February 21, 2018

Andrew H. Rawicz
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Re: Capstone Project Requirement Specifications for DynaBraille

Dear Dr. Rawicz:

Please find attached, Brailliant Solutions' requirement specifications for DynaBraille, which will give a basic overview of our Capstone project functionalities and requirements. 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 functionalities of DynaBraille. It consists of an overview of the product, system requirements, engineering standards, and safety/sustainability considerations. Using this document, we will be able to design 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' requirement 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

Functional Requirement Specifications for: DynaBraille

Team #12:

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Abstract

This requirement specification document will outline the requirements for DynaBraille. We will first go into detail concerning the functional requirements of our product. Next we will explain the engineering standard specifications concerning DynaBraille. Finally we will discuss the sustainability and safety factors. Through this document, the reader will gain a high level explanation of our product without in-depth details on how it works.

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.

Overall, there are three main sections in this document:

- The first main part of our document will go into detail regarding the system requirements of DynaBraille. This includes the general, electrical, mechanical, and software design requirements of our product along with the reasoning behind our decisions.

- Next, we will discuss the different engineering standards that DynaBraille will adhere to.

- Finally, we go into detail concerning considerations about the sustainability and safety issues regarding DynaBraille.

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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 indicates 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 details the software and hardware requirement 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 functional/non-functional requirements, engineering standards, and dependability (accuracy, sustainability, and safeness). The scope of this document includes all relevant details to the ideal build of DynaBraille, and involves details regarding different iterations of prototypes devices, as well as large-scale manufactured devices.

2. System Overview

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].

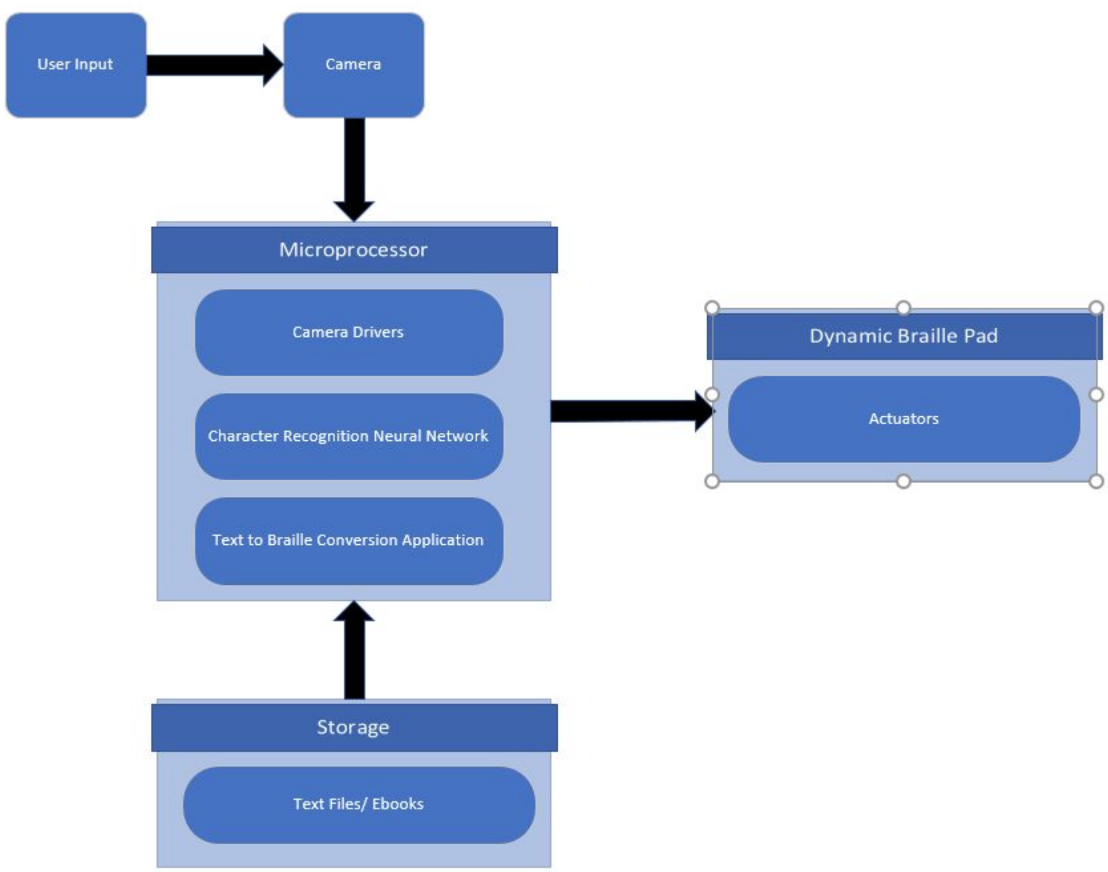

Figure 1. System overview of DynaBraille.

2.1 Text Scanner

The conceptualized physical design for DynaBraille is shown below in figure 2. The device consists of a handle to grip the device, a camera in front to scan text, a braille pad slightly below the camera where the index finger would naturally rest, and navigational buttons in the front where the thumb would naturally rest.The handle is designed to be ergonomic since ergonomics is an extremely important feature of frequently used devices [4], and in depth details of the mould will be ironed out at a later time with professional consultation. Since the device is meant to scan full pages of text at a time, copious amounts of room are dedicated towards the camera scanner to allow for inserting a camera capable of scanning full pages.

Figure 2: Physical Build of DynaBraille.

2.2 Dynamic Braille Pad

The dynamic braille pad will serve as the main output component of DynaBraille. This pad will consist of six actuators in a 2 by 3 cell used to emulate any braille character. The actuators will use piezoelectric materials which are lightweight, small, and low energy. Piezoelectric actuators were chosen by virtue of their extraordinarily slow wear, low power consumption, and low area requirement. Additionally, they have extremely fast response time, and detailed resolution of motion [5].

2.3 Data Processor

Our data processor will be the one responsible for the bulk of the work involving image processing and braille conversion. For our proof of concept, the Tesseract OCR open source library will be used along with its trained datasets to perform the character recognition from the provided image. The processor will then perform multiple steps of cleaning, denoising and aligning the image to improve the accuracy of the output. The output of the OCR will then be loaded into a braille translation application, which will be responsible for translating the input text into braille and pushing the corresponding pins to correctly and quickly display braille output to the user.

3. System Requirements

The following section will describe the requirements of the DynaBraille system designed by Brailliant Solutions. The requirements will be split up into the five sections, each with subsections of functional and non-functional:

- **G**eneral Requirements
- **P**hysical and Operational Requirements
- **H**ardware Requirements
- **F**irmware/Software Requirements
- **S**afety Requirements.

Classification

In order to create an easy to reference requirement section, the following convention as explained in figure 3 will be adopted:

[Req. A.b-XX] Device requirement.

A will refer to the section which the requirement is from, and **b** will refer to the requirement number. **XX** will refer to the stage of development which the requirement needs to be met in. Note that any requirements in the proof of concept will be in the prototype, and any requirements in the prototype will be in the final design.

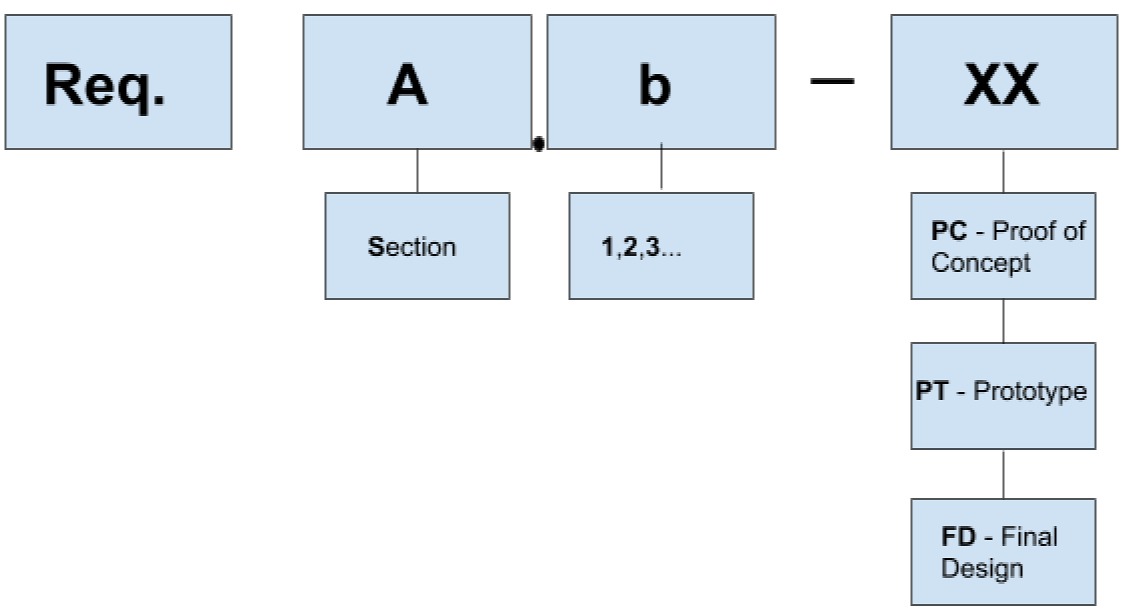

Figure 3. Reference naming convention.

3.1 General Requirements

General requirements for our device mostly consist of specifying the operating conditions that we expect our final product to be able to operate in, this includes weather, usability requirements, as well as cost and support requirements as a final finished consumer product. Also described is the main general functional requirements which is what we expect our product to do, along with the limitations of the product.

3.1.1 Functional requirements

[Req. G.1-PC]	The device shall be usable in a wide variety of temperatures
[Req. G.2-PC]	The device shall have a manageable and intuitive interface for the blind
[Req. G.3-PT]	The device shall be usable with either left or right hand
[Req. G.4-FD]	Device shall be accompanied with sufficient instructional material
[Req. G.5-FD]	The device shall be affordable [6]
[Req. G.6-FD]	Support for existing/potential customers shall be provided
[Req. G.7-FD]	The device must output braille quickly to the braille pad after selecting source of text
[Req. G.8-PC]	The device must be able to convert images with text to a text file
[Req. G.9-PC]	The device must be able to convert the text data into parsed characters and output it onto the braille pad
[Req. G.10-PC]	The device must be able to work on pictures taken at least 30cm away from the camera and will provide feedback if too far

3.1.2 Non-Functional requirements

[Req. G.10-PC]	The operating temperature of the system should be from 0° C to 85° C
[Req. G.11-PC]	The maximum operating altitude of the system should be 10,000 feet
[Req. G.12-FD]	Retail price of the final product shall not exceed $400
[Req. G.13-FD]	A physical user manual must be printed and shipped with the product. Localization of the manual will be done for major languages.
[Req.G.14-FD]	Real time 1-800 Technical support line and professional website provided to customers and general public
[Req.G.15-PT]	Latency between any actions should be no more than 0.25 seconds

3.2 Physical and Operational Requirements

The physical and operational requirements that are described here goes into more detail about the physical design and operational constraints of our product. We have done research and found out that having an ergonomic design will allow users to more comfortably use our product as well as for a longer period of time. The device interface and design will be centered around usability and acceptability [3].

3.2.1 Functional requirements

[Req. P.1-PT] The device shall be ergonomical to hold & not too heavy or lopsided [4]
[Req. P.2-PT] The device shall last a reasonable amount of time on batteries
[Req. P.3-FD] The device shall have a durable frame
[Req. P.4-FD] The device lifetime shall be reasonably long
[Req. P.5-FD] The device shall be waterproof for light splashes

3.2.2 Non-Functional requirements

[Req. P.6-PT] The center of mass is exactly centered in the grip, give or take 3 cm
[Req. P.7-PT] The device must weigh no more than 2 kilograms
[Req. P.8-FD] The device lasts at least 20 working hours on 2 double-A batteries
[Req. P.9-FD] The total device lifetime should be at least 2 years
[Req. P.10-FD] The device shall be watertight and have at least an IP53 specification [7]

3.3 Hardware Requirements

The hardware requirements listed here are critical because DynaBraille's device main attraction pivots around its functionality. They specify how text is translated into braille, how the braille is viably outputted to the user, and how many navigation buttons are to be used. For our proof of concept, we plan to output a single braille character on our device.

3.3.1 Functional requirements

[Req. H.1-PC] Camera must be able to scan full single full 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.3-PC] The microcontroller must have a convenient on board storage that's easy for the user to access
[Req. H.4-PC] Force exerted by each pin of the braille character pad must be strong enough to feel
[Req. H.5-PT] The braille character pad pins must be synchronized
[Req. H.6-PT] The braille character pad pins must be able to change positions quickly
[Req. H.7-PT] The device must have 3 navigational buttons
[Req. H.8-PT] The device must have an on/off switch in an easy to reach place
[Req. H.9-PT] Buttons on the device must read input correctly and not read false input

3.3.2 Non-functional requirements

[Req. H.10-PC] Camera has sufficient resolution to scan A4 sized letters legibly,
[Req. H.11-PC] Camera must be no bigger than 5 by 5 by 3 cm

[Req. H.12-PC]	The microcontroller must have a microSD slot and must support up to 256GB microSD cards
[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. H.16-PT]	Buttons must be debounced to ignore consecutive input within 100 milliseconds

3.4 Firmware/Software Requirements

The firmware requirements specify how input is received, processed, and sent to the hardware. These requirements have been chosen to optimize usability, speed, and efficiency, in that same order. For our design, we plan to use a raspberry pi instead of an arduino due to the heavy image processing that will be involved in the process. Along with that it also boasts a faster processor which allows for quicker computations. For our final product, we plan to design our own chip to optimize power and speed at the hardware level.

3.4.1 Functional requirements

[Req. F.1-PC]	Can use either scanned picture or archived file as source of text
[Req. F.2-PT]	Software does not crash or become unresponsive
[Req. F.3-PT]	Software can handle fast, frequent inputs to navigational buttons
[Req. F.4-PC]	Main processor capable of performing tasks consistently under all operating conditions
[Req. F.5-PT]	Software will perform image processing quickly
[Req. F.6-PT]	Software will convert outputted text from OCR into braille output quickly and efficiently

3.3.2 Non-functional requirements

[Req. F.7-PC]	Can accept .PNG and .JPEG picture formats from camera or storage, and Advanced image processing algorithms are used to
[Req. F.8-PT]	Software utilized is commercially reliable, and implemented algorithms are tested by the QA team thoroughly
[Req. F.9-PT]	Software must be able to handle frequent inputs and process them in at most 500 milliseconds
[Req. F.10-PC]	Raspberry pi, as its specifications meet the device specifications [8]
[Req. F.11-PT]	Software must finish all processing on the image in at most 2 seconds

[Req. F.12-PT]	Software must finish text to braille conversion in at most 1 second

3.5 Safety Requirements

The safety requirements are vital to the final production version, and is necessary to prevent danger from befalling our users. Safety will definitely be in our top priority when finalizing our design, and will take into account the high voltages necessary to drive the piezoelectric actuators. The requirements apply only to the device when used in the intended way, and these may not be covered under the case of misuse.

3.5.1 Functional requirements

[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
[Req. S.3-FD]	The device must have safety measures in case of excessive voltage

3.5.2 Functional requirements

[Req. S.1-FD]	The device is waterproof, and has a soft insulative exterior, as well as buttons in firm, fixed positions
[Req. S.2-FD]	The internal circuits has short circuit protection and components run at minimum necessary frequency (clock speed)

4. Engineering Standards

To create and market a dependable product, engineering standards are a necessity. These standards create a sense of confidence in our product and creates a normative reference to what our product promises. DynaBraille will be initially marketed and sold in Canada, with future plans to expand worldwide. Therefore, we will try to design it with Canadian engineering standards primarily, along with other standards. Our device is categorized as an assistive device, so medical device regulation requirements will not apply.

The standards that we use are taken from CSA and ISO as they are widely recognizable and very reputable standardization bodies. By the end of our prototype stage we are hoping to have met some of these standards, and by our production model we aim to meet all of our stated standards. The engineering standards chosen will be shown and described below in table 1.

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 [11]
CSA-C22.2 NO. 0-10	General requirements - Canadian electrical code, part II [12]
ISO 13854:2017	Safety of machinery -- Minimum gaps to avoid crushing of parts of the human body [13]
ISO 13850:2015	Safety of machinery -- Emergency stop function -- Principles for design [17]
ISO/DIS 21600	General requirements of mechanical product digital manual [15]
ISO/IEC Guide 46:2017	Comparative testing of consumer products and related services -- General principles [14]
ISO/IEC/IEEE 12207:2017	Systems and software engineering -- Software life cycle processes [16]
ISO 6196-5:1987	Micrographics -- Vocabulary -- Part 5: Quality of images, legibility, inspection [18]

Table 1. Engineering standards adhered to by DynaBraille.

5. Sustainability and Safety

5.1 Sustainability

The sustainability has been designed with the cradle-to-cradle life cycle in mind. Figure 4 shows the life cycle of our product.

5.1.1 Proof of concept/project prototype:

The prototype for the purposes of this project will consist of easy-to-acquire parts and software which adequately demonstrates the use of DynaBraille. Because of such, parts used will likely not be identical those used in large scale production. The prototype will be made up of easy-to-acquire parts which are only needed to last past the demonstration (and then some). Its spacing, software, and structure will be optimized only to the extent that is needed for the demonstration.

5.1.2 Production version:

In terms of reliability, the final production version of DynaBraille is intended to have a minimum target lifetime of one year, with the intent that only 1% of all fabrications will be defective before the one year period. All externally sourced parts and materials will be chosen such that they are the cheapest which can be acquired while still maintaining sufficient performance and a defect rate of much smaller than 1% under the specified operating and storage conditions of DynaBraille. The defect rate must be much smaller than 1% to ensure a safety net exists, as the chances of defect/failure increase multiplicatively with the addition of each component. Furthermore, the physical build and software algorithms will be reasonably optimized with ergonomics and efficiency in mind, respectively. There would be a series of designated quality assurance process for the software, hardware, and final product, to ensure the finalized device is up to standards.

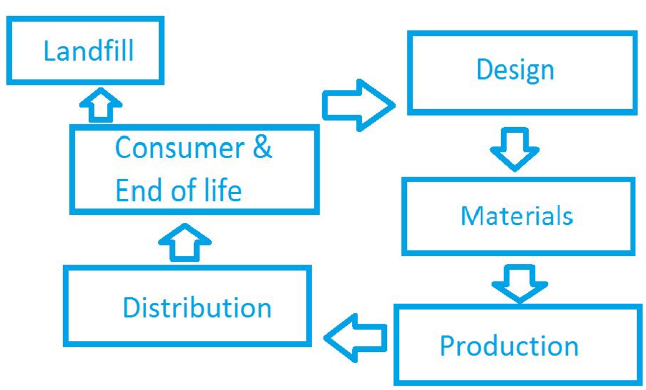

Figure 4: Life cycle of the product

5.2 Safety

5.2.1 Proof of concept/project prototype:

The prototype will be implemented with only the safety standards needed to prevent serious altercations, such as shocks, burns, and lacerations. The device will not be designed around minor safety issues such as minor pinches, uncomfortable temperatures, and uncomfortable grip.

5.2.2 Production version:

To ensure reasonable safety standards, the device will be designed to ensure harm that from the device should be rare if not non-existent. Based on Health Canada's risk-based system, the device is an active and non-invasive device which falls under Class I [9]. This means the device is relatively low risk. In order to further protect the users and meet certain standards, the product will be designed with safety in mind [10]. Since the device involves electrical power and moving mechanical parts, precautions will be taken to prevent the user from getting electrocuted, burned or pinched. Short circuit protection will be integrated into the hardware of the device, and the device will be sealed shut and waterproof. Since the software of DynaBraille requires only low effort computations, waterproofing the device will not exacerbate any heat issues. Moreover, the physical build will be arranged such that no pinching can occur while using the device.

Although the differences between the prototype/production version may result in deviations in cost (thus skewing numbers from preliminary pricing analysis), the scope of technology needed to meet DynaBraille's specifications are much within the scope of modern technology, and is likely to only drive up costs within reasonable limits.

6. Conclusion

Brailliant Solutions' aim is to create a small, convenient, and easy to use device which will improve a blind person's life by allowing them to read text by scanning and converting text into braille. By making this product, there are different kinds of requirements necessary to determine the device's functionality. The main sections of requirements which were provided are the following:

- **G**eneral Requirements
- **P**hysical and Operational Requirements
- **H**ardware Requirements
- **F**irmware/Software Requirements
- **S**afety Requirements.

In addition to the physical requirements for our product, we also need to make sure it conforms to the usability and acceptability in the market; therefore, engineering standards are necessary. They will ensure that the performance and safety requirements of our device will be on an acceptable level measurable through internationally recognized standardization bodies. The standards that we used were taken from CSA and ISO as they are highly reputable.

Moreover, these standards will help to make sure the device is carefully analyzed and capable of achieving the specified sustainability and safety requirements. We include a life cycle for the current device and major considerations for the production stage. The device will be designed to mitigate any possible damages to the user, and to last just long enough to minimize costs.

Finally, as noted by the design specification, the team members will provide clear goals toward the completion of each requirement. The procedure mentioned above is a formula used to aid us in ensuring the proof of concept device is developed properly and up to standard.

7. 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
IP	-	International Protection Marking
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

8. Appendix A: Proof-of-Concept

In order to demonstrate the feasibility of our product and to attract potential investors, we will provide a proof-of-concept by the end of the 4th month of our product development. Our proof-of-concept will show many of the main concepts involved in our device while additionally serving as a foundation to the prototype and production models. Here we will define our deliverables for DynaBraille's proof-of-concept :

1. Working 3x2 matrix of piezoelectric actuators with the ability to move each one as desired
2. Successful implementation of Tesseract open source OCR for translating images with text into plain text for good quality images.
3. Read output file from previous section and output some of the text to our braille output
4. Read a text file and convert some of its contents into corresponding braille output
5. Functional camera with the ability to take high enough resolution photos for testing of image to text translation.
6. Basic 3D printed enclosure to encompass our proof-of-concept device.
7. External storage as an accepted form of input to device.

9. References

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