ENSC 405W Grading Rubric for Design Specification

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project.	**/05%**
Content	Document explains the design specifications with appropriate justification for the design approach chosen. Includes descriptions of the physics (or chemistry, biology, geology, meteorology, etc.) underlying the choices.	**/20%**
Technical Correctness	Ideas presented represent design specifications that are expected to be met. Specifications are presented using tables, graphs, and figures where possible (rather than over-reliance upon text). Equations and graphs are used to back up/illustrate the science/engineering underlying the design.	**/25%**
Process Details	Specification distinguishes between design details for present project version and later stages of project (i.e., proof-of-concept, prototype, and production versions). Numbering of design specs matches up with numbering for requirements specs (as necessary and possible).	**/15%**
Test Plan Appendix	Provides a test plan outlining the requirements for the final project version. Project success for ENSC 405W will be measured against this test plan.	**/10%**
User Interface Appendix	Summarizes requirements for the User Interface (based upon the lectures and the concepts outlined in the Donald Norman textbook).	**Graded Separately**
440 Plan Appendix	Analyses progress in 405W and outlines development plans for 440. Includes an updated timeline, budget, market analysis, and changes in scope. Analyses ongoing problems and proposes solutions.	**Graded Separately**
Conclusion/References	Summarizes functionality. Includes references for information sources.	**/05%**
Presentation/Organization	Document looks like a professional specification. Ideas follow logically.	**/05%**
Format/Correctness/Style	Includes letter of transmittal, title page, abstract, table of contents, list of figures and tables, glossary, and references. Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted. Correct spelling, grammar, and punctuation. Style is clear, concise, and coherent. Uses passive voice judiciously.	**/15%**
Comments		

March 31, 2018

Andrew H. Rawicz
School of Engineering Science
Simon Fraser University
V5A 1S6

Re: Capstone Project Design Specifications for DynaBraille

Dear Dr. Rawicz:

Please find attached, Brailliant Solutions' design specifications for DynaBraille, which will give an in-depth description of our Capstone project design choices and considerations. We hope to improve the lives of the visually impaired by using DynaBraille which will convert multiple different forms of text into a convenient refreshing braille display.

This document outlines the design specification of each component used in DynaBraille. It consists of an overview of the product, design guidelines, and design specifications regarding physical architecture, hardware architecture,firmware/software design, and safety design. Three appendices attached at the end of the document will explain our test plan, user interface, and 440 plan. Using this document, we will be able to build DynaBraille accordingly and effectively.

At Brailliant Solutions we have a diverse and talented group of engineering students from Simon Fraser University in Biomedical Engineering, Computer Engineering, and Systems Engineering: Homan Lam, Kevin Cheng, Daniel Tan, and Jeffrey Wong. Not only are we all hard workers, but we are also extremely passionate about our work and our products.

Thank you for taking time out of your day to review Brailliant Solutions' design specifications for DynaBraille. If you have any questions or concerns, feel free to contact our team lead, Homan Lam, via email at hla125@sfu.ca or via phone at (604) 600-3282.

Yours truly,

Homan Lam

Homan Lam
Team Lead
Brailliant Solutions

Design Specifications for: DynaBraille

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Issue Date:

March 31, 2018

Abstract

This design specification document will outline the design choices and specifications for DynaBraille. We will first go into detail concerning the detailed design of our product which consists of software and hardware modules. Next we will analyze the problem and also justify and explain our chosen parts and design choices according to the requirements specified previously. Through this document, the reader will gain valuable insight on the detailed design of our product as well as understanding the choices made to realize our product in the given constraints.

DynaBraille is a product that consists of a text scanner, data processor, and a dynamic braille pad. Using DynaBraille will allow the user to easily convert plain text into an easily readable braille format. Our device will revolutionize the assistive devices in the visually impaired community.

This document will also provide an user interface design appendix which will describe the steps we will take to plan for usability testing, as well as a test plan appendix describing how we will fully test our product as well as individual components to ensure that it functions as specified as well as meets the strict standards set in our requirements. Along with this, our plan to ensure the successful completion of this project over the next phase will be detailed in our 440 planning appendix.

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Glossary

DynaBraille	-	Name of Text-to-Braille translator device, object of interest for this project
Piezoelectric	-	Type of material which creates displacement when subjected to voltage
OCR	-	Optical Character Recognition
CSA	-	Canadian Standards Association Group
ISO	-	International standardization for Standardization
DIS	-	Distributed Interactive Simulation
IEC	-	International Electrotechnical Commission
IEEE	-	Institute of Electrical and Electronics Engineers

1. Introduction

1.1 Background

In the modern day and age, being blind can be a big disadvantage and cause many difficulties in life. Based on the Global Data On Visual Impairments 2010, there are 285 million people visually impaired, 39 million being blind, and 246 million having low vision [1]. These numbers are only expected to grow with the aging population, as well as from the increased usage of visually strenuous electronic devices. These statistics indicate the presence of a relatively large market and desire for improving the quality of life for blind people.

Brailliant Solutions has explored the idea of developing and marketing a mechanical text-to-braille translator device, and after acquiring marketing/technological data suggesting its feasibleness, is undertaking a project which involves prototyping and testing the aforementioned device to acquire realistic preliminary data for such a device. Should the preliminary data indicate beneficial marketing potentials, the company name of “Brailliant Solutions” and the product name of “DynaBraille” are ideal candidates due to the advantages of being easy to pronounced and being intuitively indicative that the company/device concerns braille. These two advantages allow for easy brand recognition, which could contribute largely to the success of company [2].

1.2 Scope

This document entails the software and hardware design specification for the proposed text-to-braille translator, DynaBraille, and is intended for use by project managers, development teams, and quality assurance teams. This document will serve as a technical guideline and an estimate for the design architecture of DynaBraille, including the hardware architecture, software architecture, physical architecture, security architecture, as well as performance and data flow of the device. The scope of this document includes all relevant details to how the pieces of DynaBraille function alone, and how they work together as a system to achieve the capabilities as specified in the requirements document. The Document will also include details on the interfaces between components, the graphical interface of the device, and the different use cases under which the device is expected to encounter.

2. General Overview & Design Guidelines

DynaBraille is an assistive device for the visually impaired which will help them convert plain text into a braille format. The main components of DynaBraille are the text scanner, data processor, and the dynamic braille pad. As shown in figure 1, DynaBraille is planned to support two different types of user input. The first is via the camera module, with which the user will take a picture of the desired text to be translated, and the second is through the internal storage where users can upload a text file or an ebook. These inputs will be processed, translated and output to braille via the dynamic braille pad. The device has been designed with usability and user-friendliness in mind, as these features are critical to successful commercial products [3].

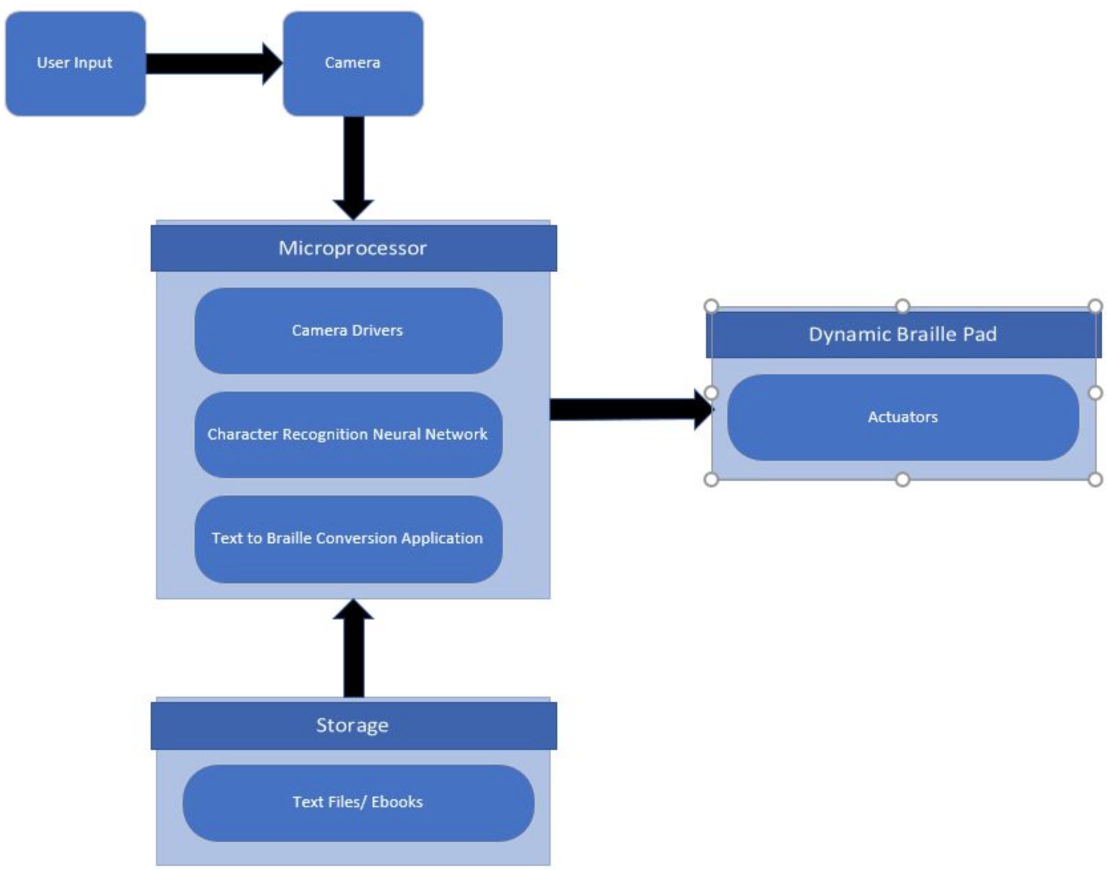

Figure 1. System overview of DynaBraille.

DynaBraille will be split into two main modules, the main processing unit which will handle the image processing and text translation, and the output module or dynamic braille pad which is responsible for displaying braille to the user. The main processing unit will be a Raspberry Pi running raspbian linux and it will be connected to a Raspberry Pi camera module through the provided interface that will take the image. The image obtained from the camera will then be processed by a C++ application that will translate the text in the image to a text file which the characters will be mapped to corresponding braille outputs. Using this mapping, the relays to activate each piezoelectric actuator will be connected to the GPIO pins and the correct pins will be pushed up to form each braille character.

2.1 Use Case

Figure 2 depicts a typical use case of DynaBraille and describes the flow of information between the user and the underlying internals of the product. The user will interact with the device via buttons. The scan button will directly interact with the processing to translate the text in the image into a text file which will then be outputted into an application that converts that text to braille. Finally the user will receive the braille output via the piezoelectric actuators.

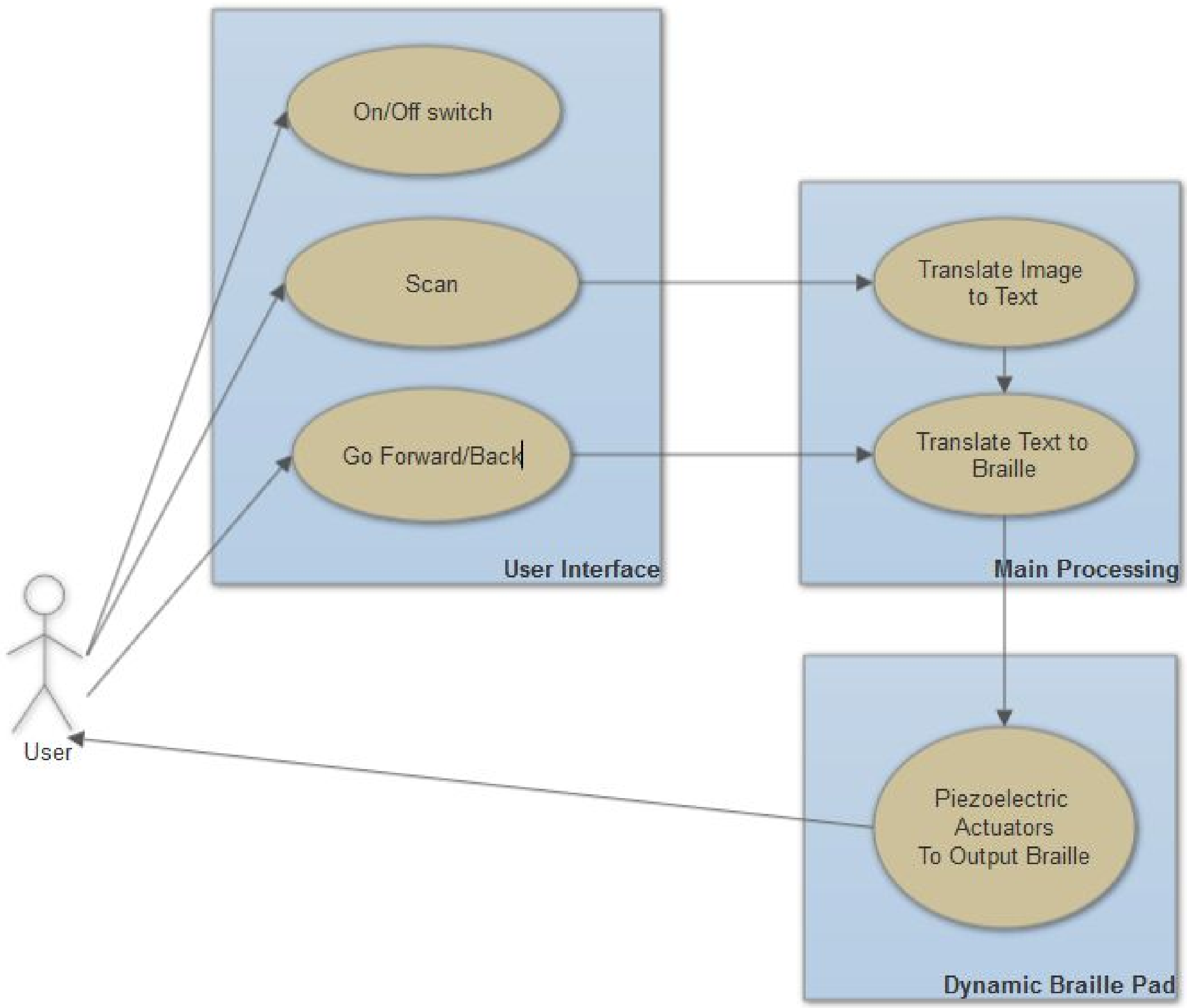

Figure 2. Use case diagram of DynaBraille.

2.2 Assumptions

During the design of DynaBraille, it is assumed that licenses can be acquired to use commercial software and hardware used in the construction and and retail sale of DynaBraille for a reasonable cost, and that the production cost per unit will be relatively low and static. Moreover, the users are assumed to be able to read braille, and have no other physical handicap other than blindness. On the software side, it is assumed that pre-developed software can be easily loaded onto devices during large scale production, and that the device will be used for its intended purposes.

2.3 Constraints

Constraints set for DynaBraille are largely subjected to by the requirements specification document, and the time-to-market constraints. The device will have to be easy to use, durable, portable, and safe. This involves choosing components which would collectively have a failure rate of no more than 1% after one year of usage, choosing components which would not cause hazards such as heating/shocking/pinching issues, and making sure the components allow for usage in a wide variety of temperatures/humidity/pressure conditions. All the components will also have to fit within a reasonably small enclosure, to satisfy portability issues. Lastly, the device must react quickly to the users' responses, and must perform actions reasonably fast. To ensure that the device is accessible to most blind people, the device needs to be reasonably priced, meaning that the cost to gather and assemble the components must not be too high. Refer to the requirements specifications document for more details. Listed below are the most important functional requirements:

[Req. G.2-PC]	The device shall have a manageable and intuitive interface for the blind
[Req. G.7-FD]	The device must output braille quickly to the braille pad after selecting source of text
[Req. G.5-FD]	The device shall be affordable
[Req. H.1-PC]	Camera must be able to scan full single pages of text with camera with ease
[Req. H.2-PC]	Camera must be of size small enough to fit in our enclosure
[Req. H.13-PC]	The piezoelectric braille actuators must exert a minimum force of 0.5 Newtons
[Req. H.14-PT]	The piezoelectric braille actuators must all be synchronized to within 100 milliseconds of each other
[Req. H.15-PT]	The piezoelectric braille actuators shall have a height of 1.5 mm and be able to change positions within 150 milliseconds
[Req. S.1-FD]	The device shall not shock or pinch users in any way
[Req. S.2-FD]	The device must not overheat or combust under specified working conditions

2.4 Standards

DynaBraille will be built with engineering standards in mind, specifically ISO 9001 standards. Refer to our requirements specifications for a full list of standards to be satisfied. Table 1 shows a copy for reference.

Standard	Description of Standard
CSA-C22.2 NO. 61508-1:17	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements [9]
CSA-C22.2 NO. 0-10	General requirements - Canadian electrical code, part II [10]
ISO 13854:2017	Safety of machinery -- Minimum gaps to avoid crushing of parts of the human body [11]
ISO 13850:2015	Safety of machinery -- Emergency stop function -- Principles for design [15]
ISO/DIS 21600	General requirements of mechanical product digital manual [13]
ISO/IEC Guide 46:2017	Comparative testing of consumer products and related services -- General principles [12]
ISO/IEC/IEEE 12207:2017	Systems and software engineering -- Software life cycle processes [14]
ISO 6196-5:1987	Micrographics -- Vocabulary -- Part 5: Quality of images, legibility, inspection [16]

Table 1. Engineering standards adhered to by DynaBraille.

3. Design Specification

This section will give an in-depth design description on the different components used in DynaBraille. Each subsection will provide justifications for components used, technical design descriptions, and the integration into the overall system. We will be using requirement specification codes outlined in our requirement specifications document.

3.1 Physical Architecture

3.1.1 Device Housing

The shell of a device can arguably be considered one of the most important parts of a product. When designing DynaBraille's case, key properties considered to fulfill Req. P.1-PT and Req. P.3-FD were: ergonomics, durability, and aesthetics. The dimensions of the case is 12cm*8cm*5cm. This size was designed to conveniently fit all our components in the prototype stage, while still being small enough to hold with one hand. The 4mm thickness of the case is designed to be thick enough to protect internal components in case of drops while still being thin enough for expense constraints. Furthermore, ribbed sides and rounded edges are incorporated to improve ergonomics and grip. Figure 3 shows a preliminary model of DynaBraille's prototype device shell which will be 3D printed. Not shown is a camera cutout which is located on the bottom of the device shell.

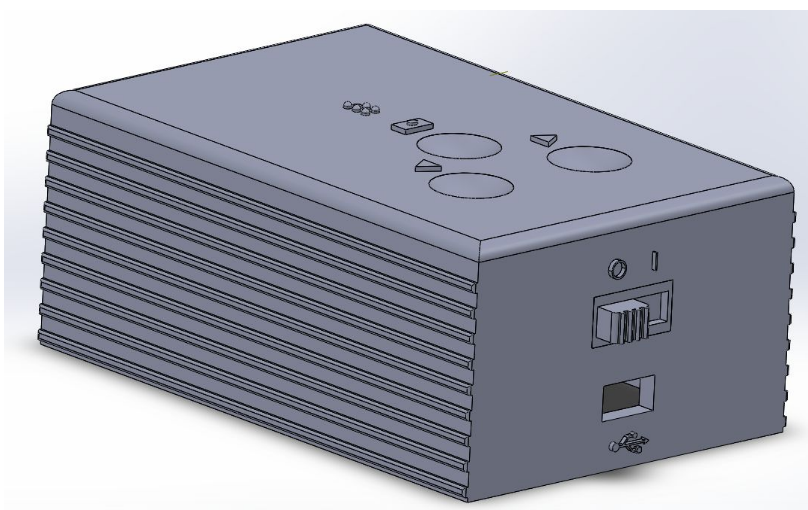

Figure 3. 3D model of our device shell created using Solidworks.

In the later prototype and production stages, we will be improving our design by making it as small and compact as possible, providing a more ergonomic shape to hold, and improving the aesthetics. Additionally, we will be moving onto a large scale manufacturing process using proper materials for production models as opposed to the current 3D printed prototypes.

3.1.2 Braille Pins

There are a total of six braille pins placed on the top of the device. The diameter of each pin is 1.5mm which adheres to a standard braille pin size. A clearance of 0.1mm around each pin will fulfill Req. S.1-FD and conform to ISO 13854:2017. The rounded heads will provide a good tactile feeling without causing uncomfort. The wide base will allow the pins to be raised and stopped at a uniform height.

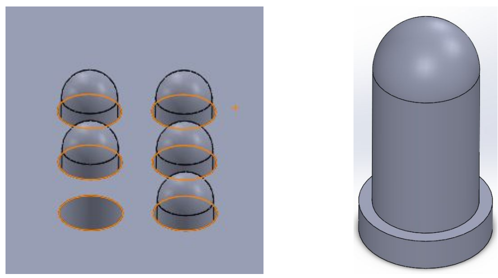

Figure 4. Close up view of braille pins protruding from the case and the braille pin by itself.

Figure 4 shows the proof-of-concept of the braille pins. There will be five fixed pins and one hole for a controllable braille pin. Prototype stages will contain six fully functional braille pins.

3.1.3 Buttons and Switches

There are a total of three concave buttons on the top of the case, and one switch located on the side. Table 2 gives an outline of the exact functions and locations of each component. A closeup of each component is provided in figure 5.

Component	Quantity	Function	Location
Concave circular shaped button	3	**Scan button:** This button is mainly used to initiate a scan, or start braille output from file.	Middle of the top face of the case.
		Forward button: This button is used to control the braille, fast forwarding to the next character.	Below the scan button and next to the backward button.
		Backward button: This button is used to control the braille, rewinding to the previous character.	Below the scan button and next to the forward button.
Switch	1	**ON/OFF switch:** Power control of the device.	Side/bottom.

Table 2. Function and location of DynaBraille’s buttons and switch.

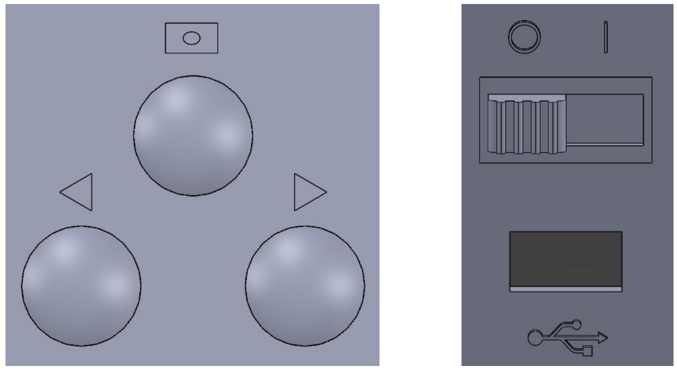

Figure 5. Scan, forward, and backward buttons (Left). Switch and USB cutout (Right).

3.1.4 Material

In the proof-of-concept stage and early prototype models, 3D printed material will be used to provide quick and cost efficient models of our device housing, braille pins, buttons, and switches. The production version of DynaBraille will involve an aluminum frame, and a plastic cover made of ABS (Acrylonitrile butadiene styrene). The buttons and braille dots will also be made of ABS. Internal electric circuitry will be connected via copper wires insulated with HDPE (High Density Polyethylene). Aluminum was chosen because it is relatively sturdy, hard, and cheap, and ABS was chosen because it impact and heat resistant, as well as being tough [3][4]. Copper was chosen as a connector because it has good electrical/thermal conductivity, and is corrosion resistant [5]. Lastly, HDPE is the primary candidate for insulation because it is a good electrical insulator, has high ductility/impact strength, and has low friction [6]. Together, these will ensure that the device is solid and built to last at least one year which will help fulfill Req. P.3-FD and Req. P.4-FD.

3.2 Hardware Architecture

The main processor to be used will be the Raspberry Pi 3, and the Raspberry Pi specific camera module accessory Camera Module V2, which is available from the same company. This choice is due to the fact that the Raspberry Pi is readily available and relatively cheap. The camera will be used to take pictures and send .JPG or .PNG files to the Raspberry Pi for processing. An Anker 13000 power bank will be used to power the device since it can supply the voltage and current required by the Raspberry Pi, and is also readily accessible and cheap. The general purpose input/output pins of the Raspberry Pi will connect to a boost converter. The output of this boost converter will be hooked up to 6 relays in parallel, each of which will connect to a piezoelectric actuator. The relays will be controlled by the GPIO pins of the Raspberry Pi. The voltage source will cause the respective piezoelectric actuator to flex and push up braille dots.Together, the 6 braille dots will be used to mechanically output any braille character.

3.2.1 Electrical Circuitry Overview

The Raspberry Pi requires an input voltage of 5 volts and a typical current draw of 2 amps, but may use up to 3 amps. The Anker 13000 Power Bank is chosen to power the Raspberry Pi 3 because it supplies 5 volts at a maximum of 3 amps. In turn, the Raspberry Pi will power the camera module and boost regulator with its 3.3V GPIO pins. The output of the boost converter, which sits at ~200V, will then be connected to 6 relays in parallel, with each relay connecting to a piezoelectric actuator. These relays will be controlled on/off by the remaining 3.3V GPIO pins from the Raspberry Pi. Aside from the camera module, the ground net will return to the ground pin of the Anker battery bank, because the ground pin of the Raspberry Pi may not be able to handle the high current. Figure 6 shows the electrical schematic of DynaBraille.

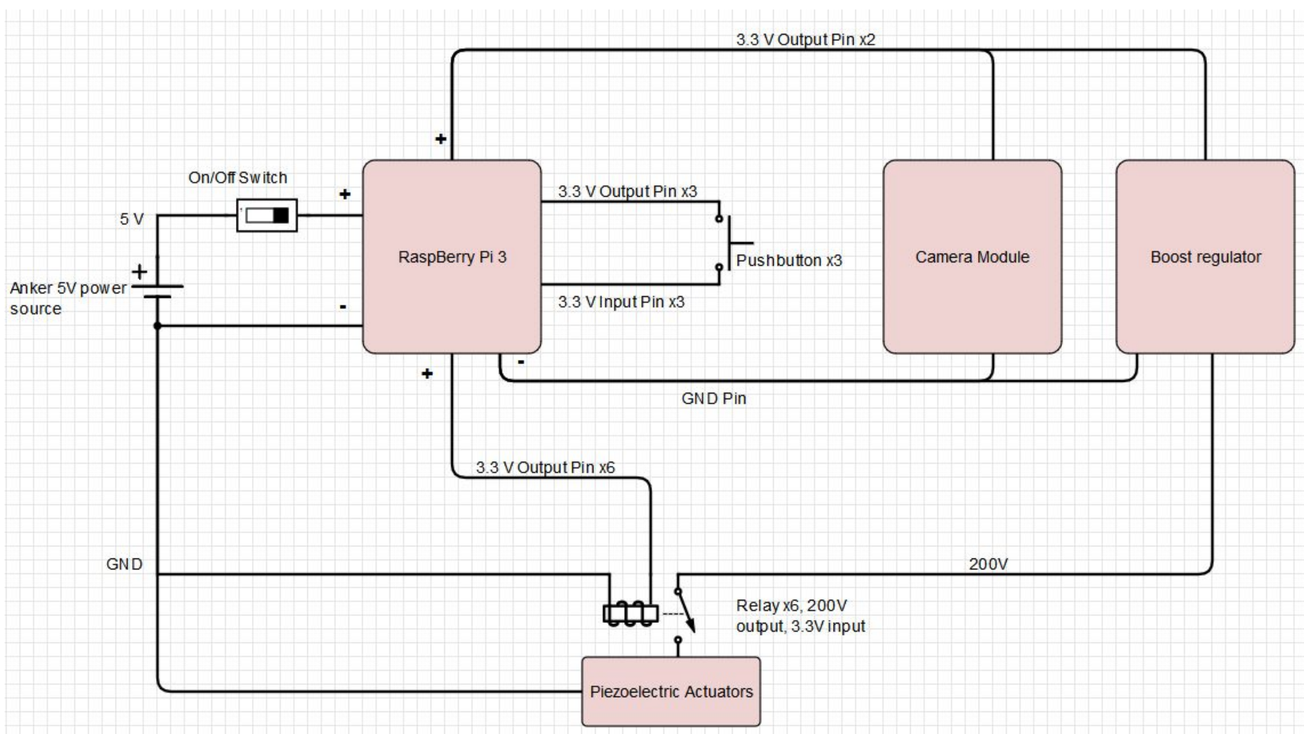

Figure 6. Electrical schematic of DynaBraille.

3.2.2 Piezoelectric Actuators

The piezoelectric actuators will be used to drive our braille pins up and down. The QDA36×2.1×0.7 piezoelectric actuator from Sinocera is chosen for both our proof-of-concept and our final product as it is very inexpensive while still meeting deflection, force, and timing requirements of our device. A summary of the properties of the piezoelectric actuator and the requirements met are shown below in Table 3.

Property	Value	Requirement Met
Length (mm)	36	N/A
Width (mm)	2.1	N/A
Thickness (mm)	0.7	N/A
Free Length (mm)	25	N/A
Voltage (DC V)	200	N/A
Deflection (mm)	1.5	Req. H.15-PT
Force (mN)	140	Req. H.4-PC
Reaction Time (ms)	100	Req. H.6-PT

Table 3. Piezoelectric Actuator Specifications

Our piezoelectric actuators will be fixated in a 3x2 matrix within our device as shown below in Figure 7. At the deflection end of the piezoelectric actuators, our braille pins will be attached. The 3 different heights of braille pins will be attached to their respective actuator such that they will have a uniform height exactly at the holes of the device shell when the actuator is in its relaxed state. Each piezoelectric actuator will be connected to its own relay where it will receive voltage and control.

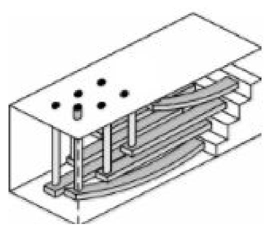

Figure 7. Physical layout of the piezoelectric actuators [17]

3.2.3 Raspberry Pi

For our main processor, we have decided to go with the Raspberry Pi 3 over an Arduino. The main factor that pushed us towards this is the amount of processing power that is necessary for image processing. The Broadcom BCM 2837 has a CPU containing a 4 core ARM Cortex A-53 which provides the necessary power needed compared to just the Atmel microcontrollers used in Arduinos. It also has an expandable memory microSD card slot, as well as allows for extra modules to easily be added. Along with this, Raspberry Pi also has a large community backing of developers which allows for easier development as well as a lot of topics on debugging any problems that we may run into. The Raspberry Pi also supports a lot of open source development which means that our hardware will not become obsolete in the near future. Figure 8 below shows the Raspberry Pi 3 GPIO layout, while table 4 shows various specifications.

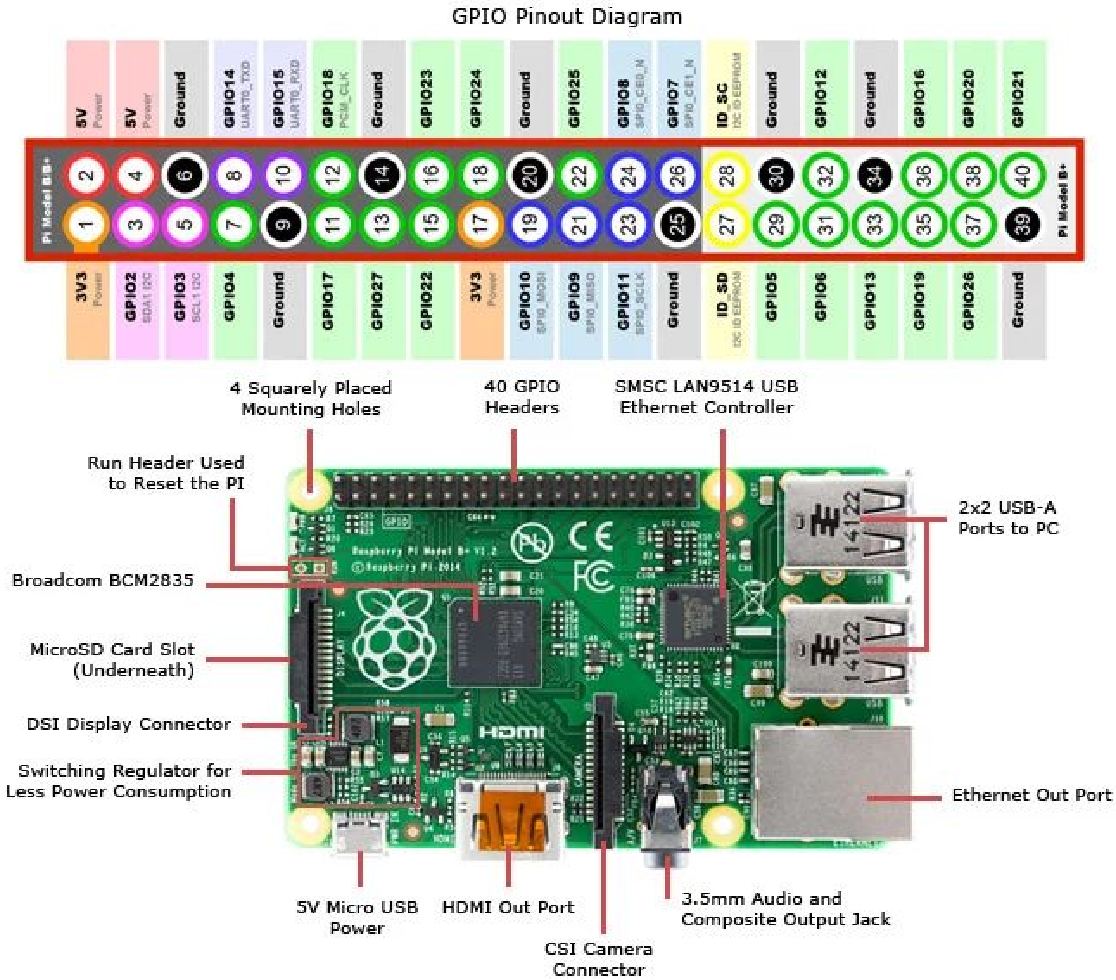

Figure 8. Picture of Raspberry Pi 3 and GPIO Layout.

SoC	Broadcom BCM2837
Operating Voltage	5 V
Input Voltage (recommended)	5 V
Input Voltage (limit)	4.75V - 5.25 V
Digital I/O Pins	40
PWM Digital I/O Pins	28
DC Current per I/O Pin	16 mA max, 50mA for all I/O pins
DC Current for 3.3V Pin	1A Max

SDRAM	1Gb
Clock Speed	1.2 GHz
Dimension	9.2 length 6.1 width and 2.8 height
Weight	45g

Table 4. Raspberry Pi 3 specifications.

3.2.4 Boost Converter

The boost converter chosen is a generic DC to DC step up converter purchased off ebay. The input ranges from 3-5V, with an output range of 200-620 volts, which satisfies our needs to supply the piezoelectric actuator with 200V. Figure 9 shows a picture of the boost converter and table 5 describes its specifications.

Figure 9. Image of our Ebay boost converter.

Operating Voltage	3-5 V
Output	200-620 V (controlled by screw)
Dimensions	5 x 2.5 x 1 cm

Table 5. Boost converter specifications.

With a 3V input, the output is 200-450V, and with a 5V input, the output is 280-620V. The exact output is controlled by the white screw. The size of the boost converter is 5 x 2.5 x 1cm.

For our proof-of-concept however, we plan to use an up to 80V step up as our delivery is not going to arrive on time. If we surmise that it is still insufficient voltage to flex our piezoelectric actuator, we plan to get a DC to AC step up transformer and then create a rectifier circuit if necessary.

3.2.5 Relays

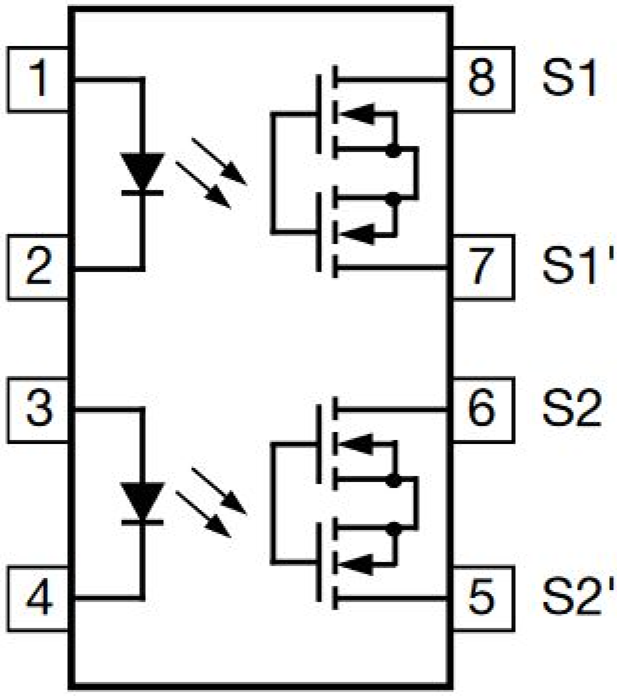

Figure 10. Circuit diagram of relay.

To allow us to electronically control our actuators, we have decided to use relays to control the signal to the actuator from the Raspberry Pi GPIO. Above is a circuit diagram of our chosen relay which allows us to control up to two actuators on one relay. The use of relays also allow us to fulfill Req. S.3-FD by separating our high and low voltage circuitry, which is a main safety concern of our product. Table 6 shows the relay specifications outlining various relevant input and output currents, and maximum ratings all at T_{amb} = 25℃ obtained from the datasheet.

Max Input Current	50 mA
Max Output Voltage	250V
Switch turn-on current	2 mA
Typical Turn-on time	0.2 ms
Typical Turn-off time	0.03 ms

Table 6. Outline of relay specifications.

3.2.6 Camera

The camera is an essential part of our product and for our design we decided to use the Raspberry Pi camera module due to its ease of use as well as its inherent plug and play nature and integration with the Raspberry Pi [7]. The Raspberry Pi already has a dedicated interface for the camera module and along with this it also satisfies the size constraints that we have outlined in our requirements document. Table 7 lists major specifications of the camera module.

Size	25 x 24 x 9 mm
Weight	3g
Still resolution	8 Megapixels
Focal length	3.04mm

Table 7. Raspberry Pi camera specifications.

3.2.7 Battery Module

The Anker 13000 Power Bank will be the main power source for DynaBraille. As mentioned before, this battery pack is chosen because it is more user friendly (since it is rechargeable), has a sufficiently large capacity to allow DynaBraille to operate for at least 3 hours, is relatively cheap/accessible, and meets the power requirements of the Raspberry Pi. Table 8 shows the specifications for the power bank. Figure 11 illustrates how our components are powered.

Input	5 Volts @ 2 amps max, USB Micro
Output	5 Volts @ 3 amps max, USB B
# of inputs	1
# of outputs	2
Weight	240 grams
Capacity	13000 mAh
Dimension	3.8 x 3.1 x 0.9 inches

Table 8. Specifications of the Anker Power Bank.

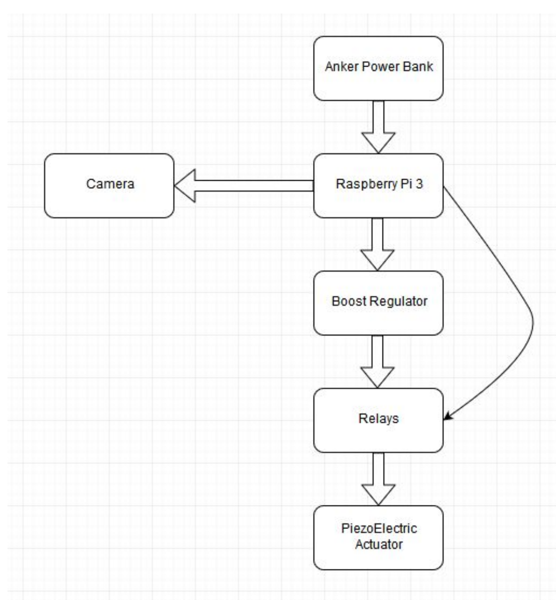

Figure 11. Power supply flow.

3.3 Firmware/Software Design

For our application we have decided to program it mainly in C++ as it is what we are most familiar with. C++ is also closely interrelated to C which allows us to easily access hardware compared to our second choice language of Python, which offers easier usage of libraries as well as less development time. Other than that, depending on any extraneous API or functionality that might not be easily implemented in C++, integration of other languages might be necessary in order to fully realize our desired functionality.

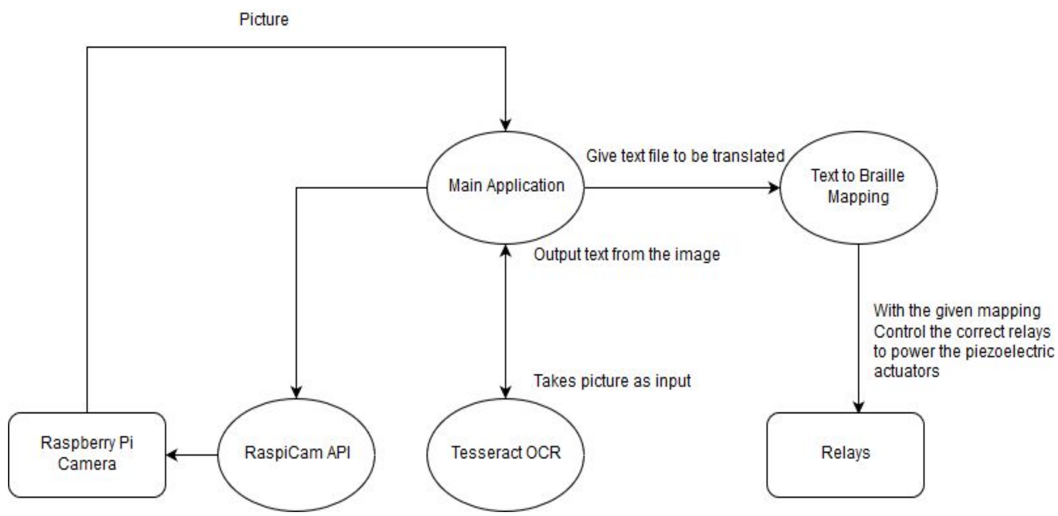

Figure 12. Flow diagram of data through our application.

Figure 12 shows a simple flow diagram that describes how our program will function at a high level. The main application is responsible for using the API to take a picture, which will then be fed into Tesseract OCR and returned as a text file. With this text file, a mapping of alphanumeric characters to GPIO pins that will control the relays will be realized to output the corresponding character.

3.3.1 RaspiCam API

DynaBraille's main function requires the user to capture images via the camera which operates as the primary input to the device. Although Raspbian OS internally provides a raspicam command line command, to allow a program to control it via C++ we will use this open source API to allow use to interface with the Raspberry Pi camera [7]. This API also provides methods to control exposure and other modes which will allow us to more intricately control the camera to get optimal pictures in different lighting conditions. This API is developed by the AVA research group and also supports openCV interface in case we decide to use that in the future.

3.3.2 Tesseract OCR

After acquiring a suitable image, the next step in the process requires a quick and efficient solution to translating text in the image to a text file. We found that Tesseract is the most suitable and versatile solution to our problem [8]. Tesseract is a widely used open source Optical Character Recognition (OCR) engine that has trained datasets for a multitude of different languages. It has been worked on and developed since 1985 when it was originally created at Hewlett-Packard Laboratories Bristol and at Hewlett-Packard Com Greeley Colorado [8]. Tesseract also supports a variety of different APIs for popular programming languages which allows us to be flexible in our development.

3.3.3 TensorFlow

Although Tesseract OCR has been chosen for now, in the future if time permits or if Tesseract does not meet the standard and/or functionality that we need to properly develop our application, Tensorflow might be substituted to allow for more trained datasets. Tensorflow is an open source machine learning framework and through this, we will be able to train our own neural network that will allow us to perform character recognition on different types of fonts as well as the ability to add more data when needed to allow for more accurate translations and decrease in overall error in translation.

3.3.4 Usage States

DynaBraille utilizes three buttons for user input and one switch to turn the device on or off. In order to maintain ease-of-use for the visually impaired, simplicity was they key attribute considered when designing the form of navigation through the different modes and functions of the product. Our braille device manual will thoroughly explain how to use the device.

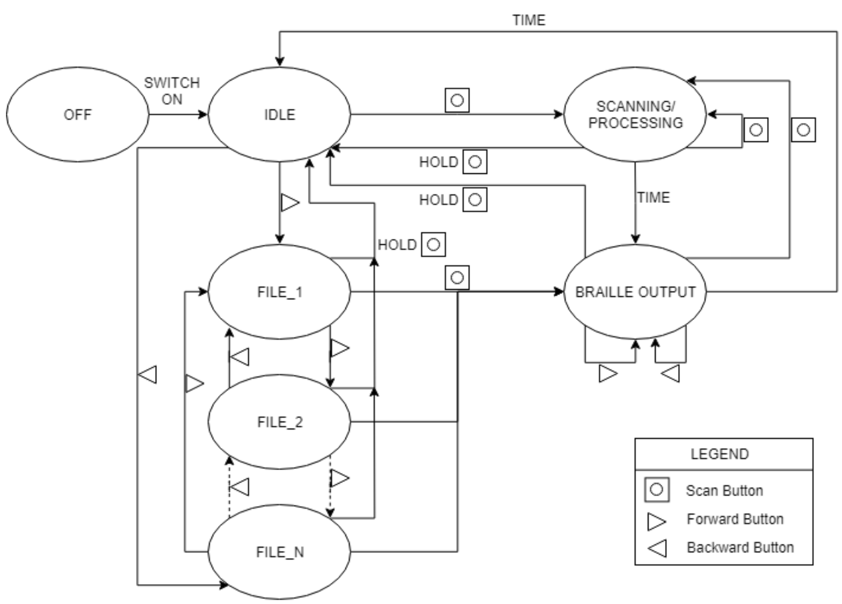

Figure 13. Usage state diagram of DynaBraille.

Moving the power switch to the "ON" position will power the device and bring it to the "IDLE" state. From here, it is defaulted to operate in the scanning mode. Clicking the "Scan" button will bring the device to the "SCANNING/PROCESSING" state where it will take a picture and convert it into text, when it is finished it will automatically move the next state "BRAILLE OUTPUT". When all the braille is finished outputting, it will return to the "IDLE" state. During the "SCANNING/PROCESSING" or "BRAILLE OUTPUT" states, pressing the "Scan" button will cancel current operations and move back to the "SCANNING/PROCESSING" states to take a new picture. From the "IDLE" state, to switch modes to file input, pressing the "Forward" or "Backward" buttons will bring the device to a state selecting either the first or last file respectively in alphabetic order. Using the same buttons, users will be able to go through their list of files. When switching file states, the file name will be outputted on the dynamic braille pad for user feedback. During any of the file states, pressing the "Scan" button will being the device to the "BRAILLE OUTPUT" state where it will start outputting the files in braille. During any state, pressing and holding the "Scan" button will kill the current operation and move the device back to the "IDLE" state. Also, turning the power switch the "OFF" position during any state will power the device off and bring it to the "OFF" state. Lastly, any buttons pressed in a state where the button has no function will have no effect on the states or operations of the device. Figure 13 above shows an overview of the usage states of DynaBraille.

3.4 Safety Design

The overall design of the device has been chosen such that it will minimize chances of harming the user, even in the event of total failure. Safety issues in the following categories are addressed:

- Electrical hazards
- Burn/Fire hazards
- Mechanical hazards

3.4.1 Electrical Hazards

The internal circuits will mainly consist of components externally sourced, and pieces of the internally design circuitry. The externally sourced components are chosen such that they don't overheat and can handle the required workload in DynaBraille, and with safety mechanisms such that there are no serious repercussions in the event of worn out components or short circuit. Internally designed circuits will be made with components chosen such that they also fulfill the same criteria of having no disastrous effects in the event of failure. Wires are to be made of copper wire for it's low resistance (hence low thermal issues). At the end, everything will be covered with HDPE (for its durability and insulative properties), so that the components won't accidentally short circuit with each other or with the metal frame of the enclosure.

3.4.2 Burn/Fire Hazards

One temperature sensor will be added to the hardware, in the location of the boost regulator. In theory, there should not be any issues to due temperature since the Anker battery pack and Raspberry Pi has a built in over-temperature shutdown protection, and does not supply enough power to the boost regulators such that the regulator or anything further down the path could heat up significantly. Nevertheless, the temperature sensor is added as back up, and is placed by the boost regulator because the boost regulator is the next most likely candidate for temperature issues, should there be any. The circuit will temporarily shut down if 100℃ is reached, until the device cools down to 75℃.

3.4.3 Mechanical Hazards

The only moving part in DynaBraille is the braille dots, and as a consequence, the region near the moving braille dot will be designed to have a tight fit, rounded surface, and low friction. Furthermore, the overall enclosure of the device shall be reasonably rounded such that no sharp corners exist. These design constraints will help prevent user from being pinched or scratched.

4. Conclusion

DynaBraille is an assistive device for the visually impaired which will help them convert plain text into a braille format. The main components of DynaBraille are the text scanner, data processor, and the dynamic braille pad. DynaBraille can support two different types of user input. The first is via the camera module, which the user will take a picture of the desired text to be translated, and the second is through the internal storage where users can upload a text file or an ebook. These inputs will be processed, translated and output to braille via the dynamic braille pad. Our system design specification consists of four major sections:

1) Physical architecture which highlights the material and shape design choices regarding the device housing, braille pins, buttons, and switches. Factors considered also include ergonomics and durability.
2) Hardware architecture which highlights various hardware component choices and their properties. It also shows how our components will be electrically and physically integrated with each other and as a whole.
3) Firmware/Software design which will explain in detail how we programmed DynaBraille’s data flow and image to text recognition, as well as how we designed the usage state flow of different modes and functions.
4) Safety design which goes through hazards addressed and design choices specifically made to increase the safety of the device.

The combination of the above four sections will help to ensure that the user experiences is as pleasant as possible. The physical architecture is designed to reduce physical strain and improve usability, while the hardware is designed to both last beyond one year of use and safe even in the case of catastrophic failure. The firmware is optimized to be as reactive and efficient as possible, to prolong usage and improve responsiveness. Together, these design choices will help ensure DynaBraille is an intuitive, reactive, portable, easy to use, safe to use, and useful device.

The development of DynaBraille's design specifications have been mainly created to meet the functional requirements previously developed by our team. While our requirements specifications document outlined "What" we needed to meet, this design document shows "How" to meet. This design specification document will be essential for reference during the next stage of our project when we fully build and implement our device. Details regarding exact functional requirements are extensively documented and can be found in the requirements specifications document.

5. Appendix A (Test Plan)

5.1 Introduction

This appendix will outline important information relating to our intended approach on the testing of DynaBraille. The quality assurance of our device is extremely important as it will determine DynaBraille's durability, function, and bring out any hardware or software flaws. A high quality product is essential in creating a successful consumer product. This appendix's intended audience is the project managers, development teams, and quality assurance teams.

While in the proof-of-concept and prototype stages, testing will be focused on more basic functional requirements of our device to verify design and functionality, and bring out major flaws. Reaching the final production model stage, a more comprehensive testing plan will be executed, including more detailed and edge case testing.

5.2 Unit Testing

Unit testing will be performed in order to check the validity of specific portions of DynaBraille to ensure they are individually working correctly. Our team will test the components they are working on during the development of our device in an ad-hoc fashion. During large scale production, individual components will be tested by a quality assurance team before assembly, or we will require third party components to have already passed through a form of quality validation.

Due to the upper layers of our device depending on the functionality of the lower layers, the device's appropriate subsections will be tested first. Once completed and passed, subsections will be integrated and we will continue to test the device as whole.

5.2.1 Piezoelectric Actuator

Test	Description	Result
Voltage control and deflection	Delivering 200V DC voltage to the piezoelectric actuator will create a deflection of >=1.0mm.	
Comments:		
Test	Description	Result
Force	Delivering 200V DC voltage to the piezoelectric actuator will generate a force of	

	>=140mN.	
Comments:		
Test	Description	Result
Reaction Time	Delivering 200V DC voltage to the piezoelectric actuator will finish actuation within 100ms.	
Comments:		

5.2.2 Camera

Test	Description	Result
Resolution	The camera will take a picture at 8 megapixels.	
Comments:		
Test	Description	Result
Focus	Image taken must be in focus.	
Comments:		

5.2.3 Buttons/Switch

Test	Description	Result
Scan, forward, backward buttons	Each button when pressed will complete a circuit to elicit a signal.	
Comments:		
Test	Description	Result
Switch	On position will complete a circuit, off position will open the circuit.	
Comments:		

5.2.4 Battery

Test	Description	Result
Battery lifetime	Draining the battery at a max rate of 3 Amps, the battery must last for at least 4 hours.	
Comments:		
Test	Description	Result
Rechargeability	Using an USB cable, the battery can be fully recharged at a reasonable rate.	
Comments:		

5.2.5 Boost Converter

Test	Description	Result
Boosting capability	An input of 3.3V will provide an output of 200-240V.	
Comments:		

5.2.6 Relay

Test	Description	Result
Relay Functionality	A GPIO signal from the Raspberry Pi is able to correctly switch the relay on and off.	
Comments:		

5.2.7 Raspberry Pi

Test	Description	Result
Input/Output pins	Input/Output pins correctly output a signal when triggered in software.	
Comments:		

Test	Description	Result
Basic functionality	Software application is able to run properly on the Raspberry Pi.	
Comments:		

5.2.8 Software

Test	Description	Result
Image to text translation	A sample image can be accurately converted into a text file.	
Comments:		
Test	Description	Result
Character to braille conversion	A alphanumeric character is able to be converted into corresponding GPIO signals.	
Comments:		

5.3 System Integration Testing

Following successful completion of our unit tests and basic assembly of our device, we will begin to run our integration tests in our device prototype stage. Our integration testing will ensure that not only are the individual parts of our system working correctly, but they also work correctly when combined together as a whole running higher level system tasks. The integration tests will cover all high level functionalities of our device such as scanning and converting an image to braille, or converting a file to braille. All usage states and navigation in section 3.3.4 shall be covered. In addition, our integration tests will cover edge cases or unique scenarios to ensure our that our software will be free of glitches or unexpected behaviour.

Test	Description	Result
Basic image to braille translation	Pressing scan while in the IDLE state will initiate a scan, followed by the correct braille output.	
Comments:		
Test	Description	Result

Basic file to braille translation	Pressing scan while in a FILE state will initiate braille output.	
Comments:		
Test	Description	Result
State navigation	User can navigate all the different states as shown in figure 13. File names are displayed as braille while selecting a file.	
Comments:		
Test	Description	Result
Forward/Back braille output	User can rewind or fast forward during braille output using the respective buttons.	
Comments:		

5.4 Physical/Mechanical Design Testing

Our physical/mechanical testing will ensure that DynaBraille is sturdy and can handle everyday wear and tear, as well as small collisions such as hip level drops. We will continue to test the operation of the device with various environmental factors such as temperature or weather. In our prototype stage we will fit all of our components into a convenient form size, while in our final product we will test different ways of fitting components into the case to create a device as compact as possible.

Test	Description	Result
Device drop	A drop from a height of 1 meter will cause no damage to the device.	
Comments:		
Test	Description	
Device temperature	Device can function properly at a high temperature of 75° C and low of 0° C.	
Comments:		
Test	Description	

Natural Elements	Sand or raindrops will not damage of affect the functionality of the device.	
Comments:		
Test	Description	
Compactness	The device is holdable in one hand easily and comfortably.	
Comments:		

5.5 Safety Testing

At the prototype stage, we will conduct basic safety tests to ensure that our device will not cause harm to our development team and potential investors attending a demonstration of our device.
To ensure our product is safe for the consumer, at the production stage more extensive tests will be set out to cover all possible sources of harm from our device.

Test	Description	Result
Physical Hazards	Physical contact along the edges of the device will cause no harm.	
Comments:		
Test	Description	
Mechanical Hazards	Switches,buttons, and dynamic braille pad will not be able to pinch or scratch the user.	
Comments:		
Test	Description	
Electrical hazards	Device is correctly grounded and no current shall be present on the outer perimeter of the device.	
Comments:		
Test	Description	
Temperature hazards	Device shall not reach harmful temperatures during prolonged usage.	
Comments:		

ENSC 405W Grading Rubric for User Interface Design

(5-10 Page Appendix in Design Specifications)

Criteria	Details	Marks
Introduction/Background	Appendix introduces the purpose and scope of the User Interface Design.	**/05%**
User Analysis	Outlines the required user knowledge and restrictions with respect to the users' prior experience with similar systems or devices and with their physical abilities to use the proposed system or device.	**/10%**
Technical Analysis	Analysis in the appendix takes into account the "Seven Elements of UI Interaction" (discoverability, feedback, conceptual models, affordances, signifiers, mappings, constraints) outlined in the ENSC 405W lectures and Don Norman's text (*The Design of Everyday Things*). Analysis encompasses both hardware interfaces and software interfaces.	**/20%**
Engineering Standards	Appendix outlines specific engineering standards that apply to the proposed user interfaces for the device or system.	**/10%**
Analytical Usability Testing	Appendix details the analytical usability testing undertaken by the designers.	**/10%**
Empirical Usability Testing	Appendix details completed empirical usability testing with users and/or outlines the methods of testing required for future implementations. Addresses safe and reliable use of the device or system by eliminating or minimizing potential error (slips and mistakes) and enabling error recovery.	**/20%**
Graphical Presentation	Appendix illustrates concepts and proposed designs using graphics.	**/10%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear concise, and coherent. Uses passive voice judiciously.	**/05%**
Conclusion/References	Appendix conclusion succinctly summarizes the current state of the user interfaces and notes what work remains to be undertaken for the prototype. References are provided with respect to standards and other sources of information.	**/10%**
CEAB Outcomes: Below Standards, Marginal, Meets, Exceeds	1.3 Engineering Science Knowledge: 4.1 Requirement and Constraint Identification: 5.4 Documents and Graphic Generation: 8.2 Responsibilities of an Engineer:	

6. Appendix B (User Interface)

6.1 Introduction

This section entails the user interface design, which is mainly focused on ensuring that DynaBraille is easy to use, intuitive, easy to learn, and stress-free. It considers user knowledge, the “Seven Elements of UI Interactions”, engineering standards, testing, and possible candidates for layout. The testing will consist of two sub-categories: analytical usability testing and empirical usability testing, and together will improve current and future iterations of DynaBraille’s reliability and functional abilities.

6.2 User Analysis

Although DynaBraille targets the market for the visually impaired, it is important to note that the users themselves must possess certain priors skills and knowledge to fully benefit from DynaBraille. This includes:

- Ability to read braille
- Basic understanding of navigational keys, such as rewind/fast forward, and on/off button
- Basic understanding of camera usage, such as aligning the camera still against a flat surface
- Sufficient motor control to hold camera relatively still and aligned on a target
- Basic understanding of digital file management, such as PDFs, save files, JPGs, and PNGs

In addition, they should have the grammatical prowess to understand the english language, as well as basic knowledge of how to care for and use electronic gadgets. Having fulfilled these mentioned skill sets, a visually impaired user can optimally benefit from DynaBraille.

6.3 Technical Analysis

This section will analyze how we considered the “Seven Elements of UI Interaction” as outlined by Don Norman when designing the UI of DynaBraille. Incorporating these elements into our design will greatly improve the usability and quality of our device.

6.3.1 Discoverability

Discoverability is one of the key components to good design, and it generally refers to being able to easily find important information or complete a task. When designing DynaBraille, we first determined the main functions of the device, which was where our focuses for high discoverability laid. Table B1 below shows the main functions and tasks of our device and how we considered discoverability in our design of those functions.

Function/Task	Design Consideration
Turning the device on	Large switch is placed on the side of the device with ON and OFF positions clearly marked in braille.
Scanning an image	Large concave button is placed in the middle of the top of the device with SCAN clearly marked in braille.
Rewinding or fast forwarding braille	Two large concave buttons are placed below the scan button side by side with rewind on the left and fast forward on the right. Both buttons are clearly marked as BACKWARD and FORWARD in braille.
Reading the braille output	Dynamic braille pad is placed in an obvious location on the top face of the device. Thin line outlining the braille pad allows for easy finger placement.

Table B1. Designs used to enhance discoverability in DynaBraille's main functions and tasks.

6.3.2 Feedback

Feedback is used to provide users with a form a confirmation that the device is performing as intended when input is provided. As our device is generally marketed towards the visually impaired, our forms of feedback do not include visual and are mostly limited to auditory and tactile sensations. To maximize the user satisfaction when operating our device, we attempted to provide a form of feedback in all the functions and tasks of our device. Table B2 below shows the different forms of feedback provided for the user when operating DynaBraille.

Function/Task	Feedback Provided
Turning the device on/off	The switch used will have an obvious tactile and auditory click when fully and correctly switch to the ON or OFF position.
Traversing through the list of files	Dynamic braille pad will begin outputting the file name when switching between file states.
Using any of the buttons	Buttons will have a tactile and auditory click when pressed and released to signify a successful button click.
Initiating a scan	While the device is scanning and processing, the dynamic braille pad will move all six pins up to signify that the device is busy.
Outputting text to braille	Dynamic braille pad will display the text in braille format.

Holding scan button to return to idle state	Dynamic braille pad will raise all six pins, then lower all pins to neutral position signifying back to idle state.

Table B2. Feedback provided for DynaBraille's different functions and tasks.

6.3.3 Conceptual Models

For our design, we have modeled a simple mental model that will be easy and intuitive for users. Since buttons switches and buttons are common ways to interact with handheld devices, our switch is used to turn our device on/off which is similar to a lot of other devices. A button could have also been modeled but since we are using buttons for our forward/back buttons for braille as well as for scanning, a switch makes it less confusing for the user to turn the device on and off. To compliment this, buttons with corresponding symbols engraved in them are used as to perform different functions of our device as they are again intuitive and proven methods of user interface that allow our device to conform to the general metal models people have. Buttons and switches used in DynaBraille are shown in figure B1.

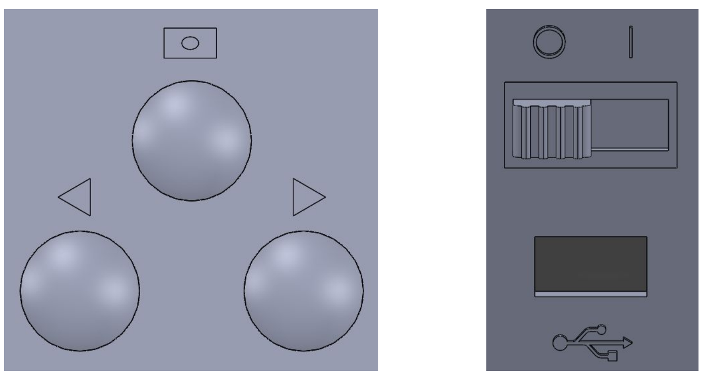

Figure B1. Model of buttons and switches.

6.3.4 Affordances

Affordance is a quality of an object that enables an individual to understand how to correctly operate it. It can be seen a visual clue, giving a hint on how the device is to be properly used. Having strong affordances is important in designing a device that is intuitively easy to use. The main affordances of DynaBraille are as follows:

- Having ribbed grips on the sides of the device show how the user is supposed to hold the device during operation.
- A camera cutout at the button of the device showing the camera lens will signify how the user should point and aim the device the scan accurately.
- Buttons are concave, inviting the user to correctly press downward to use the buttons.
- A standard sized cutout for the USB cable will let the user infer that a USB should be plugged in there to charge the device.

- On/off switch located at the side of the device can be clearly interpreted to only move laterally between two states, giving a clue that the switch controls the device between two states.

6.3.5 Signifiers

Signifiers are very important for a product, especially when the target users of DynaBraille are the visually impaired. Therefore, signifiers with carved in shapes that correspond to the function of the button are necessary to allow the user to easily identify what each button does. Figure B2 shows the signifiers for each of the buttons. A camera shape signifier represents the scanning button while the back arrow represents displaying the previous braille character while the forward arrow represents displaying the next braille character.

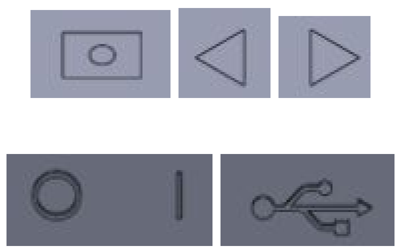

Figure B2. Signifiers used in DynaBraille.

6.3.6 Mappings

The relationship between buttons and their actions follow the principles of good mapping. Therefore, the backward button is placed towards the left side of the device and forward button is placed towards the right. Also, the camera button will be placed in the middle and just under the braille pad to allow for both easy to locate area between the forward and back buttons, but also allows the user to easily access the braille pad right after taking a picture. Figure B3 below displays a mockup of how our button mappings and layout will look like.

Figure B3. Mockup button mappings.

6.3.7 Constraints

Constraints help limit the range of possible actions a user can make, simplifying the user interface and guiding the user to an appropriate next action. Having clear constraints in our design is important in clarifying to the user what they can and cannot do. As DynaBraille only has three main input buttons, they generally always have an usage and there are not too many constraints limiting when you can use each button.

DynaBraille's constraints mainly consist of physical ones. The concave buttons used are a good example where when the user put their finger on the button, the only possible action is to pressing downward. Another physical constraint is our charging port which will only allow a USB type wire inserted in the correct orientation to be used.

6.4 Engineering and Safety Standards

6.4.1 Engineering Standards

The user interface is coupled with engineering standards which have a direct relation to what the user can see and do. Table B3 shows the engineering standards from the requirements document which are relevant to the user design.

Standard	Description of Standard
CSA-C22.2 NO. 61508-1:17	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements [18]
ISO 13854:2017	Safety of machinery -- Minimum gaps to avoid crushing of parts of the human body [19]
ISO 13850:2015	Safety of machinery -- Emergency stop function -- Principles for design [20]
ISO/DIS 21600	General requirements of mechanical product digital manual [21]
ISO/IEC Guide 46:2017	Comparative testing of consumer products and related services -- General principles [22]
ISO 6196-5:1987	Micrographics -- Vocabulary -- Part 5: Quality of images, legibility, inspection [23]

Table B3. Engineering standards adhered to by DynaBraille.

The above standards cover safety issues the user may experience, user manuals, and matters which improve the effectiveness and quality of life when using DynaBraille. The CSA-C22.2 NO. 61508-1:17, ISO 13854:2017 and ISO 13850:2015 are in place to ensure that the risks to electrical and physical hazards are minimized, specifically with the risks of electrocution and pinching of hands/fingers from physically moving components. The device will either temporarily shut down or stop working altogether, should a critical failure occur. ISO/DIS 21600 ensures that the user manual will be sufficient for the use of the device, while ISO/IEC Guide 46:2017 and ISO 6196-5:1987 sets standards such that the use of DynaBraille is stress-free with minimized fault occurrences.

6.5 Analytical Usability Testing

To test the usability of DynaBraille, the QA team has decided that the tests will involve a test subject and a testing overseer. The test subject will perform the tests blindfolded with minor verbal assistance from the overseer to fill in knowledge gaps that blind people would possess. The subjects will be given a piece of paper with a paragraph written on it, and attempt to convert it to braille using DynaBraille. Afterwards, the subject will rate the device out of five in the following categories:

1. Comfortability (how comfortable it is to hold it, whether buttons can be easily pressed, and no safety issues)
2. Navigational capabilities (how easy it is to find the buttons the user needs, and how many steps the user needs to take to perform something simple or frequently used)
3. Responsiveness (how quickly the device responds to user inputs and generates outputs)
4. Learnability (how intuitive the interface is, and whether the user can get to where he/she wants without much thinking)
5. Mapping (how often the user accidentally triggers the wrong action, and how manageable it is to undo the mistake)
6. Error resolution (how often the user encounters an error, and how easy it is to recover from the error)

Furthermore, the overseer will take the translation and examine its accuracy, and give it a rating in one more category: accuracy. This test should be conducted using at least three different test subjects under the same conditions. Using the results of our analytical usability testing, we will be able to determine if there are any design flaws or problems in our user interface model.

6.6 Empirical Usability Testing

Empirical usability testing is equally as important as our analytical usability testing and will be carried out as part of our development plan in creating the final design of DynaBraille. We will be executing this testing from the beginning of our prototype stage up to the finalization of our device. Being an agile environment company, we believe that it is important to frequently keep in check the validity of the state of our design, and constantly make iterative changes in order to efficiently and effectively create a well designed and tested device.

In the early stages of our prototype stage we will aim to first verify the design of our device housing with considerations such as ergonomics and aesthetics. A variety of design choices will be sent out to random individuals who could be potential users for ranking and general feedback/concerns. Taking the results into account, changes will be implemented and new designs will be tested. This process will occur iteratively until we are confident we have a well designed device housing that also meets design and quality standards.

Next, we will move into the mid stages of prototyping where our device operates as a whole and can perform basic device functions. To conduct usability testing at this stage safely, reliably and accurately, we will be creating appointments with visually impaired individuals in our community where a member from our team will personally oversee the usage/testing of our prototype.This method of testing is important as it will ensure safety of the user, allow the overseer to give guidance if necessary, and gain immediate feedback which can be clarified on the spot. Taking into account the feedback and concerns, we make changes and iterate through the design and test procedures until we feel that confident in the safety and basic functions of our device and are ready to move onto the final stages of prototyping.

In the final stage of our prototyping, we will have a device which we are confident in its safety and can do all the functions/tasks it is meant to do. Fully packages units with the intended user manual documents and accessories will be sent out for testing to a diverse range of visually impaired individuals with no prior experience with our device. This range of individuals includes but is not limited to: variety of ages, different genders, and different levels of visual impairment. The users will test the device for a total of two weeks. This criteria will ensure that we a) simulate a range of different types of users, b) simulate an user discovering and learning how to use the device on their own, and c) emulate short and long term usage satisfaction of the device. Also provided with the device will be forms allowing easy documentation of feedback, complaints, bugs, and other comments which we encourage to be completed during and at the end of the testing period. Throughout the testing period, our team will readily available for any contact or support required. When the testing is finished we will conduct an additional survey asking participants to rate the usability of DynaBraille, and whether they would recommend it to a friend or family member. This will allow us to gain an understanding of their overall experience with our device.

Analyzing and reviewing all the collected feedback and data, we will make the necessary design revisions and create the final iteration of our device. For quality assurance, a final round of unit testing and integration tests will be executed at this point. We are now ready to finalize all design decisions and release the finished version of DynaBraille.

6.7 Conclusion

This appendix was used to show design choices made in the development of DynaBraille while considering user interface. Having a well designed user interface is essential in ensuring that DynaBraille is easy to use, easy to learn, intuitive, and stress-free.

In order to design a good user interface, we first performed user analysis to determine everything we needed to know about consumers we expected to use our device. From this we were able to determine that key skills and knowledge required by the user to use our device effectively included: being able to read braille, and having sufficient motor skills to hold a camera steady.

After defining our users and performing user analysis, we began technical analysis of the designs in our device specifically made with the consideration of the “Seven Elements of UI Interaction”. Our proof-of-concept will have no relevant discoverability or feedback, as we are only showing the device shell, and our software separately. Our proof-of-concept enclosure will show the basic conceptual model along with affordance and signifiers of the final device by having the physical buttons and labels planned for the production version. Mapping may shift around a bit as development goes on. The final prototype will contain all attributes of the proof-of-concept and more, specifically, it will address the discoverability, feedback, conceptual model, affordance, signifier, mapping, and constraint design requirements as mentioned in this appendix.

The proof-of-concept and final prototype will fulfill the same engineering requirements: ISO 6196-5:1987 and ISO 13850:2015. The physical design will not be optimized for ideal electrical protection or ideal physical comfortability until later stages in prototyping.

Analytical Usability Testing will involve an overseer and a blindfolded test subject (to simulate the limited sensory experienced by visually impaired users), with the test subjects rating the device in the following categories: comfortability, navigational capabilities, responsiveness, learnability, mapping, and error resolution. The accuracy of the translation will be rated by the overseer.

The empirical usability testing will involve many progressive and iterative testing phases over the production of DynaBraille. The tests will be in the order of: ergonomics and aesthetics, basic device functionality, and finally, complete sufficient satisfaction of all planned requirements.

ENSC 405W Grading Rubric for ENSC 440 Planning Appendix

(5-10 Page Appendix in Design Specifications)

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project. Includes clear project background.	**/05%**
Scope/Risks/Benefits	Clearly outlines 440 project scope. Details both potential risks involved in project and potential benefits flowing from it.	**/10%**
Market/Competition/ Research Rationale	Describes the market for the proposed commercial project and details the current competition. For a research project, the need for the proposed system or device is outlined and current solutions are detailed.	**/10%**
Personnel Management	Details which team members will be assigned to the various tasks in ENSC 440. Also specifically details external resources who will be consulted.	**/15%**
Time Management	Details major processes and milestones of the project. Includes both Gantt and Milestone charts and/or PERT charts as necessary for ENSC 440 (MS Project). Includes contingency planning.	**/15%**
Budgetary Management	Includes a realistic estimate of project costs for ENSC 440. Includes potential funding sources. Allows for contingencies.	**/15%**
Conclusion/References	Summarizes project and motivates readers. Includes references for information from other sources.	**/10%**
Rhetorical Issues	Document is persuasive and demonstrates that the project will be on time and within budget. Clearly considers audience expertise and interests.	**/10%**
Format/Correctness/Style	Pages are numbered, figures and tables are introduced, headings are numbered, etc. References and citations are properly formatted. Correct spelling, grammar, and punctuation. Style is clear, concise, and coherent.	**/10%**
Comments:		

7. Appendix C (440 Plan)

7.1 Introduction

7.1.1 Background

In the modern day and age, being blind can be a big disadvantage and cause many difficulties in life. One of the biggest problems which the visually impaired face is the inability to read plain text. Our product is a hand-held assistive device which will revolutionize theirs lives by allowing them to instantly translate text braille. To date, Brailliant Solutions has determined DynaBraille's requirement specifications, outlined device design specifications, developed test plans, reviewed user interface design, and prepared a proof-of-concept. The next step is to begin physically prototyping DynaBraille based on our requirements and designs. Upon successful completion, we will then be able to start marketing, mass producing, and selling DynaBraille.

7.1.2 Purpose

This appendix entails the upcoming tasks and important notes pertaining to ENSC 440. ENSC 440 will involve replicating a prototype which emulates production versions of DynaBraille, and concludes with a demo which exhibits all the features of the aforementioned device. In contrast to the proof-of-concept, the prototype will have a polished enclosure, functional buttons, and all components shall fit nicely inside the box. Scopes, risks, and benefits will be addressed. Moreover, the current market and competition will be explored, establishing an objective research rationale. Roles and duties of team members will be clarified, and the projected time/budgetary management will be reviewed. Overall, the purpose of our project is to fully develop a revolutionary assistive device for the visually impaired to help them easily translate text to braille.

7.2 Scope/Risks/Benefits

7.2.1 Scope

The scope of ENSC 440 involves bringing to fruition the ideas behind DynaBraille, and expressing these ideas into a physical, tangible form. Over the next four months, the development team and Brailliant Solutions will dedicate their focus on fabricating a DynaBraille prototype which closely resembles ideal production versions. This involves setting up the final software inside the Raspberry Pi, hardware and all circuitry inside the enclosure, and adding physical touch ups to add to aesthetics. At the project's end, there will be a demo showcasing all the major features and uses of DynaBraille.

7.2.2 Risks

The risks which may be encountered the next four months in ENSC 440 comprises of similar risks in ENSC 405 and more. The risks include: technological/skill barrier which prevents the satisfaction of certain requirements, inability to finalize prototype within the four month time window, physical hazards accompanied with equipment usage, possible component damage or defects (which would impede development), reduced man power count due to sickness/personal problems, insufficient funding, and design flaws/problems. To mitigate the possibility of failing to meet deadlines, the team members plan to produce a strict project timeline with gratuitous leeway. The team will also hold weekly meetings to check up on progress and redistribute the workload where necessary.

7.2.3 Benefits

Economical benefits: Successful marketing and sales of this product will mean help to accrue a hefty profit for the company and stakeholders, as well as the build up brand/company reputation and more business opportunities.

Cultural benefits: With the successful completion of our product, DynaBraille will revolutionize the way visually impaired people are able to interact with the world. The need for people to accompany them will decrease significantly and they will be able to become more self sufficient. The ability to read any text on the fly is something that will benefit the visually impaired greatly and will improve their quality of life immensely.

7.3 Market Analysis

Based on existing data in 2010, there were 26 million people in the Americas and 28 million people in Europe who suffer from visual impairment [1]. Other data from 2011 suggest that over half the population in Europe and the Americas have upper-middle or high class income. A preliminary and simple extrapolation can be made, concluding that half of all blind people in these two regions can afford this product, and should be the target of this product. This number of blind people is also steadily growing overtime. This suggests that the market is trending upwards.

Although there are many blind people, the ratio of them is still relatively small. This means that advertisement and product awareness will be a difficult and expensive venture. We expect that sales potential will be much smaller compared to conventional products. To compensate, the device must be appropriately priced. According to the fact that there are competitors as well, the final polished version of this product should be priced around $300 to $500.

Competition includes direct competitors who are making text to text to braille scanners, as well as indirect competitors creating products which may decrease the need for our device. The existing direct competitors who make similar text to braille scanners possess the advantage of already being on the market, but their drawback is that they are not readily available, and they are all either quite bulky or extremely expensive. Indirect competitors include mobile applications which can perform text to speech, as its function is quite similar to a text to braille converter. These applications have the advantage of being free or inexpensive, however DynaBraille can be held and felt in the hands of the user, like a real braille parchment.

7.4 Personnel Management

Brailliant solutions consists of a diverse and talented group of engineering students from Simon Fraser University in Biomedical Engineering, Computer Engineering, and Systems Engineering: Homan Lam, Kevin Cheng, Daniel Tan, and Jeffrey Wong. Not only are we all hard workers, but we are also extremely passionate about our work and our products.

Homan has had previous internship experience working in hardware and software design, as well as experience working in highly agile company environments. As such, Homan Lam has been assigned the role of Team Lead, and will oversee the development of the project while also providing help in software or hardware components where required. Furthermore, his knowledge from biomedical engineering will help ensure human factors are adequately considered when developing physical components of the device.

Jeffrey is familiar with SolidWorks, and knowledge of programming, database, and electric circuits. Jeffrey has taken the role of a systems engineer, and will work on developing the physical enclosure of DynaBraille, in addition to providing assistance relating to system software development where needed.

Kevin has acquired prior experience as a software and hardware engineer intern. He possesses solid knowledge in the field of designing and testing electric circuits, and has also worked in an agile programming environment. From this profile, it was deemed appropriate to assign the role of a hardware engineer who focuses on the circuitry, but also provides support with software.

Daniel has extensive experiences working with software in past internships, and is acquainted with the ins and outs of software development and debugging. His primary expertise is coding in C++. Daniel has taken the mantle of a Computer Engineer, and will code DynaBraille's system software and firmware.

External consultation will come in the form of assistance from professors, teaching assistants, colleagues in the same field, and the visually impaired community. In particular, we will be consulting the Canadian National Institute For The Blind (CNIB) for specifics on user interface and functional design choices. These sources of assistance will help to ensure that DynaBraille is up to standards, safe, efficient, easy to use, and most of all, useful.

7.5 Timeline

Our project will follow a strict timeline defined by the gantt chart in figure C1. There is also a timeline chart along with certain milestones that give a better idea on the overall schedule of our project. As stated above this timeline must be followed strictly and our team will ensure that deadlines are met. Since we have low course loads for the next term, we are sure that we will be able to perform our duties as needed to assure the successful completion of our project.

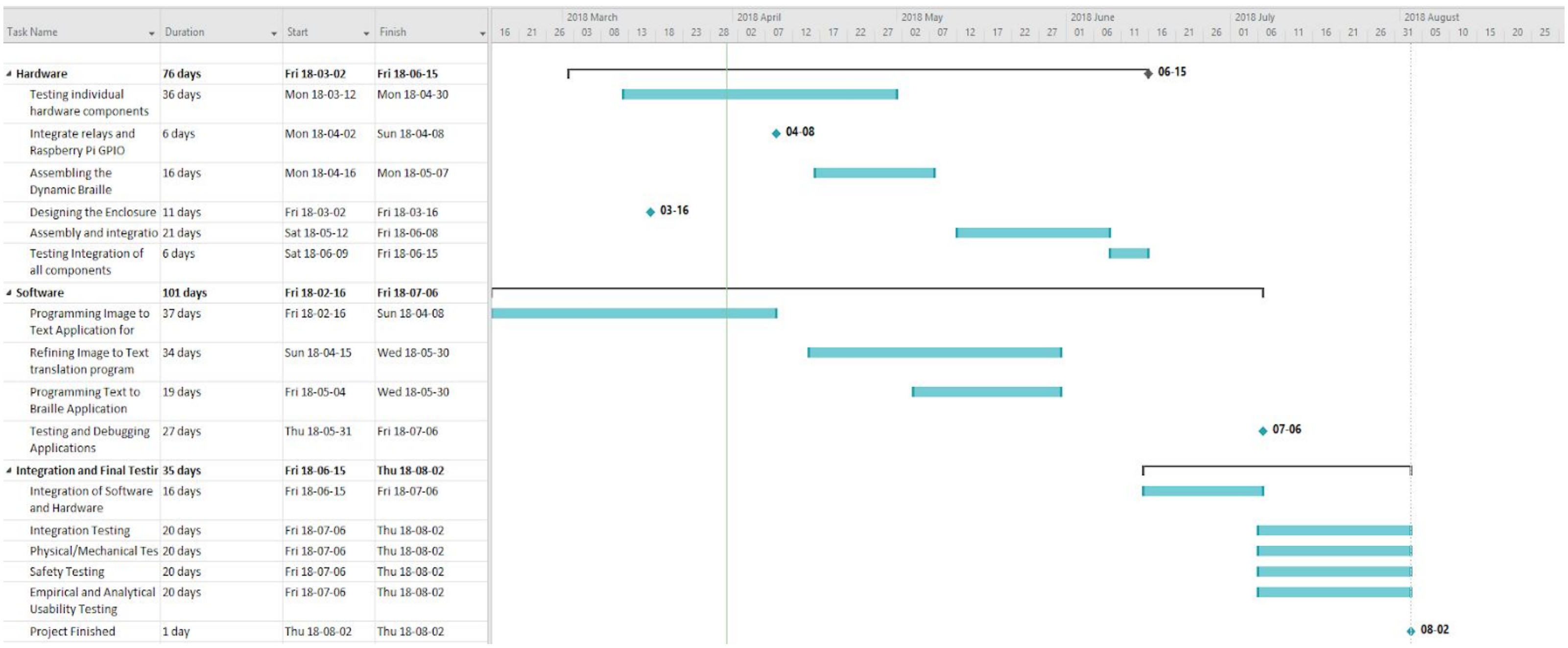

Figure C1. Gantt chart for 440 planning.

Along with the gantt chart, a timeline chart seen in figure C2 shows the overlap in tasks as well as milestone tasks to help us focus our efforts. This will also help ensure the successful completion of our project.

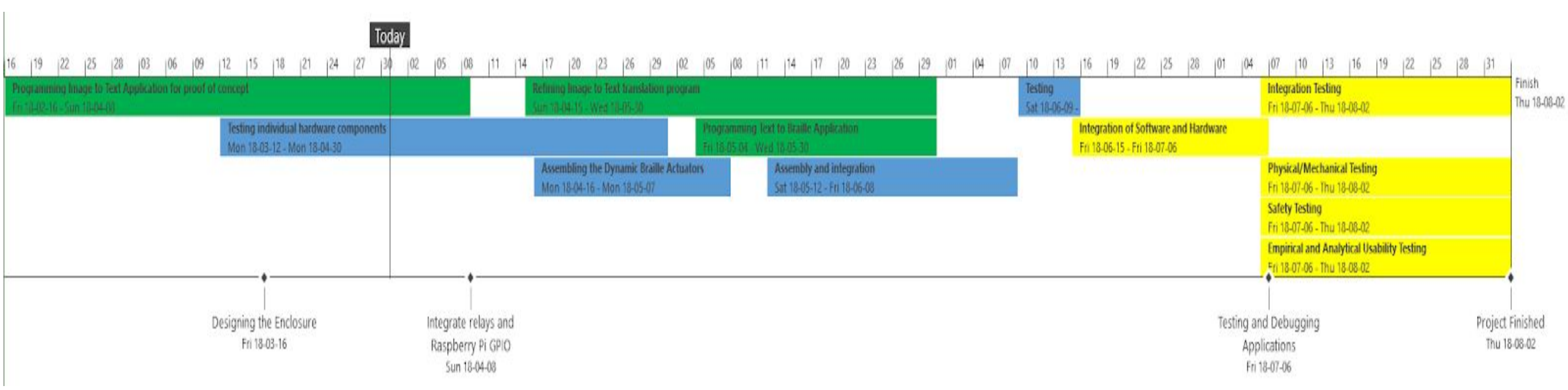

Figure C2. Timeline chart for 440 planning.

7.6 Budget

DynaBraille will mainly be composed of off the shelf components, due to the fact that they are readily accessible, relatively cheap, and have already been thoroughly tested by the respective companies which produce them. Table C1 shows a breakdown of the major components used in DynaBraille, and their costs.

Component	Quantity	Cost (CAD)
Raspberry Pi 3 Model B	1	60
Raspberry Pi Camera Module	1	30
Piezoelectric Actuators	12	60 (5 each)
Relays	4	20 (5 each)
Boost Regulators	2	16 (8 each)
Anker 13000 Battery Pack	1	40
3D Printed Enclosure	1	15
Copper Wires/Connectors	-	2
Contingency/leeway budget	25%	60.75
	Total Cost:	303.75

Table C1. Expenses for DynaBraille to date.

Altogether, the final cost is approximately $300. The members of Brailliant Solutions intend to acquire reimbursement via the Wighton funding program, with any extra finances required from our own company. There may some shifts in suppliers or parts, hence a contingency safety net of 25% is added into the calculations to compensate for any possible influxes in cost.

7.7 Conclusion

The current state of our proof-of-concept possesses basic functions such as being able to scan and store text as an array of characters, and actuate a single pin of a braille character. The enclosure has no interactive buttons, and contains only the mechanical part of one moving braille pin. Our Raspberry Pi is controlled externally by mouse and keyboard. The next phase involves beginning to physically prototype DynaBraille based on our requirements and designs. This appendix showed various updated planning needed to successfully prototype up to a final product.

We first explored the updated scope, risks, and benefits related to developing our prototype. Next, a revised market and competition analysis was conducted, establishing an updated objective research rationale. Afterwards, roles and duties of team members were clearly defined in order to explain how the exact device development is planned to occur. Finally, an updated projected timeline and budgetary management was reviewed and explained.

The final prototype at the end of this project's scope is expected to contain all our production version features. Components will be wired and partially insulated inside the enclosure, the device shell will be aesthetic and ergonomic, and the braille pins will all be fully functional. The entire device shall be powered by the Anker power supply, and the internal components shall be held in place by adhesives. Moreover, the usb slot and micro-usb charging port will be placed seamlessly against the side of the enclosure with dedicated cutouts.Overall, we aim to deliver a highly polished final prototype of DynaBraille which meets all our requirements and designs. Upon successful completion, we will be able to start marketing, mass producing, and selling DynaBraille.

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