February 14, 2014

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 305/440 Functional Specification for Auto Shopping Guide

Dear Dr. Rawicz:

Attached is a document from Easy Way Inc. describing the functional specification of Easy Way Auto Shopping Guide (ASG). We are designing and implementing an auto shopping guide that can automatically guide customers to the products that they want. The ASG will find the shortest path to the desired product and provide detailed price information to customers.

This functional specification provides a set of high-level requirements for the system's functionality, which includes proof-of-concept and production phase of development. This document will be used by Easy Way engineers as a guide through the research, design and development process.

Easy Way Inc. is founded by 5 creative and skillful senior engineering students: Joseph Lu, James Lin, Jacqueline Li, Tao Xiong and Enzo Guo. If you have any question about this proposal, please feel free to contract me by phone at (778) 385 – 0321or by email at zla18@sfu.ca.

Sincerely,

Joseph Lu

Joseph Lu
Chief Executive Officer
Smart Way Inc.

Enclosure: Functional Specification for Auto Shopping Guide

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Functional Specification for Auto Shopping Guide

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Executive Summary

The idea of the Auto Shopping Guide System is enlightened based on the shopping experience of part of the people, especially new immigrants and foreigners who are not familiar with the layout of local supermarkets. The system will offer the services of quickly locating consumers' targeting items and physically guiding consumers to the locations.

Since the design of the system is user—oriented, Easy Way Inc. intends to build a system that can be operated by people without technical training. The entire system is comprised by two parts. One is the robotic part that is mainly assembled with hardware. And the other one is the central terminal part that consists of a database server and a user interface. The major designing aspects are listed below:

I. The user interface shall be ideally implemented under cross—platform environment that includes Windows, IOS and Android handhelds and tablets.
II. The database server that contains the information of products and market layout shall be embedded in the program and able to calculate the locations of items and the optimum routes of the robot using the famous Travelling Salesman Algorithm.
III. The robot with its sensing and alarm system shall be able to respond to the signal sent from the central terminal that contains the information regarding locations and routes. And it shall be capable of avoiding possible collisions and minimizing errors.

Throughout our first development phase, most of the robotic part has already been developed via PCB insertion and assembling. And it will soon be entering the first testing phase for the verification of electrical connections and components.

The upcoming second development phase will involve mainly software design and implementation. Algorithms and GUI will be coded and generated using various programming languages such as C and Java.

The third and last development phase will be signal transmission and receiving development. The development team will focus on how to generate signals and commands, and transmit them to the robot, as well as how the robot would react correspondingly.

During each development phase, comprehensive tests will be performed to verify and validate the functionalities of each components of the system. This document will outline both the hardware and software functional specifications. Different topics will be covered and a proposed test plan will also be attached. Please refer to specific sections inside the document for detailed descriptions of the functional requirements of the Auto Shopping Guide System.

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Glossary

AC	Alternating current
ASG	Auto Shopping Guide
AWI	Approved new Work Item
CAD	Canadian dollar
GUI	Graphical user interface
IC	Integrated circuit
IR-Transceiver	Infrared transceiver
ISO	International Organization for Standardization
IEC	International Electro-technical Commission
LED	Light-emitting diode
PC	Personal computer
UI	User interface

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1 Introduction

The Auto Shopping Guide is a system combining hardware and software components that allows users to be able to quickly locate items on their shopping lists. The entire system consists of two parts. The software part features a central terminal with a database and a GUI. By inputting their desired items through the GUI, users are able to acquire the locations of the items from the database. The hardware part is an automatic robotic car that receives signals and commands from the central terminal and then leads users to targeting locations. The system will certainly benefit consumers by saving time on shopping in large supermarkets. And it is designed to be friendly to users of all ages. The requirements for the Auto Shopping Guide System, as proposed by Easy Way Inc., are described in this functional specification.

1.1 Scope

The document indicates the necessary requirements that must be met by the functioning Auto Shopping Guide System. The set of the requirements fully describes the functional specifications of the proof—of—concept prototype, and partially describes the production device. This document will be used as a functionality reference that will drive the future design of the system. As well modifications and improvements will be made during the developing and testing process.

1.2 Intended Audience

This functional specification is intended for use by all members of Easy Way Inc. The operating director shall refer to the functional requirements as the measurement of progress throughout the development phase. Designers shall refer to the requirements as technical objectives that the system needs to achieve during design and implementation. Testers shall use this specification as a guide to verify the functionalities of the system according to the requirements addressed in this document.

1.3 Classification

The following conversions shall be used throughout this document to represent functional requirements:

[Rn-p] A functional requirement.

Where **n** is the functional requirement number, and **p** is the priority of the functional requirement as denoted by one of three values:

A. The requirement applies to the proof-of-concept system only.
B. The requirement applies to both the proof-of-concept system and the final production system.
C. The requirement applies to the final production system only.

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2 System Requirements

2.1 System Overview

The Auto shopping guide is a revolutionary design of current shopping method. It is car which will help customers find what they need quickly. The system can be modeled as shown in the Figure.

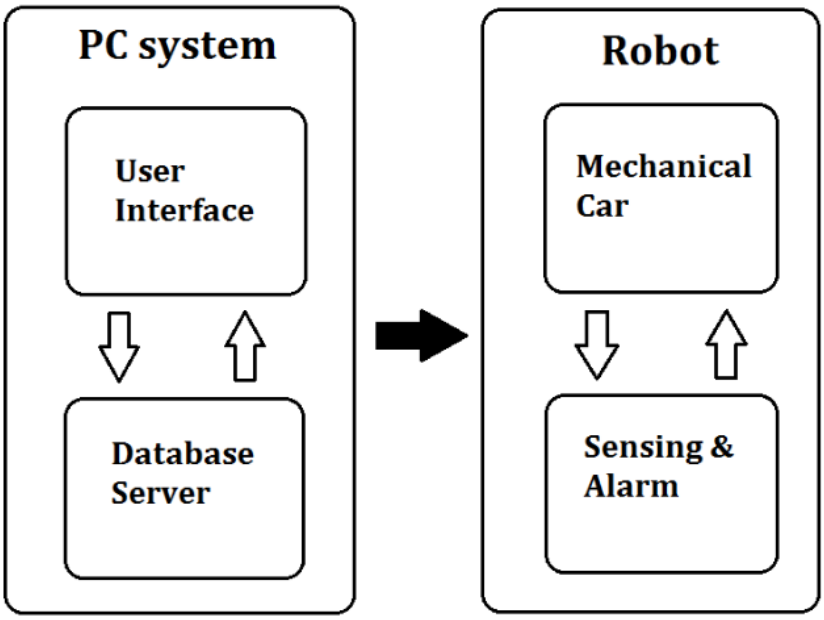

Figure 1 System Overview: System is separated to be 2 major parts: PC system and Robot

The design consists of two major parts: PC system and Robot, and each part contain two individual modules. PC system contains user interface (UI) module and database server module. Robot contains mechanical car module and sensing and alarm module. The user interface will allow user to input data. The database server module will process the input data and manage the route calculation. Once the route being managed, the route data will be transmitted to the Robot part through IR transceiver. Once the Robot receives the route data, the mechanical car will start moving following the calculated route. Meanwhile, the sensing and alarm module will monitor the road conditions and warn user.

Once all the modules are powered, the system should automatically configure them to perform all the functionalities. The user interface will allow customers to input all the shopping items. Once all input data is received by database server, the server will process the data, calculate the route, and transmit the calculated route data to the Robot. When the car receives the route data from the PC system module, the car will start guiding customers with the calculated route. Meanwhile, the sensing and alarm will be active. This module contains two distance sensors: one is placed in the front and the other one is placed in the back. The front sensor will prevent the car from hitting the front barrier. The back sensor will detect the distance between the car

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and the customer behind to prevent the customer getting too far away from the guide car and eventually losing his direction.

2.2 General Requirements

[R1-A] The price shall be under 600 CAD.

[R2-B] The robot shall have a switch to easily turn the device ON and OFF.

2.3 Physical Requirements

[R3-A] Dimension of the guide shall not exceed 30cm*30cm*30cm

[R4-A] Weight of the guide shall not exceed 1000g.

[R5-B] Components of each module shall be firmly fixed/attached.

[R6-C] Product itself shall be water-proof and shock-proof.

[R7-B] The system as a whole shall not have any sharp edges.

2.4 Electrical Requirements

[R8-B] The power supply shall be able to last at least 5 hours continuously.

[R9-C] The power supply shall be easily recharged via 110V/120V at 60 Hz AC (North America Standard).

[R10-B] As an alternative of recharging the power supply, batteries should be quickly replaced with new ones for continuous usage.

[R11-C] In the future, power supply shall be able to get recharged with different standards of wall outlets such as 220V at 50 Hz AC (China Standard).

2.5 Environmental Requirements

[R12-B] The car shall operate normally under room temperatures (10-35°C).

[R13-B] The car shall operate normally under room humidity conditions (50%).

[R14-B] The car shall operate normally on the flat ground.

[R15-B] Noise generated during periods of activity shall be minimized.

2.6 Standards

[R16-B] The robot module shall conform to ISO 4141-1:2005 standards.

[R17-B] The system shall conform to ISO/IEC 10536-3:1996 standards.

[R18-B] The robot module shall conform to ISO/AWI 11898-1 standards.

2.7 Reliability and Durability

[R19-B] Each module shall be easily maintained on an at least six—month basis.

[R20-C] Each module shall be serviceable by trained technicians.

[R21-C] Failures of the product functionality shall not be encountered during regular usage.

[R22-B] The robot shall be able to continuously run for at least three hours without recharging or replacing batteries.

[R23-B] The function of locating shall have minimized errors in terms of item positions.

[R24-C] Database and user interface shall be updated on a regular basis corresponding to real life situations.

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2.8 Safety Requirements

[R25-C] The electronic components and power connections shall be enclosed.

[R26-C] The electronic components shall not cause any interference with other devices.

[R27-B] The electronic components shall not spontaneously combust.

[R28-C] The robot shall not cause any bodily damages to users.

[R29-B] The robot shall be able to detect, avoid and alarm users with possible collisions.

2.9 Performance Requirements

[R30-B] The time cost of system setup shall not exceed 5 minutes.

[R31-B] The robot shall respond to system setup within 5 seconds.

2.10 Usability Requirements

[R32-B] The robot shall perform a reasonable time delay before proceeding to the next location.

[R33-C] Speed of the robot should not exceed 1 m/s which is approximately the average human walking speed.

[R34-C] The distance between the robot and the user shall not exceed 2 meters, otherwise the robot shall instantly stop its current motion.

[R35-B] The software setup shall be simple enough for users of all ages to operate.

3 Robot Module

3.1 General Requirements

[R36-B] The robot should be programed in C language.

[R37-B] The robot should be able to transmit the signal with the PC.

[R38-B] The robot shall have a switch to easily turn the device ON and OFF.

[R39-A] The robot product cost should not exceed $500.

[R40-B] The robot should satisfy the requirement of all applicable standard that list above.

3.2 Mechanical Requirements

[R41-B] There is an ultrasonic ranging sensor in front of the robot.

[R42-B] There is a temperature sensor at the bottom of the robot.

[R43-B] The robot shall have two identical motors that each motor supply power to a cogwheel to rotate a wheel.

[R44-B] The robot will turn left when the right wheel was rotated clockwise by the right cogwheel.

[R45-B] The robot will turn right when the left wheel was rotated counterclockwise by the left cogwheel.

[R46-B] The robot will move linearly when both wheel were rotated with the angular speed

3.3 Electrical Requirements

[R47-A] The Status-LED will glow when the switch is turned on.

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[R48-A] The Front-LED at the bottom side will glow when the robot is moving, otherwise the Front-LED at the bottom side will not glow when the robot is at rest.

[R49-A] The Left Back-LED will glow when the robot is turning left.

[R50-A] The Right Back-LED will glow when the robot is turning right.

[R51-A] The robot will be supplied by 6 V power source.

[R52-B] The robot should have minimum of 5 hours battery life.

3.4 Physical Requirements

[R53-C] The robot should be water proof.

3.5 Performance Requirements

[R54-B] The robot shall be able to reach targeting locations with minimized errors.

[R55-B] The robot shall be able to move in four directions: front, back, left and right.

[R56-B] If obstructions are ahead of the robot, the robot will stop.

[R57-C] If the distance between user and the robot exceeds 1 meter, the robot will stop.

3.6 Integrated Circuits

3.6.1 Electronics Requirements

[R58-B] Integrated Circuits contain processor, oscillator, logic circuit, IR-Transceiver and IR-receiver.

3.6.2 Physical Requirements

[R59-B] The size of integrated circuit should be small enough to solder on robot.

3.7 Motor

3.7.1 Physical Requirements

[R60-A] The motor contains an armature, a pair of permanent magnet, three coils and a commentator.

[R61-A] The range of operating voltage is from 3.0-12.0.

[R62-A] The voltage rating is 12.0V.

[R63-A] The unloaded speed of motor is 17500 rpm.

[R64-A] The standard speed of motor is 12400 rpm.

[R65-A] The current rating is 0.34A.

[R66-A] The weight of the motor is 18g.

[R67-A] The torque of the motor is 0.10 N*cm.

4 Sensor Modules

4.1 Ultrasonic Ranging Sensors

4.1.1 General Requirements

[R68-B] The ultrasonic ranging sensor should be able to be programed in C language

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4.1.2 Physical Requirements

[R69-B] The ultrasonic ranging sensor should have small dimension that does not consume much space of the robot.

[R70-B] The ultrasonic ranging sensor should be soldered in front of the robot.

[R71-A] The identification range of the ultrasonic ranging sensor is from 0cm to 50cm.

4.2 Temperature Sensor

4.2.1 General Requirements

[R72-B] The temperature sensor should be able to be programed in C language.

4.2.2 Physical Requirements

[R73-B] The temperature sensor should have small dimension that does not consume much space of the robot.

[R74-B] The temperature sensor should be soldered at the bottom of the robot.

[R75-B] The range of the temperature will be sensed by the temperature sensor is from 30 degree Celsius to 50 degree Celsius.

5 User Interface

The user interface unit shall consist of a set of windows and bottoms for both inputs and outputs. Users will be able to input the names of the items. And the interface will then send the input information to the database server for it to perform the calculation. Additionally, the user interface will also display the items' names on screen and list the prices that are loaded from the database.

6 Central Database Servers

[R76-C] The information of items that consists of coordinates and prices shall be stored in the central database server.

[R77-C] The map information shall be stored in the central database server as well.

[R78-C] The motion of the robot shall be calculated inside the central database server.

6.1 Connectivity and Communication Requirements

[R79-B] The terminal program normally should display the signal. The IR-Transceiver transmits the signal by IR-Diode, the transmitted signal reflects at the paper surface and is send back to receiver-IC, from which it is being returned to the computer.

[R80-B] The robot shall be able to react to the signals transmitted correspondingly.

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7 User Documentation

[R81-C] User documentation shall include the website with technical support information and a user manual.

[R82-C] User documentation shall be provided in English, French, German, Japanese, Korean, Traditional Chinese and Simplified Chinese to satisfy the language requirements for international markets.

[R83-C] A detailed installation & repair guide shall be provided to customers.

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8 System Test Plan

In order to ensure the system will execute properly, the system test plan has to be setup. This session demonstrates that the system testing will not only cover individual modules testing, but also combined modules testing. Both testing methodologies will carry out from different levels with an emphasis on the requirements of the proof-of-concept version. Additionally, the system test plan is designed to satisfy all requirements of the product, such as physical requirements, electrical requirements and so on. All possible situations will be discussed in this session.

8.1 Individual module testing

Individual module testing consists of three main aspects: user interface testing, data transmit testing and robot testing.

8.1.1 PC System Testing

The PC system contains the database server and the user interface. There are three main purposes of PC system testing. The first test objective is that the user interface shall be able to read the input data from tester. The second and most important test objective is to ensure that the database server is able to properly store the map of model supermarket and all grocery items. If the layout is changed, it can be modified inside the database server. The database server is also responsible for calculating the route once tester submits grocery items on user interface. The following Table of PC System Testing shows the details of PC system module testing.

Test Cases	Steps	Expected Result
Test Case 1. Input data on user interface	1. Add one grocery item A on user interface 2. Confirm the item A as input data	1. Able to type item (A) on user interface 2. The item A is listed on the shopping list without any error message
Test Case 2. Edit, Add, Delete and confirm the input data on user interface	1. Add one item (A) to user interface. 2. Add another item (B) to user interface 3. Confirm items A and B as input data 4. Edit the input data 5. Add item C to user interface 6. Delete item B from the user interface 7. Confirm the items A and C as input data 8. Submit the items to calculate the route	1. Able to add item (A) to user interface 2. Able to add another item (B) to user interface 3. Able to confirm item A and B as input data. And the items are listed on the user interface. 4. Able to edit the input data 5. Able to add item C 6. Able to delete item B 7. The input data is updated. The list shows item A and C as input data. 8. The route is calculated on database servers

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Test Cases(continue)	Steps	Expected Result
Test Case 3. Database server distinguishes if the grocery items are listed in database	1. Input one item (F) which is not memorized in database server. 2. Confirm item F as input data	1. Able to input item (F) 2. Error message “Unable to find item” is shown.
Test Case 4. Database server rejects to add duplicated items	1. Input one item (A) 2. Confirm item (A) as input data 3. Input and confirm item (A) again	1. Able to input item A 2. Able to confirm item A 3. Message “Item has been added”
Test Case 5. Route is calculated	1. Add one item (A) to user interface. 2. Add another item (B) to user interface 3. Confirm items A and B as input data 4. Input calculating the route command in database server	1. Able to add item (A) to user interface 2. Able to add another item (B) to user interface 3. Able to confirm item A and B as input data. And the items are listed on the user interface. 4. “Calculating” message will be shown. And database server will be calculating the route.

Table 1 PC System Testing

8.1.2 Data Transmit Testing

Data transmit is established based on the wireless communication between PC system and Robot. The major purpose of doing Data Transmit testing is to ensure the data transmission can be completed within certain range. The Data Transmit Testing Table shows the possible situations during the communication between PC system and Robot.

Test Cases	Steps	Expected Result
Test Case 1. Data Transmit within 50CM	Prerequisite: The route is calculated on database servers 1. Place PC system and robot in 50 CM 2. Allow the route data transmitted from PC system to robot	2. The route data is able to be transmitted from PC system to robot successfully and completely.

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Test Cases(continue)	Steps	Expected Result
Test Case 2. Data Transmit out of range 50CM	Prerequisite: The route is calculated on database servers 1. Place Robot far away from PC system out of range 50CM 2. Allow PC system transmit the data to Robot	2. Robot cannot be detected by Robot. Unable to deliver the data to Robot.
Test Case 3. Data Transmit get interrupted	Prerequisite: The route is calculated on database servers 1. Place PC system and robot in 50 CM 2. Allow the route data transmitted from PC system to robot. 3. During the route data transmitted, put the robot away PC system	2. The route data is able to be transmitted from PC system to robot. 3. The data transition get interrupted.

Table 2 Data Transmit Testing

8.1.3 Robot Testing

One of the tasks of the robot is being a professional guide. After transmitting the route to Robot, Robot shall guide the tester to find the proper location. It also shall detect any barriers on its way to the target locations. Once it detects any obstacles in front of it, the robot shall give a response correctly. Furthermore, the robot will detect and make sure the tester is in the certain range. Table Robot Testing shows the details of Robot module test. And the prerequisite of the module test is that route has been successfully loaded to the robot.

Test Cases	Steps	Expected Result
Test Case 1. Success to find the correct location	1. Place robot on the designed point 2. Let robot start	Able to get the designed location
Test Case 2. Able to detect barriers	1. Put some blocks on the road 2. Place robot on the starting point 3. Let robot start	Able to detect barriers and pause working until the barriers are moved.
Test Case 3 Detect host	1. Place robot on the designed point 2. Let robot start working 3. During the robot working, the host will stop walking and try to get far away from the robot	3. Once robot cannot detect the host, it will stop working.

Table 3 Robot Testing

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8.2 Combined modules testing

Once all individual testing are passed, the combined modules testing shall be executed. The purpose of the combined modules testing is ensuring the whole system is functional, and runs properly.

Step1. Tester shall entry and submits various grocery items on user interface.

Step2. Transmit route data from user interface to Robot.

Step3A. Tester shall follow Robot to complete a shopping trip without barriers.

Step3B. Repeat step1 and step2. However, put a barrier on the shopping route when tester is following Robot to complete a shopping trip.

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9 Conclusion

The functional specification accurately provides a comprehensive set of functionalities and requirements of the Auto Shopping Guide System. As the progress is demonstrated earlier, the first development phase for our proof-of-concept model, which mainly focuses on the hardware is properly underway and close to completion. With the software development phases coming up, it is certain that the project is strictly following the timetable. The project can be expected to complete by April, 2014. This functional specification will be referred to frequently throughout the entire development process, and individual requirements that are stated in this document will be achieved corresponding to their priority levels.

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