UNIVERSITY OF WATERLOO

FACULTY OF ENGINEERING

FINAL PROJECT INTERIM REPORT

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Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

Many individuals encounter situations in everyday life in which they are required to create aesthetically pleasing lettering but do not have the skills or time to do it themselves. This can be applied to many environments and situations such as organizing a wedding which requires beautifully written lettering on invitations and name place cards.

We chose this problem because we have all personally been in the situation where we have had the need to write visually appealing lettering but did not have the skills to write it ourselves. For example, in the past we were required to create posters for clubs by hand, however we were unable to create them beautifully with our current lettering skills. For this reason, we want to build a robot that has the ability to write with a brush pen in simple calligraphy. The robot will be stationary but will use motors to maneuver the brush pen and paper to form the letters.

2. SCOPE

Table 2.1 Task List

1	The user types in the word they want into the computer
2	The program must verify if the word is too long
3	The word is stored into a file, called the user input file
4	The user input file and font file (containing coordinate systems of each letter A-Z) will be downloaded to RobotC
5	RobotC will read and interpret the font file
6	The robot will then write each letter distinctly on the page

Table 2.2 Measurements the robot must take

1	The robot must read the font file and execute the corresponding letter(s)
2	Motor encoders will be used to determine the font size
3	Ultrasonic sensor to detect how far the page is from the tip of the brush pen, so that the motor is able to apply pressure accordingly (affecting the thickness of the stroke)
4	Timer to calculate the number of letters written per minute which measures the efficiency of the bot

Table 2.3 What the robot will affect

1	The robot will hold a brush pen and maneuver it
2	The robot will hold, move and apply pressure to a paper
3	The robot will be placed on the table

The task completion will be identified when the word that has been completely inputted by the user is written on the paper and the robot has displayed the number of letters written per minute. The task will have failed if the pen starts to write off of the paper or if the robot does not follow the correct coordinates to write each letter. The shutdown procedure is that the user will simply press the exit button on the EV3 brick. This will not be an issue because the brick will be stationary and easily accessible.

To effectively evaluate if the robot has completed its tasks successfully, we will ask the user to fill up a short questionnaire at the end of each demo regarding the performance of our robot. We will then record the statistics in MS Excel and create graphs that clearly shows the results of our observations. The graphs can then be included in the final report. We will also evaluate our success based on how well our robot was able to fulfill the constraints.

To complete the project, we have access to many resources. These resources include a TETRIX kit, LEGO Mindstorms EV3 kit and LEGO Mindstorms NXT kit. Furthermore, we have access to the Engineering machine shop ESMS and WATiMake which can be used to custom make parts for our robot, such as the brush pen holder and additional gear racks for the y-direction of our bot. Moreover, we have many advisors who are available to answer any questions that we may have regarding the final project.

3. CRITERIA AND CONSTRAINTS

3.1 Constraints

Table 3.1 Justification of constraints

	Constraint	Specifications	Method of Measurement
1	The robot must be able to effectively hold the brush pen.	Whether or not the robot is able to hold the brush pen.	Observe that the brush pen is securely held to the robot when in use. If this is not done, the pen may continue to fall out of the holder or not be able to write any letters correctly, thus failing to meet the constraint.
2	The robot must be able to write all of the letters in the alphabet in uppercase.	Whether or not the robot is able to write uppercase letters.	We will conduct tests to see whether or not all the uppercase letters in the alphabet can be written by the robot.
3	The letters must be legible.	Whether the letters are legible or not legible.	A survey will be given to those who have used the plotter robot to determine if they could read the output.
4	The robot must be able to apply two different pressures on the brush pen.	Whether or not two different pressures are applied on the pen.	If there are two different pressures being applied on the pen, there will be a clear distinction between the thick and thin lines in our letters. This will be measured by surveying the user to see if they can identify the two different thicknesses.
5	The robot must be able to move in three different directions.	Whether or not the pen holder was able to move in both the x- and z-directions. Additionally, whether or not the page can be moved in the y-direction.	Without the robot's ability to move in these specific directions it will be unable to write the letters. Therefore, we will be able to measure this through observation.
6	The robot must be able to write one word.	Whether or not the robot completes the word.	The robot must be able to write the same word that the user inputs. This will be measured through observations made by the user.

3.2 Criteria

Table 3.2 Justification of criteria

	Criterion	Justification	Method of Measurement
1	The line thickness could gradually go from thick to thin.	The creation of a gradient of line thicknesses would make the output appear more calligraphy-like. However, it would require the calibration of the motors in the x-, y- and z-direction to achieve this.	Through observation and surveying the user to see if they can see a variance in the line thickness.
2	The robot could write upper and lower case letters.	Having a variety of letters would satisfy the user expectations more due to the fact that it is more common to write calligraphy using upper and lower case letters. However, it will demand additional programming.	We will conduct tests to see whether or not all the upper and lower case letters in the alphabet can be written by the robot.
3	The robot could write more than one word	It would be nice to have the robot write more than one word as it could be used in a wider range of applications. However, this would require additional programming as the spacing between words and the reconfiguration of a new line would need to be taken into account.	The user will observe if the words they inputted were written correctly by the robot and these observations will be included in the survey.

4. DESIGN

The robot we built has three main functions: to move the pen in the x-direction (left and right), z-direction (on and off the page) and to move the page in the y-direction (forwards and backwards). There are many ways to accomplish these basic functions using actuators. The three main methods we considered were a conveyer belt, a rack and pinion system and wheels. We came up with three designs that explored the different ways we could combine and implement these methods in our design. In all our designs, the ultrasonic sensor is mounted to the brush pen holder and we use brackets to keep the TETRIX columns stable. The tables below, Table 4.1, Table 4.2 and Table 4.3, describe which methods were used in each of our designs. Sketches of our three different designs can be found in the appendix on pages 10 to 12.

Table 4.1 Possible methods for x-direction

	Design #1	Design #2	Design #3
Conveyor Belt	x		x
Rack and Pinion		x	

Table 4.2 Possible methods for y-direction

	Design #1	Design #2	Design #3
Conveyor Belt	x		
Rack and Pinion			x
Wheels		x	

Table 4.3 Possible methods for z-direction

	Design #1	Design #2	Design #3
Conveyor Belt	x	x	
Rack and Pinion			x

5. DESIGN DECISION

Factors that were taken into account during the design process were stability, ease of implementation, availability of parts and appearance. We then assigned weightings to each factor depending on how important they are for our design. Stability is rated the highest because our robot's stability greatly affects the quality of the lettering it will plot. Appearance received the lightest weighting because it does not affect the functionality of our robot however it was still considered as the robot should look professional. Ease of implementation and availability of parts were accounted for and weighed equally as they both affect the duration of the building process.

Table 5.1 Design matrix for x-direction

	Weighting	Design #1	Design #2	Design #3
Stability	0.4	1	0.5	1
Ease of implementation	0.25	0.5	1	0.5
Availability of parts	0.25	1	0.3	1
Appearance	0.1	0.7	1	0.7
Total	1	0.845	0.625	0.845

Table 5.2 Design matrix for y-direction

	Weighting	Design #1	Design #2	Design #3
Stability	0.4	0.5	0.4	1
Ease of implementation	0.25	0.5	0.7	1
Availability of parts	0.25	1	0.8	0.5
Appearance	0.1	0.3	0.7	1
Total	1	0.605	0.605	0.875

Table 5.3 Design matrix for z-direction

	Weighting	Design #1	Design #2	Design #3
Stability	0.4	0.4	0.4	1
Ease of implementation	0.25	0.4	0.4	0.7
Availability of parts	0.25	1	1	0.5
Appearance	0.1	0.4	0.4	1
Total	1	0.550	0.550	0.800

Overall, design three scored the highest. For this reason, we chose to implement it as our official design.

6. PROJECT PLAN

Task Name	Start Date	End Date	Duration (Days)	Days Complete	Days Remaining	Percent Complete
Researching	23-10-17	31-10-17	8	8.00	0.00	100%
Mechanical Design	31-10-17	03-11-17	3	3.00	0.00	100%
Building	03-11-17	11-11-17	8	8.00	0.00	100%
Software Design	10-11-17	13-11-17	3	0.00	3.00	0%
Coding	14-11-17	22-11-17	8	0.00	8.00	0%
Testing/ Troubleshooting	16-11-17	22-11-17	6	0.00	6.00	0%
Finalize Robot	22-11-17	24-11-17	2	0.00	2.00	0%
Final Report	24-11-17	04-12-17	10	0.00	10.00	0%

Table 6.1 Tasks completion timeline

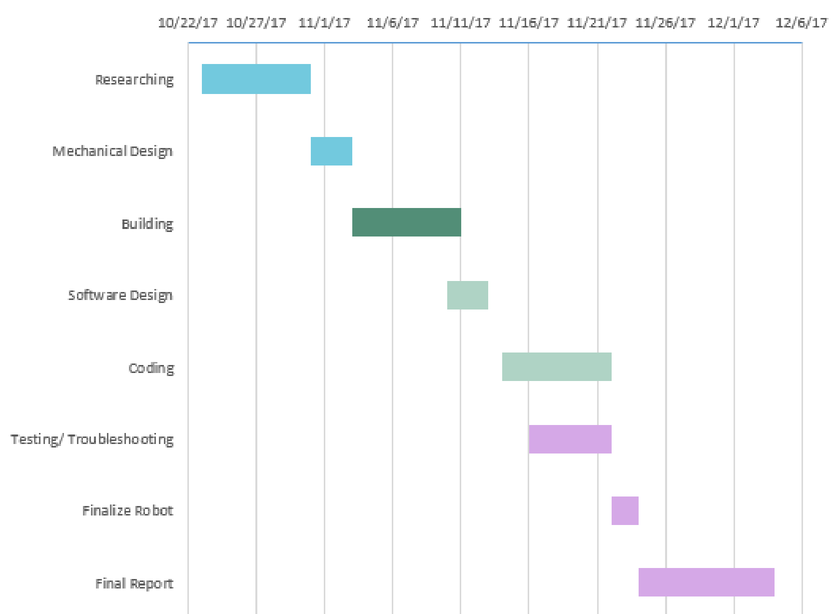

Figure 0.1 Project schedule

There are certain tasks that must be completed before proceeding to the next. As shown in Figure 6.1 above, we must complete the basic structure of our robot to be able to code and test the software aspect. Furthermore, once we have a preliminary program we can start testing and troubleshooting. During the testing process we will also be modifying and enhancing our code. The overall performance of our robot should be satisfactory before we present it during the demo day. Afterwards, we will complete the final report.

7. APPENDIX