SFWRENG 4G06 - System Requirements

Group: NextStep (Group 10)

Justin Rosner, rosnej1
Daniel Noorduyn, noorduyd
Mengxi Lei, leim5
Alexander Samaha, samahaa
Tishko Araz, arazt

Department of Computing and Software
McMaster University
October 18, 2021

Contents

List of Tables

List of Figures

1 Revisions

Revision Number	Date	Reason for Change
Revision 0	October 18, 2021	N/A

Table 1: Revision History

2 Project Drivers

2.1 Purpose

2.1.1 Purpose of the Project

The purpose of this project is to create a device that will help visually impaired users navigate around objects and hazards in their path. Currently, a visually impaired person would use a walking stick to help them navigate. A walking stick functions by providing tactile feedback to the user that something is in their way, and they can adjust their path. These walking sticks can be personalized to a user's preference and terrain to suit their needs. Our group aims to remove the need to have an object provide tactile feedback to the user. NextStep aims to replace it with a device that will provide navigational directions to a user, detect objects or hazards, determine its distance from the user and deliver that information along with directions to avoid it.

2.1.2 Purpose of the Document

The purpose of this document is to provide the functional and non-functional requirements for a device that will provide navigational directions, identify objects and hazards in a user's path and relay feedback and directions to the user. This will identify the application domain of the resulting product and provide a description of the resulting system to be developed. This document will serve as a baseline for subsequent design, development, testing, validation & verification activities and lay the foundation for future changes to requirements as the project develops.

2.2 Scope

NextStep will detect static objects and slow moving dynamic objects (such as a pedestrian) in a user's direct path and will identify what those objects are, their distance to the user and provide the appropriate course of action for the user to avoid them. NextStep will also communicate navigational direction to a user from a chosen destination. The device will be a wearable device that will communicate to the user using an audio output. Due to the device being a physical object, NextStep will have a physical battery that will need to be charged and used for a reliable amount of time during a single day.

NextStep is not meant to detect automobiles, intersections, construction zones and other road signs. These items are deemed out of scope and will not be worked on.

2.3 Stakeholders

2.3.1 The Client

The clients for NextStep are the instructor, Dr. Alan Wassyng, and the teaching assistants for the course SFWRENG 4G06.

2.3.2 The Users

NextStep is being developed to help individuals with a visual impairment. The product will require the user to be able to hear instructions being delivered by the product. It is also necessary for the user to be able to wear the product and remove it to be charged. So the user should be able to understand instructions on how to use the product and maintain it.

2.3.3 Other Stakeholders

Organizations and professionals that help people who are visually impaired have an interest in a device that is related to the field they work in. This may involve consulting these individuals to uncover tacit knowledge not obvious to the design team.

2.4 Naming Conventions and Terminology

The words in the table below can be found throughout the document. Clicking any of the words within the document will link back to this table if the reader requires clarification.

Name	Definition
SFWRENG 4G06	The Software Engineering Design IV - Capstone Design Project course administered by Dr. Alan Wassyng.
NextStep	The name of the product to be built.
Object/Obstacle/ Hazard	Interchangeably used throughout the document to refer to slow moving and stationary entities that the device will detect and warn a user about to prevent collision.
Path	Direction a user is traveling which is being monitored by the device.
Braille	A written language for blind people where the text is translated into patterns of raised dots.

2.5 Relevant Facts and Assumptions

2.5.1 Facts

- Visual impairment is defined as any loss of vision (partial or complete) which is not fixable by glasses. Our product's target audience aims to encompass all individuals on the spectrum of visual impairment.

2.5.2 Assumptions

- The user is able to understand or be taught how to wear the product and maintain it.
- The user does not have total hearing loss and can understand the instructions being delivered by the product.
- The user can understand and is comfortable receiving instructions in spoken english.
- The user will only be using the device while walking or stationary.

3 Normal Operation

3.1 Desired

To use NextStep, the user will put on the device and proceed to power it on. Once the device is powered on, it will notify the user that it is running and what the remaining battery life is.

If it is the first time the device is powered on, it will first provide auditory instructions on how to use the device. It will then prompt the user for certain personal information to calibrate the device in order to better detect and prevent collisions with obstacles in the user's path. Lastly, it will notify the user that the device is ready to be used and recommend the user to fully charge the device before each use.

After the device is powered on, it will start to use the sensors to detect the location and velocity of obstacles in the direct path of the user, and the velocity of the user. It will use this information to determine whether there will be a potential collision between the user and any of the aforementioned obstacles. If so, it will communicate and warn the user when the distance between the user and the obstacle is below a certain threshold.

When the device is powered on, the device will communicate to the user about its battery life when it drops to certain thresholds.

When the device is powered off by the user, it will notify the user through speech that the device is powered off.

3.2 Undesired

When the device is not worn properly, or the sensors are being covered or blocked, it will warn the user that the device cannot function properly and recommend that the user fix this before continuing to use it.

When using the device in areas with lots of fast moving obstacles around the user, the device will warn the user that the outputted result might not be desired and could be delayed.

4 Monitored and Controlled Variables

4.1 Constants

Constant Name	Value	Unit	Description
$d_{warning_{min}}$	0.5	m	Minimum allowed distance between the obstacle and user before warning the user about it.
$t_{warning_{min}}$	5	seconds	Minimum allowed expected collision time between the obstacle and user before warning the user about it.
$S_{min\_detection}$	0.01	m	Minimum object detection size.
$S_{min\_distance}$	0.1	m	Minimum object separation.

Table 2: Constants Table

4.2 Monitored Variables

Monitored Name	Type	Unit	Description
$d_{obstacle}$	Distance[ ]	m	Array of distances between the obstacles and the user.
$a_{obstacle}$	Angles[ ]	degree	Array of degrees of where the obstacles is located with respect to the user.
$v_{obstacle}$	Velocity[ ]	m/s	Array of velocities of the obstacles.
$p_{battery}$	Percentage	%	Percentage of battery life remaining.

Table 3: Monitored Variables Table

4.3 Controlled Variables

Controlled Name	Type	Unit	Description
v_{self}	Speed	m/s	Movement speed of the user who is wearing the device.
$a_{turning}$	Angle	degree/s	Turning angle of the user who is wearing the device.
$destination_{final}$	Location	Latitude and Longitude (degrees)	The users inputted final desired destination.
height	Height	m	The height of the user
width	Width	m	The width of the user
vol	Volume	decibels	The volume that NextStep uses to communicate.
word_speed	WordSpeed	wpm	The rate at which NextStep communicates at.

Table 4: Controlled Variables Table

5 Context Diagrams

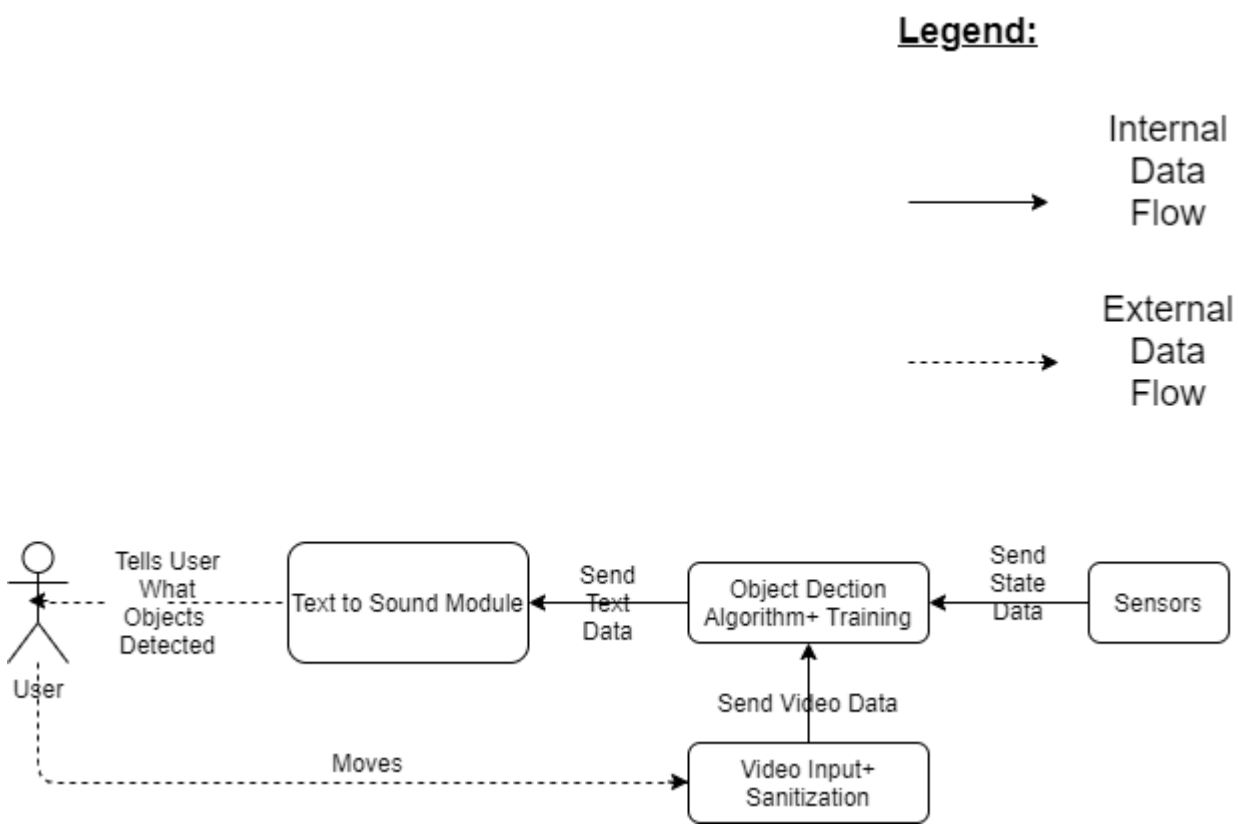

Figure 1: Context Diagram to show interacting bodies with outside world

6 Functional Decomposition Diagrams

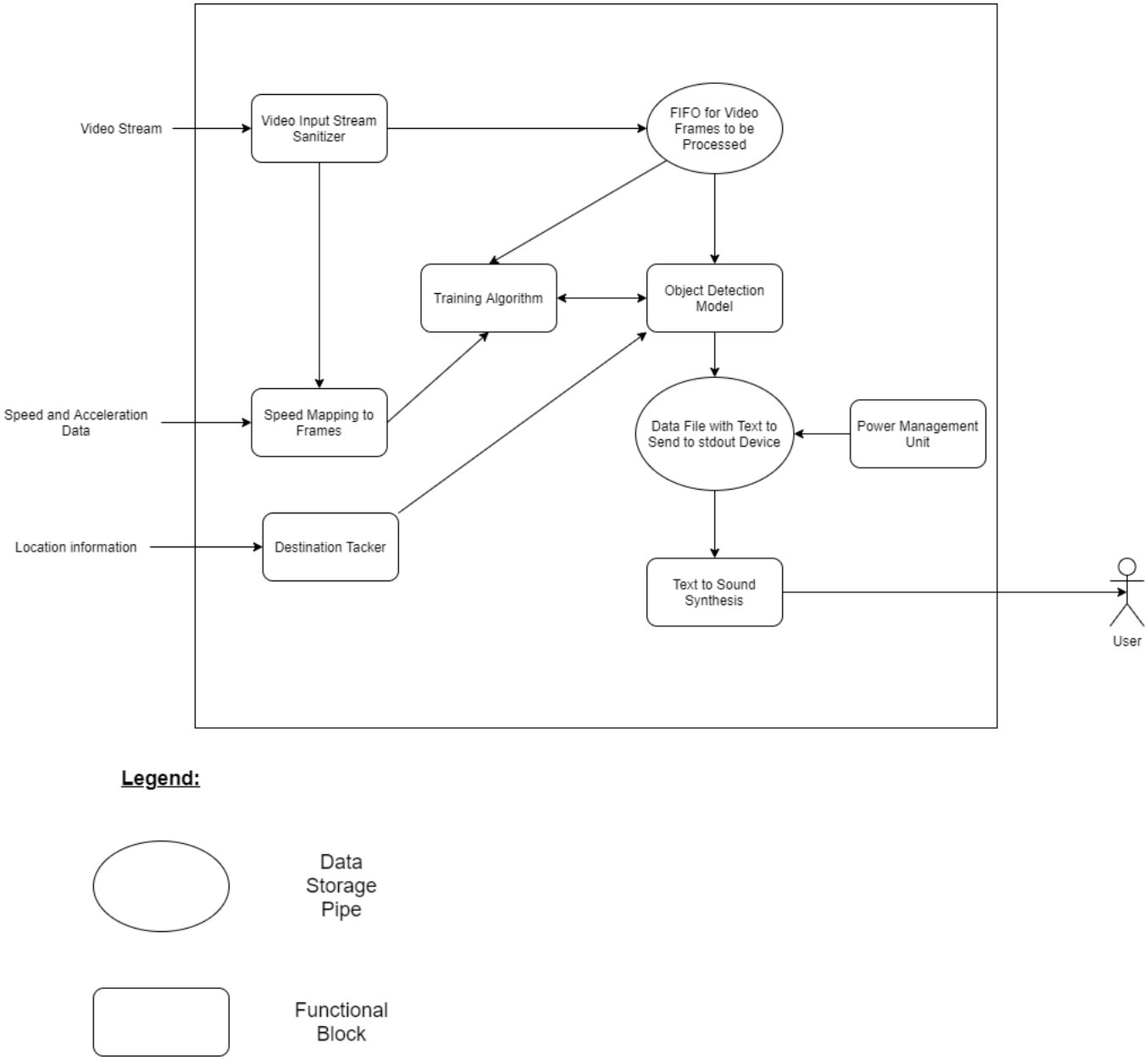

Figure 2: Shows inner interacting components within system

7 Functional Requirements

The following system requirements outline the desired basic functionalities that NextStep will need to implement.

FR1	NextStep must be able to detect when an object is in the path of the user.
Rationale	NextStep should be able to prevent users from walking into objects.

FR2	NextStep must be able to orally communicate with the user.
Rationale	The user will be visually impaired and audio communication is more practical than braille when the user is walking around.

FR3	NextStep must be able to communicate to the user what actions they must take to avoid hitting the object in front of the user.
Rationale	NextStep's purpose is to be able to guide users through a variety of obstacles to reach their destination safely without hitting anything.

FR4	NextStep must communicate to the user when the remaining battery level ($P_{battery}$) reaches 10%.
Rationale	Since users will be relying on NextStep to navigate the world, having the device die on them suddenly would leave them stranded. Communicating when there is only 10% battery left will give the user time to make it back home, or find a place to charge the device.

FR5	NextStep must communicate to the user when they have reached their final destination ($destination_{final}$).
Rationale	Without this functionality, users will never know when they have reached their destination, and would continue to walk until they receive feedback from an external source.

FR6	NextStep will communicate with the user when to make turns onto streets.
Rationale	NextStep will function as both an object detection device and as a map-like service. Telling the users what streets to turn onto and when, enables the user to eventually reach their final destination.

FR7	When there are multiple objects in the path of the user, NextStep must communicate the objects back to the user in order of which objects are closest using the array of distances in $d_{obstacle}$.
Rationale	The user will need to act on the closer objects before the further ones.

FR8	NextStep must allow for the user to enter in a final destination ($destination_{final}$) that they wish to travel towards.
Rationale	This step allows for NextStep to relay the proper directions back to the user to aid them on their travels.

FR9	If there is no way to move forward around an object (think of approaching a wall), NextStep must inform the user that their path is blocked and ask them to rotate 90 degrees ($a_{turning}$) (to the left or right) to try and find a new path.
Rationale	If every forward path is blocked, we don't want the product to crash and stop working. We want the NextStep to be able to find a way around the obstacle and get the user back on the path to their final destination.

FR10	The user should be able to change the final destination ($destination_{final}$) at any point of their journey.
Rationale	The user may change their mind as to where they are going at any point of the journey, and should not be forced into completing a trip which they no longer wish to make.

FR11	The user should be able to cancel the destination that they chose to travel towards ($destination_{final}$) at any point in their journey.
Rationale	The user may change their mind at any point of their journey and wish to cancel navigation, and should not be forced into completing a trip which they no longer wish to make.

FR12	The user must be able to input their height and shoulder width (*height* and *width*) into NextStep.
Rationale	Knowing the users' size will help NextStep properly determine how much movement is needed to avert running into an object currently blocking the path of the user.

FR13	The user must be able to adjust the volume of NextStep (*vol*).
Rationale	If the user is in a busy public setting they need to be able to properly hear NextStep in order for the product to be of any use for them.

FR14	If the mechanism used to detect objects is malfunctioning, NextStep must inform the user of this.
Rationale	The user should not continue to rely on NextStep as their only source of guidance in the scenario where object detection is malfunctioning.

FR15	The time between when NextStep detects an object and when it relays this information to the user must be less than 1 second.
Rationale	The real world is constantly changing, so just because NextStep detected an object in a certain location in one second is no guarantee that it will be there the next. To minimize this risk of reporting false information to the user, we want to relay to them the location of the object as soon as possible.

FR16	The rate at which NextStep communicates with the user (*word_speed*) will be adjustable.
Rationale	Different users may have different levels of verbal comprehension and may will only be able to understand slower speech. Conversely, some users may prefer to use a higher words-per-minute rate so that they can receive faster information.

FR17	NextStep must not communicate objects blocking the path if they are less than $S_{min\_detection}$.
Rationale	NextStep should not report on things like raindrops, snowflakes, or tiny insects that may be in the path of the user.

FR18	If there are enough small objects less than $S_{min_detection}$ clustered together (clustered means that they are within $S_{min\_distance}$ of one another), NextStep must treat these as one larger object.
Rationale	This would cover cases like when you have a swarm of tiny insects that you would wish to avoid.

FR19	When NextStep directs the user to make a move to avoid running into an object, these directions must not direct the user into another obstacle.
Rationale	Directing the user away from one obstacle right into the path of another is of no functional use to the user.

FR20	NextStep will communicate to the user when it is turning off.
Rationale	The users of NextStep may not be able to visually see that they turned off the device, and need some form of confirmation.

FR21	NextStep must be able to communicate to the user how to use the device properly.
Rationale	The first time a user uses NextStep they may need directions on what the proper usage looks like.

FR22	NextStep must be able to detect the velocity of the user (v_{self}).
Rationale	This velocity is needed to determine when the user will potentially run into objects.

FR23	NextStep must be able to detect the velocity of objects in the path of the user ($v_{obstacle}$).
Rationale	The velocity is needed in order to determine when an object would potentially hit the user of NextStep.

FR24	NextStep must provide the user with any information about obstacles 5 seconds before the user makes potential contact ($t_{warning_{min}}$).
Rationale	This gives the user enough time to properly react before potentially running into any obstacle.

FR25	NextStep must continue to provide the user with updated information about an obstacle every second after the initial communication is relayed to the user.
Rationale	This gives the user the most up to date information about the obstacle to make a proper decision before running into the obstacle.

8 Functional Requirements Likelihood

Requirement	Likelihood of Change	Rationale	Ways to Change
FR1	Very Unlikely	Fundamental component of the product.	N/A
FR2	Very Unlikely	Fundamental component of the product.	N/A
FR3	Very Unlikely	Fundamental component of the product.	N/A
FR4	Unlikely	This is dependent on how long the remaining 10% of the battery will last. If the 10% only lasts for 10 minutes, then this will potentially not be enough time for the user to make it somewhere to charge the device.	The 10% will have to be adjusted either higher or lower to accommodate the time it would take for the user to make somewhere to charge the device.
FR5	Very Unlikely	Fundamental component of the product.	N/A
FR6	Very Unlikely	Fundamental component of the product.	N/A
FR7	Very Unlikely	Fundamental component of the product.	N/A
FR8	Very Unlikely	Fundamental component of the product.	N/A
FR9	Very Unlikely	Fundamental component of the product.	N/A
FR10	Very Unlikely	Fundamental component of the product.	N/A
FR11	Very Unlikely	Fundamental component of the product.	N/A
FR12	Unlikely	Users may be uncomfortable entering in personal data about themselves.	The product could assume a standard width, and then add a buffer zone that would accommodate users of all sizes.
FR13	Very Unlikely	Fundamental component of the product.	N/A
FR14	Very Unlikely	Fundamental component of the product.	N/A
FR15	Very Unlikely	Fundamental component of the product.	N/A
FR16	Unlikely	NextStep communicating at a rate too slow or too fast could lead to the user missing out on some critical information.	Remove the choice to choose the speaking speed, and just have the user stick with the default option.
FR17	Very Unlikely	Fundamental component of the product	N/A
FR18	Unlikely	The objects that are clustered could disperse. If treated as one, this could cause the user to run into one of the moving objects.	Treat all objects individually, regardless of size and proximity to one another.

FR19	Very Unlikely	Fundamental component of the product.	N/A
FR20	Very Unlikely	Fundamental component of the product.	N/A
FR21	Unlikely	It may be decided in the future that an instruction manual separate from the product is more efficient way of relaying information to the user.	The instructions for NextStep may be in an instruction manual instead of being verbally communicated to the user using NextStep.
FR22	Very Unlikely	Fundamental component of the product.	N/A
FR23	Very Unlikely	Fundamental component of the product.	N/A
FR24	Very Unlikely	Fundamental component of the product.	N/A
FR25	Very Unlikely	Fundamental component of the product.	N/A

9 Non-Functional Requirements

9.1 Look and Feel Requirements

9.1.1 Appearance Requirements

LF1	The wearable sensors must appear almost not noticeable when the user is wearing them.
Fit Criteria:	Out of 10 people observing the final product, 9 must not notice the sensors before 2 seconds.
LF2	The physical device shall have no exposed electrical components.
Fit Criteria:	N/A

9.1.2 Style Requirements

LF3	The fashion item the sensors will be a part of must fit with the fashion of today.
Fit Criteria:	The item chosen and modified must be able to be purchased from a general clothing store.

9.2 Usability and Humanity Requirements

9.2.1 Ease of Use Requirements

UH1	The product shall be usable by anyone over the age of 12.
Fit Criteria:	From putting on the product to engaging full functionality takes 1 minute after the first 5 uses.
UH2	Those who are visually impaired must be able to set up the device for use just as well as those who aren't.
Fit Criteria:	Someone who isn't visually impaired takes +/- 10 seconds to set up device compared to someone who is.

9.2.2 Personalization and Internalization Requirements

UH3	The wearable aspect of the product must be customizable to fit different people.
Fit Criteria:	In a random sample of 15 people, the device must fit well for 13.
UH4	The product must work in North America.
Fit Criteria:	In a product test of 100 people spread across North America, 75% must report that the device recognized 95% of all obstructing objects.

9.2.3 Learning Requirements

UH5	After hearing a description of the device and a walk-through of how it works, the user should be able to use the device help free.
Fit Criteria:	In a random sample of 10 people, 9 people can use it after the initial explanation and 50% of the 9 people must rate their experience favourable in terms of ease of use.

9.2.4 Understandability and Politeness Requirements

UH6	The product's initial explanation and any other verbal cues must be understood by the user.
Fit Criteria:	Out of a sample of 20 English speaking people, 80% must rate their experience favourable regarding clarity and understanding of the information the device is relaying.

9.2.5 Accessibility Requirements

UH7	The product packaging must be easily opened by visually impaired people.
Fit Criteria:	In a test of 10 people, 9 open the product within 30 seconds.
UH8	The product must come with braille on the packaging to help those visually impaired identify what it is.
Fit Criteria:	Out of 10 people in a test who can read braille, 10 can determine what the package is purely based on the braille within 5 seconds.

9.3 Performance Requirements

9.3.1 Speed Requirements

PR1	The product must inform the user of an obstructing obstacle in enough time in advance to avoid a collision.
Fit Criteria:	There must be a warning a minimum of 5 seconds before intersection with an obstructing obstacle.
PR2	The product must boot up within 10 seconds of powering it on.
Fit Criteria:	N/A

9.3.2 Safety-Critical Requirements

PR3	The physical product must have no sharp edges that can cause physical harm to the user.
Fit Criteria:	N/A
PR4	The physical product must be made of materials that aren't harmful to the human body.
Fit Criteria:	N/A

9.3.3 Precision Requirements

PR5	The product must correctly identify where the obstructing obstacles are with a certain level of confidence.
Fit Criteria:	In 10 tests lasting 30 minutes of simulated real-life use, 90% of all obstacles must be correctly identified.

9.3.4 Reliability or Availability Requirements

PR6	The product must be able to function for 3 hours of real-life use.
Fit Criteria:	N/A

9.3.5 Robustness or Fault-Tolerance Requirements

PR7	The product shall not crash when multiple obstacles are in front of the user.
Fit Criteria:	In a test of 10 simulated scenarios with up to 10 obstacles placed in the path of the user, the product functions without crashing 100% of the time.
PR8	If the product cannot identify where the obstructing obstacle is, it can still inform of its general vicinity.
Fit Criteria:	N/A

9.3.6 Capacity Requirements

PR9	The product shall be able to function for one user.
Fit Criteria:	N/A

9.3.7 Scalability or Extensibility Requirements

PR10	The product shall be easily upgrade-able to add features or increase the amount of objects it can recognize.
Fit Criteria:	N/A

9.3.8 Longevity Requirements

PR11	The product must have a guaranteed life-time of 5 years.
Fit Criteria:	N/A

9.4 Operational and Environmental Requirements

9.4.1 Expected Physical Environment

OE1	The product shall run on some embedded processor.
Fit Criteria:	N/A
OE2	The product shall run in conjunction with sensors.
Fit Criteria:	N/A

9.4.2 Requirements for Interacting with Adjacent Systems

N/A

9.5 Maintainability and Support Requirements

9.5.1 Maintenance Requirements

MS1	The product shall be maintained by developers until early April, 2022.
Fit Criteria:	N/A
MS2	The product shall receive updates to fix bugs and increase the ability to recognize obstacles.
Fit Criteria:	N/A

9.5.2 Supportability Requirements

MS3	The product shall be come with minimum viable documentation in the form of braille as well as access to more robust auditory documentation online (access via text to speech).
Fit Criteria:	N/A

9.5.3 Adaptability Requirements

N/A

9.6 Security Requirements

9.6.1 Access Requirements

SR1	The product's source code is proprietary and shall not be accessed by anyone but the developers.
Fit Criteria:	N/A

9.6.2 Integrity Requirements

SR2	All possible user data shall be stored locally on the device.
Fit Criteria:	N/A

9.6.3 Privacy Requirements

SR3	All personal user data cannot be accessed by anyone by the user.
Fit Criteria:	The user data shall be password protected and stored locally.

9.6.4 Audit Requirements

N/A

9.6.5 Immunity Requirements

SR4	Official updates shall come directly from the developers.
Fit Criteria:	N/A
SR5	The developers will have no access to personal data of the user.
Fit Criteria:	N/A

9.7 Cultural and Political Requirements

9.7.1 Cultural Requirements

CR1	The product shall not contain any controversial content.
Fit Criteria:	N/A
CR2	The product shall use Canadian English spelling and English speaking language.
Fit Criteria:	100% of all wording on packaging and product shall be Canadian English. 100% of all speaking must be in English.

9.7.2 Political Requirements

N/A

9.8 Legal Requirements

9.8.1 Compliance Requirements

LR1	The product shall not violate any copyright laws under Canadian Law.
Fit Criteria:	N/A
LR2	The product shall give credit to any and all content that was not originally created by developers to previous developers or companies.
Fit Criteria:	N/A

9.8.2 Standards Requirements

N/A