ENSC 305W/440W Grading Rubric for Functional Specification

Criteria	Details	Marks
Introduction/Background	Introduces basic purpose of the project.	**/05%**
Content	Document explains the functionality of the proposed product without excessive design content (i.e., outlines the "what" rather than the "how").	**/10%**
Technical Correctness	Ideas presented represent valid functional specifications that must be considered for a marketed product. Specifications are presented using tables, graphs, and figures where possible (rather than over-reliance upon text).	**/15%**
Process Details	Complete analysis of problem. Justification for chosen functionalities. Sources of ideas referenced. Specification distinguishes between functions for present project version and later stages of project (i.e., proof-of-concept, prototype, and production versions). Comprehensively details current constraints.	**/20%**
Engineering Standards	Outlines specific engineering standards that apply to the device or system and lists them in the references.	**/10%**
Sustainability/Safety	Issues related to sustainability issues and safety of the device are carefully analyzed. This analysis must cover the "cradle-to-cradle" cycle for the current version of the device and should outline major considerations for a device at the production stage.	**/10%**
Conclusion/References	Summarizes functionality. Includes references for information from other sources.	**/05%**
Presentation/Organization	Document looks like a professional specification. Ideas follow in a logical manner.	**/05%**
Format Issues	Includes letter of transmittal, title page, executive summary, 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.	**/10%**
Correctness/Style	Correct spelling, grammar, and punctuation. Style is clear concise, and coherent. Uses passive voice judiciously.	**/10%**
Comments		

October13th, 2013

Prof. Lakshman One
School of Engineering Science
Simon Fraser University
8888 University Drive,
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RE: ENSC440 project Functional Specification for Smart Walker System

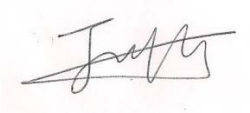
Dear Prof. One,

The enclosed document is the functional specification for our new product Smart Walker. The product is intended to help disabled or elders to keep their bodies balance and avoid obstacles at the front when they are walking. The new device has several main features, including basic walker function, obstacle detection, auto-brake function, and warning function.

The functional specification provides an outline of the high-level requirements on the product. All components of the product shall be designed to meet the minimum requirement according to this document. Also, this document is aimed to be a reference when the product development gets into the integration and testing stages.

Our company NBS^2 Solution has four motivated and enthusiastic founders who are majoring in electronic and systems engineering: Junfeng Xian, Hong kyu Ahn, Andy Back, and Seung Yeong Park. We believe that our dynamic team is able to accomplish the project within the intensive schedule. If you have any questions regarding our functional specification, please feel free to contact us via email at *jxian@sfu.ca* or phone at *778-862-7238*.

Sincerely,



Junfeng Xian
Chief Executive Officer
NBS^2 Solution

Enclosure: *Functional Specification for Smart Walker System*

NBS^2 Solution

Functional Specification: Smart Walker

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EXECUTIVE SUMMARY

Today, more than 6.5 North Americans over the age of 65 have a severe visual impairment [1]. Furthermore, one research shows that the vision loss rate is expected to double by 2030 as the boomers age, which means that lots of elders will have problems doing daily tasks, especially whenever they want to move around [2].

The Smart Walker is a roller walker that provides assistance for elders who are visually challenged. Every time the elders are on a stroll, the product will allow the elders to get alerted, whenever there is an obstacle ahead on the road, with a sound and visual notification on the screen of a smartphone or a tablet attached to the product.

Our product will include distance sensor to detect an obstacle, a camera to capture the picture and a brake system for emergency purposes. Elders can use their own smartphone or a tablet and run our Android application to access all the information, which will be transferred via Bluetooth.

In order to increase the work efficiency, the development cycle for the Smart Walker will use the Agile Methodology. The prototype is expected to be completed by the end of November, and should be ready to be demonstrated in December.

This document will outline the hardware and software functional specifications for the Smart Walker. In addition to all the requirements for various areas, it will also cover the user documentation and the test plan.

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1. INTRODUCTION

Nowadays, the rate of an aging population is increasing rapidly worldwide. Evidently, the increasing number of elderly people is in need of devices that will help, support and protect them. A walker is one of the devices that help and support elders to move and walk; however, this device might be too dangerous for many elders who have visionary difficulties. NBS^2 Solution is going to implement the walker in a way that users can get enough protection from potential dangers by detecting obstacles on the way. Once any obstacles are detected in front of the walker, various warnings, such as visual warning and mechanical warning, will alert the user to avoid the obstacles.

1.1 Scope

This functional specification document describes the functional requirements for the walker device. The priority of requirements is determined to ensure the crucial functionalities are met. Some minor modifications will be updated during the development and testing process.

1.2 Intended Audience

The intended audience for this document is the members of NBS^2 Solutions. The members will ensure to meet the all the design requirement listed in this document. Also, this document will be used to estimate and verify the expected progress during the development and testing cycle.

1.3 Classification

This document uses the following convention for the numbering and prioritization of the function requirements:

[R*n* - *p*] A specific functional requirement

Where *n* denotes the requirement number and *p* indicates the specification priority.

The following will explain further for the priority *p*;

I - These requirements are high priority and they have to be met in order to function our device. These functions are listed and examined at present project version as for the proof of concept.

II - These requirements are medium priority and necessary to meet to make the device marketable. These functions will be integrated for the prototype at the later stage of the project.

III - These requirements are low priority and they will be added after meeting all higher priority functions for the production versions.

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2. SYSTEM REQUIREMENTS

In this section, the system overview of Smart Walker is outlined. A list of specified general requirements, physical requirements, electrical and mechanical requirements, safety requirements, and usability requirements are explained.

2.1 SYSTEM OVERVIEW

The number of elderly people who are in need of the supportive devices is exponentially increasing. These devices have to aid elderly people to do their daily basic activities safely. A walker is one of the devices to help elders walking outside; however, many of walkers do not offer any safety features. For example, the existing walker is too dangerous for many elderly people with vision problems to use. Also, the existing walkers lack of any safety features for the night use when it's dark. For this reason, we are going to create a device that detects any dangerous obstacles or staircases and warns elders to protect themselves from any potential dangers.

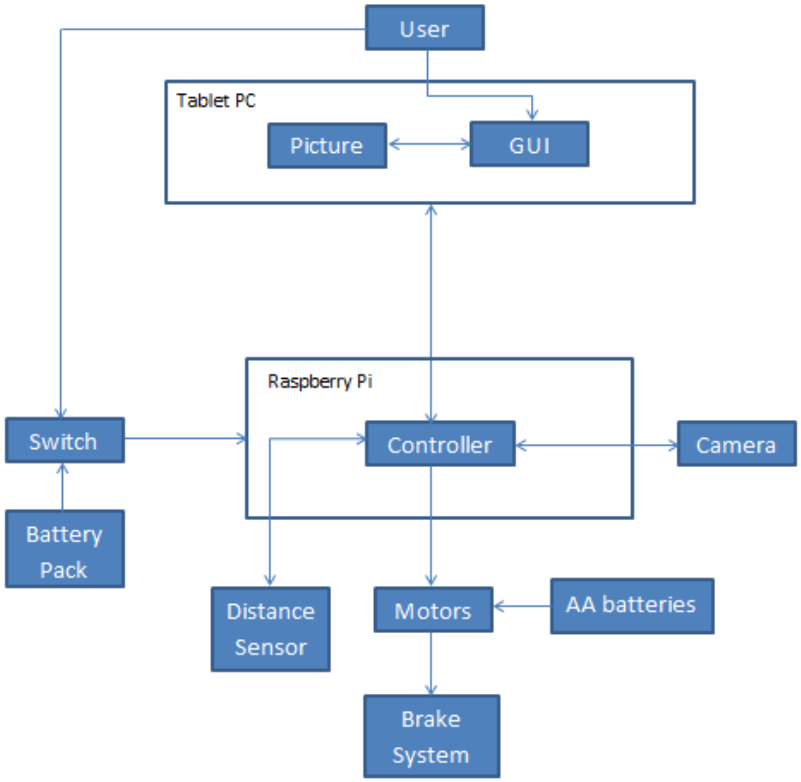

FIGURE 1 BLOCK DIAGRAM FOR SYSTEM OVERVIEW

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Our project consists of three major design components: the auto-brake system, the obstacle detection and the user interaction applications. The main functionality of the auto-brake system is to protect and warn the user by slowing down the speed of the walker. The obstacle detection will generate the warning signal once any obstacles are detected in front. This warning signal will operate stepper motors through Raspberry Pi and the stepper motors will apply an adequate amount of torque to initiate the auto-brake.

The obstacle detection part will detect any obstacles in front of the device through distance sensors. The certain amount of distance change will generate the warning signal. These sensors will also be interfaced with Raspberry Pi. The sensitivity of the sensors will be determined and modified during the testing process.

The user interaction application will provide useful information including maps and weather during the normal operation. When any obstacles are detected, a visionary warning will be displayed and the obstacle will be viewed on a tablet using the camera module attached to Raspberry Pi.

2.2 GENERAL REQUIREMENTS

[R1 - I] The system needs to have a notification system when there is an obstacle in front of the walker

[R2 - I] The device must be fixed tight to the walker so that it does not become loose in which it may cause false detections

[R3 - II] The device must have power switch to easily turn ON and OFF

[R4 - II] The final device must cost about $400 CAD

[R5 - III] The device attached to the walker should not weigh more than 1kg since it is used for elders or people with physical difficulties

2.3 PHYSICAL REQUIREMENTS

[R6 - I] Distance sensors must be adjustable in order to detect various types of obstacles

[R7 - III] The size of walker should meet the rolling walker standard

[R8 - II] The walker and devices will weigh less than 10 lbs

[R9 - II] The walker and devices will not have sharp edges

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2.4ELECTRICAL REQUIREMENTS

[R10 - I] The system must consistently detect the distance from the walker to the ground

[R11 - II] Camera should take a picture when the distance sensor detects abnormal objects in front

[R12 - III] Raspberry Pi is connected with a tablet via Bluetooth

[R13 - I] The device should be battery powered

[R14 - I] The device battery will be able to last for at least 5 hours of continuous time

2.5MECHANICAL REQUIREMENTS

[R15 - I] The stepper motors will rotate to put a brake on the wheels

[R16 - III] The stepper motors will operate at the voltage between 5V to 12V

[R17 - I] Mechanical components will not be physically obstructive

[R18 - I] The brake should be applied gradually to stop the patient pleasingly

2.6 SAFETY REQUIREMENTS

[R19 - I] All electronic components including distance sensors and motors must be securely fastened on the walker

[R20 - III] Electrical cable will not be exposed

[R21 - II] The device will contain a quick power switch

2.7 USABILITY REQUIREMENTS

[R22 - III] The device will be easily disassembled and the parts should be replaceable

[R23 - I] The software usage will be as simple as possible to accommodate elders

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3. AUTO-BRAKE SYSTEM

The auto brake system is the combination of mechanical and electrical hardware part. The purpose of the auto brake system is to receive specific signals from Raspberry Pi and operate the brake accordingly. This auto brake is intended to warn the user mechanically by reducing the speed of walker. This system will include two stepper motors positioned on right and left wheels and these motors will be connected to the rubber brake pads.

3.1 GENERAL REQUIREMENTS

[R24 - I] Must reduce the speed sufficiently for users to recognize the reduction

[R25 - III] Must cost less than $100 including motors, dedicated power supplies with batteries and brake pads

[R26 - I] Must operate as soon as the warning signal is received

[R27 - II] Must be able to control the speed and the direction of motors

[R28 - I] Must release the brake once users notice the obstacle warning

[R29 - III] Battery must be either replaceable or rechargeable in case using a dedicated power source

3.2 PHYSICAL REQUIREMENTS

[R30 - I] Must be attachable to the design of the walker

[R31 - III] Must be small enough

[R32 - III] Might be covered by hard case for the purpose of protection

3.3 ELECTRICAL REQUIREMENTS

[R33 - I] Use 4-6 AA batteries for 5-7.2V inputs for the motors depending on the required torque

[R34 - III] Use a LED indication for low power

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3.4MECHANICAL REQUIREMENTS

[R35 - I] Stepper motors must provide enough torque to operate the brake

[R36 - II] The rubber brake pads must have sufficient friction, and it should fit nicely to the wheels of walkers

3.5 SAFETY REQUIREMENTS

[R37 - I] Power source must meet the DC requirements for stepper motors

[R38 - III] Motors should be properly sealed

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4. OBSTACLE DETECTION SYSTEM

One of the critical features in Smart Walker system is that it is able to detect obstacles in front of the walker. The obstacles can be various depending on the ambient environment, but this system should be able to detect two major types of obstacles: walkway steps and walkway ramps. The following lists are the specified requirements on different aspects.

4.1 GENERAL REQUIREMENTS

[R39 - I] The system should have distance sensors to collect ambient analog signal

[R40 - II] The distance sensors should be placed in front of the walker in order to detect the obstacle

[R41- III] The distance sensors should be placed at a certain angle on the walker in order to detect the obstacle on the ground

[R42 - I] The number of distance sensors should be enough to identify obstacles in front

[R43 - I] The distance sensors should detect the distance between the sensors and the obstacles in real time.

[R44 - II] the sensors should send the signal to microprocessor

4.2 PHYSICAL REQUIREMENTS

[R45- III] The distance sensors and the camera should be as small as a coin

[R46 - II] The distance sensors and the camera should weigh less than 20 grams

4.3 ELECTRICAL REQUIREMENTS

[R47 - I] The distance sensors and the camera should be powered up with maximum 5V

[R48 - II] The distance sensors and the camera should consume a little power

[R49 - II] The system should have signal output to microprocessor from the sensor

[R50 - II] The interface between microprocessor and sensor system should be easy to use

4.4 SAFETY REQUIREMENTS

[R51- III] The system should not produce any noise

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[R52 - II] The distance sensors should not project any visible beams to the ambient environment.

4.5 USABILITY REQUIREMENTS

[R53 - I] The system should be used in both outdoor and indoor environment

[R54 - II] The system should not be interrupted by other surrounding noise and interference

4.6 PERFORMANCE REQUIREMENTS

[R55- I] The detection range of distance sensors should be between 1 to 2 meters

[R56 -II] The detection sensibility of distance sensors should be within 5 centimeters

[R57 - II] The camera should be able to capture the obstacles and clearly display it on the tablet application

[R58- I] The distance sensors should output the distance between the sensors and the obstacles in real time

[R59- III] The distance sensors should indicate a distance change when the walker gets close to the walkway steps or ramps

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5. CENTRAL MICROPROCESSOR UNIT

Smart Walker relies on a microprocessor to handle obstacles recognition, to perform appropriate reactions, and to interact with user through a mobile device application. The microprocessor is a critical part in the system. The requirements of this central component are listed below.

5.1 GENERAL REQUIREMENTS

[R60-I] The microprocessor should be able to process the input signals and to give output in real time

[R61 - III] The microprocessor should be placed in the middle of the walker and close to the battery pack

[R62 - II] The cost of distance sensors should be less than CAD $50

5.2 PHYSICAL REQUIREMENTS

[R63 - II] The microprocessor should be light and small

[R64 - II] The microprocessor and its power supply should be fitted into a 20cm x 15cm x 10cm case

5.3 ELECTRICAL REQUIREMENTS

[R65 - I] The microprocessor should have an individual power supply, such as a battery pack, to supply 5V and 1A

[R66 - II] The microprocessor should support proper input channels to connect detection sensors and a camera

[R67 - II] The microprocessor should provide output channels for controlling auto-brake system and mobile device application

5.4 SAFETY REQUIREMENTS

[R68 - II] The microprocessor should be held tightly inside the walker

[R69 - III] The microprocessor and the battery should have a case to prevent physical damages

[R70 - I] The microprocessor should not be easily removed

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5.5 PERFORMANCE REQUIREMENTS

[R71 - I] The microprocessor should process the warning signals if the distance sensors detect an obvious distance change

[R72 - II] The microprocessor should trigger auto-brake system when the obstacles are detected

[R73 - II] The microprocessor should interact with user through a mobile device application

5.6 POWER SOURCE REQUIREMENTS

[R74 - III] The dimension of battery should not exceed 15x10 cm and it will weighs less than 1.5 lbs

[R75 - I] The battery pack should supply 5V and 1A

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6. USER INTERACTION SYSTEM

6.1 GENERAL REQUIREMENTS

[R76 - I] The application should be built on Android 4.3 Jelly Bean

[R77 - I] The application should support following devices: Samsung Galaxy S3, Samsung Galaxy S4, Samsung Galaxy Note 2, Samsung Galaxy Note 3, Samsung Galaxy 8.0, Nexus 5 and Nexus 7

[R78 - II] All devices with Android 4.3 that are not listed in [R77 – I] should still be able to run the application, but the screen ratio might be affected

[R79 - I] The application will require a GPS connection

[R80 - III] The application should update periodically

6.2 GUI REQUIREMENTS

[R81 - I] Upon the initial start-up, the application should display the main screen

[R82 - I] The main screen should display the current position on the map, current weather, and an option to view the camera

[R83 - I] Warning screen should be displayed when SMART WALKER detects any obstacles

[R84 - II] When the user does not apply brakes within 5 seconds after the warning screen is displayed, the screen should display “applying brakes”

[R85 - III] From the setting screen, the user should be able to turn on and off following options: warning sound, degrees

6.3 PERFORMANCE REQUIREMENTS

[R86 - II] The application shall be bug free

[R87 - I] Warning sound should be played when SMART WALKER detects any obstacles

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7. SYSTEM TEST PLAN

We are going to test our product with various types of testing. This will ensure that, during the development, each module meets the functional specifications. Tests will be divided into subcategories; this includes sensors, motors, software, and hardware/mechanic. After the subsystem tests are completed, we will test the device as a whole prototype.

7.1 Sensor Test

Our device involves the high precision distance sensor. This will measure the distance from the sensor to the closest object right in front of the sensor.

- Measuring the accuracy of the distance sensor by placing an object at a certain distance, and comparing with sensor's given value.

7.2 Motor Test

The motor subsystem involves two motors for each wheel on the right and left. This motor will be responsible for controlling the brake system. The motors will be tested to turn at some specific speed. We will also verify that the Raspberry Pi will be able to control the motors.

- Using the Raspberry Pi to rotate the motor at a predetermined speed
- Apply force in the opposite direction of a rotating motor to test how much torque it produces
- Test at a different voltage to check if it produces more torque

7.3 Software Test

The software consists of two parts; one from tablet side and the other from Raspberry Pi controller.

First, a tablet will have an application that has an option to receive pictures taken from microcontroller

- Checking if the screen is divided into subsections to reveal maps and to receive pictures.
- Sending a signal to the application and checking if a tablet recognizes the signal
- Using GUI to receive and terminate the signal(This is to reveal and terminate pictures)

Second, microcontroller will have software programs that receive data from distance sensor, turn motors and take pictures.

- Receiving the data measured from the distance sensor
- Sending a signal to turn motors at a specific speed
- Taking pictures when distance in front is within the range

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7.4 Battery Test

Our product will be powered by a battery pack. This test will be performed after integration. Our product should last for at least 5 hours of continuous operation.

- Repeating the process of measuring distance, taking picture, and sending picture over a five hour period. This will verify that our product is capable of operating for this period

7.5 Physical Test

Our product, Smart Walker, should be stable and should not get loose. This is an important test because slight displacement of components may produce false data.

- After integration, move the walker along a bumpy/rough surface to check if the components(sensors, cameras) are fixed tightly

7.6 System Test

We will perform all of the above tests as a whole. These tests will be repeated many times during the integration. Following is the order of system test that needs to be met.

1. Putting an obstacle in order for distance sensor to identify an object
2. Taking pictures of the object
3. Sending a signal to the tablet so that user can decide if he/she wants to see the picture or not
4. Using the GUI to manually see the picture/ Using the GUI to decline
5. Continue scanning the distance
6. Repeat this process for 5 hours to test the battery

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8. USER DOCUMENTATION

The product is designed to be used for senior people who might not be familiar to technical backgrounds. Therefore, the user documentation will provide the easiest, but the complete and precise instructions on how to operate the device.

[R88 - I] User documentation should include the explanation of each physical component with pictures

[R89 - III] A quick-start guide will also be produced to describe the basic functionality like boot up process and battery replacement procedures

[R90 - II] The user guide should be quickly accessible through the device

[R91 - I] It must include any safety concerns and proper warnings

9. CONCLUSION

The functional specification precisely defines the functionalities and system requirements of the device. All the functionalities mainly consist of electrical hardware interfacing to Raspberry Pi, mechanical components and software. All these phases are the prioritized to ensure the essential functionalities working without any issues. When these high priorities are achieved, the devices will be evolved by having more features to reduce any concerns or difficulties in terms of its usability. The prototype for the proof of concept is under development and we are confident that the final product will be completed by Dec 2nd.

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10. REFERENCES

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