the trap door or the trap door may get jammed.

VALUE ADDED FEATURES:

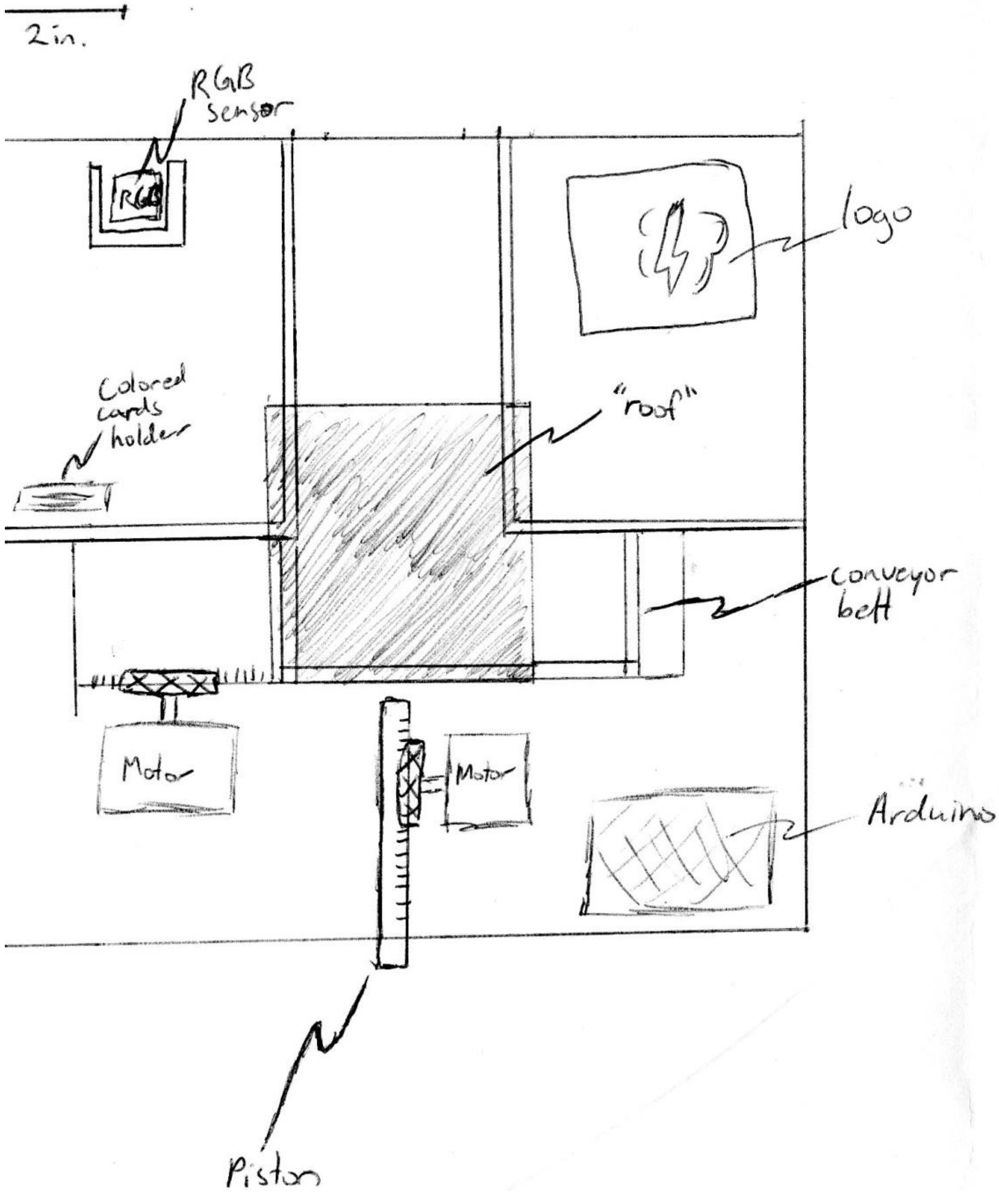
Alternatives	Pros	Cons
Our team Logo added to our mechanism.	The added logo will be stylish and aesthetically pleasing.	The printing of the logo will contribute to production cost. This has no added benefit to the functions of the mechanism.
Keyboard input for a requested sorting order of the blocks. Allowing the user to type in the final sort order the blocks will be in.	This increases the scope of the functions allowing the blocks to be sorted in whatever order they need to be rather than only 1-2-3.	This adds a lot of hardware to the design as the computer with the program needs to be attached to the Arduino.
An RGB sensor used to sense colored cards which determine the final sorting order.	This allows the user to choose the order they need the blocks to be in without the need for typing it into a computer every time. This looks more aesthetically pleasing than the above keyboard input idea.	The RGB sensor can sometimes be finnicky. The sensor also depends on the lighting in the room which may cause some difficulties when moving facilities.

SKETCHES OF PROTOTYPE:





Top View


2in.
RGB sensor
RGB
logo
Colored cards holder
"roof"
conveyor belt
Motor
Motor
Arduino
Piston

ENGINEERING DESIGN COSTS:

Material		Material Costs
Acrylic		$10
Arduino		$25
RGB Sensor		$8
Hall Effect Sensors		$2
Motors		$20
Total Cost:		$65
Personnel	Hours	Cost
Andrew V.	13	$19500
Brayden F.	10.5	$15750
Kenny L.	11.5	$17250
Lyle C.	12	$18000
Vlad S.	11	$16500
Total Cost:		$87000
Final Cost:		$87065