Auto Tech

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October 8, 2012

Dr. Andrew Rawicz

School of Engineering Science

Simon Fraser University

Burnaby, British Columbia

V5A 1S6

Re: ENSC 440W Functional Specification: Human Chasing Robot by Auto Tech

Dear Dr. Rawicz,

Please find the attached enclosed functional specification for the Human Chasing Robot from Auto Tech. It is a tracking robot that follows and monitors patients which can be widely used in hospitals, mental institutions, and nursing homes to track patients.

The functional specification presents a set of high-level requirements for the system's functionality for different phases of development. This document will be used as a guide for research and development activities.

Auto Tech consists of five brilliant students with backgrounds in Electronic Engineering and Computer Engineering: Johnny Leung, Michael Leung, Eric Zhao, Alex Jiang, and Ken Nam. For further inquires about our company and proposal please feel free to contact via our team email: ensc440-groupn@sfu.ca, or by phone at 778-855-2480.

Sincerely,

Johnny LEUNG

Chief Executive Officer

Auto Tech

Enclosure: Functional Specification for Human Chasing Robot

Auto Tech

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FUNCTIONAL SPECIFICATION FOR HUMAN CHASING ROBOT

Project Team

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Submitted to

Dr. Andrew Rawicz

Steve Whitemore

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Issued Date

October 8, 2012

EXECTIVE SUMMARY

As the number of working force is declining and the people are aging, the demands for nursing are significantly increasing. As we all know that there is always a shortage of nurses at any hospitals in Canada, there is a need of alternative solution to this situation. At Auto Tech, we believe robots are the solution to this problem. Robots can perform different tasks and thus, the most important thing is they do not require any human needs like sleeping and eating. In other words, robots can stay on duties for the whole day, which would be very beneficial to most industries and could be widely use in modern society.

Everyone agrees to that nurses are one of the highest demanded skill workers in Canada. By introducing robots to hospitals, mental instaurations, and nursing homes, nurses can focus on more technical or complex operations. Our robots would be used in monitoring patients by following them closely. Also, our robots can carry medical equipment and supplies.

There will be tracking beacons with ultrasonic transmitters that are attached to high-risk patients. Our robots would equip ultrasonic receivers to pick up the signal to determine the distance between the beacon and robot. A microcontroller processes the signals coming from the ultrasonic receivers then calculates the path of the robot. Two motors will drive the wheels of the robot and steer the robot towards its target. A camera will be mounted on the robot to capture video of the target and stream to a computer.

This functional specification is designed and implemented for the primary prototype version of the Human-Chasing Robot. Further versions of the product would strive to reduce the size of the robot, and to increase the accuracy of signal reorganization or image processing.

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1. INTRODUCTION

The Human-Chasing Robot is a tracking robot that can follow the patients and monitor their activities. This product is made up of an imaging system and a movement system. The imaging system is responsible for capturing the images of the patients and then to be recognized by the microcontroller for the commanding usage. The movement system would control the movement of the robot by indicating the direction of the motion. By combining the two systems, the tracking robot would work perfectly in any desirable environment. The detailed functional requirements for this Human-Chasing Robot are described in this document.

1.1 Scope

This document describes the functional requirements that must be met by a functioning Human-Chasing Robot. This set of requirements fully describes the proof-of-concept device and partially describes the device produced. Possible design modifications and optional features of the future implementation will also be discussed in the document.

1.2 Intended Audience

The functional specification is intended to act as a reference for all members of Auto Tech. Engineers from different departments should refer to the listed requirements as the overall design goals throughout the implementation. This document would also serve as the guideline for project management to make sure the production is on schedule.

1.3 Classification

The following convention will be used to categorize the functional requirements:

[F# – P] Functional Requirement Details

Where # is the functional requirement number and P refers to the following:

I. The requirement applies to the proof-of-concept system only.
II. The requirement applies to both the proof-of-concept system and the final production system.
III. The requirement applies to the final production system only.

2. SYSTEM OVERVIEW

Our human-chasing robot consists of two independent systems: the imaging system, a robot that follows a target. The imaging system is made up of a camera for capturing video, a computer for displaying the video, and a microcontroller for Wi-Fi communication between the camera and the computer. The robot consists of the action control circuit for movement, a wireless communication circuit for tracking the target, and a microprocessor for controlling the robot. One power management circuit delivers power to both the imaging circuit and the robot. Figure 1 shows a block diagram of the system.

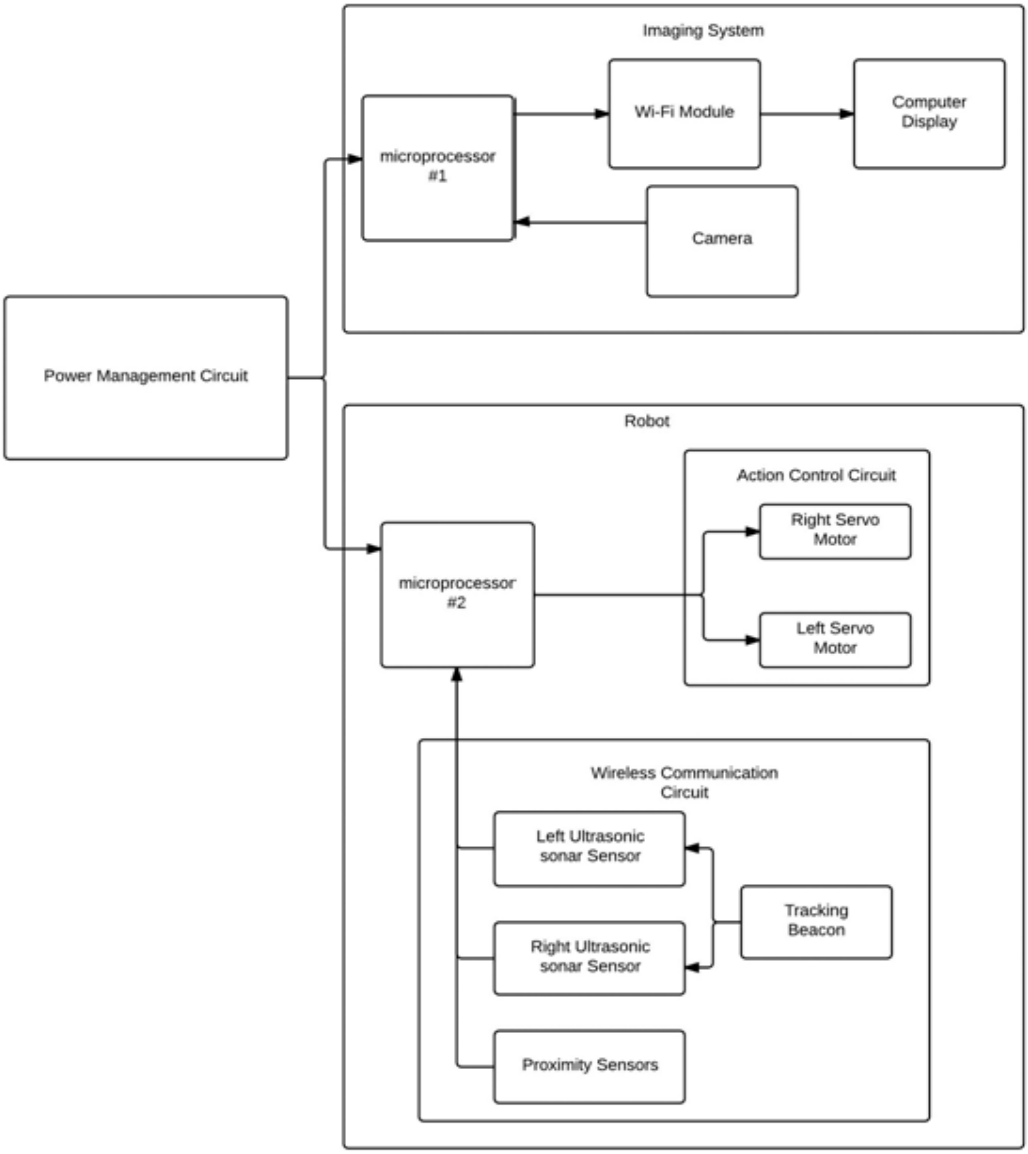

Figure 1 – System overview of the Human-Chasing robot

The wireless communication circuit is made up of a beacon that emits ultrasonic sonar signal and a pair of receivers on the robot, one on each side of the robot. Additional sensors on the robot detect objects around the robot and distance from the target. The microprocessor interprets the sensor signals and controls the two differential motors; thus, ensuring the robot does not run into obstacles.

The imaging circuit operates independently of the robot. The camera is mount on the end connected to a microcontroller that processes and stream the video to a computer via Wi-FI.

3. System Requirements

System requirements are divided into 4 separate circuits: imaging, action control, wireless communication, and power management. Requirements of each circuit are further divided into subcategories of general, physical, functional, and performance.

3.1 Imaging Circuit

The imaging circuit is a separate component from the robot that provides a video streaming service to the user. With this component, users can access the real time view of the chasing human or object. The component has a camera that captures images, a microprocessor that processes images and behaves as a web server, and a Wi-Fi module that allows the component to host a webpage on the Internet.

3.1.1 General Requirements

[F1-II] The retail price of the imaging component shall be less than $60 CAD.

3.1.2 Physical Requirements

[F2-II] The imaging circuit shall contain a camera, a microprocessor and a Wi-Fi module.
[F3-II] The imaging circuit should be small enough so it can be put on top of the robot.
[F4-II] The imaging circuit should weigh less than 100 grams.
[F5-II] The camera should have a flashlight integrated for use in dark places.

3.1.3 Functional Requirements

[F6-II] The microprocessor must host a webpage that displays a real time video of the chasing human or object.
[F7-III] The webpage should have an authentication step before displaying the video.
[F8-III] The video delay should be less than 1.5 seconds.
[F9-III] The webpage shall provide an interface that lets the user to control the camera's direction.
[F10-III] The webpage shall provide an interface that allows the user to control the robot directly.

3.1.4 Performance Requirements

[F11-II] The camera must be capable of capturing 5 frames per second.
[F12-III] The frame rate of the video on the webpage must be at least 3 frames per second.
[F13-II] The video must show the whole body of the human or the object.
[F14-II] The human or the object must be clearly viewable in the video.

3.2 Action Control Circuit

The action control circuit is responsible for the physical movement of the robot. It includes two servo motors, the wheels, and a microprocessor. The microprocessor controls the two servo motors and rotates the front wheels independently, as a result the robot can move forward, reverse, and turn.

3.2.1 General Requirements

[F15-II] The retail price of the action control component shall be less than $200 CAD

3.2.2 Physical Requirements

[F16-III] The action control circuit shall contain 2 servo motors, 2 front wheels, 1 rear wheel, and a microprocessor
[F17-II] The two motors should be small enough so both can be mounted under the robot
[F18-III] The rear wheel should be free to rotate
[F19-III] The wheels should be large enough for the robot to overcome small debris or obstacles

3.2.3 Functional Requirements

[F20-II] The robot should be able to move in reverse
[F21-II] The robot should be able to turn on its axis
[F22-II] The motors should be able to move at various speeds
[F23-III] The robot can move around obstacles
[F24-II] The robot should stop a fixed distance behind the target
[F25-III] The robot should know when there is no possible path to reach the target

3.2.4 Performance Requirements

[F26-II] The motors should have enough torque to push the weight of the robot
[F27-III] The motors should have enough torque to push the weight of the medical supplies
[F28-II] The rotations of the wheels should be accurately controlled by the microprocessor
[F29-III] The speed of the robot should be proportional to the distance away from the target

3.3 Wireless Communication

The wireless communication circuits contain two parts, which are ultrasonic transmitter circuit and ultrasonic receiver circuit.

3.3.1 General Requirements

[F30-II] The retail price of the wireless communication components shall be less than $50 CAD

3.3.2 Physical Requirements

[F31-III] The size of transmitter shall be within 2cm x 2cm x 1cm.
[F32-III] The transmitter shall have an USB port to connect with a wheelchair for power receiving.
[F33-II] The sensor shall be attached in front of the robot car
[F34-III] The sensor shall be positioned on an aperture of the robot car casing with an area of 10 mm x 10 mm

3.3.3 Functional Requirements

[F35-II] The receiver shall output a High square wave.

3.3.4 Performance Requirements

[F36-II] The transmitter shall send stable signal twice per second.
[F37-II] The signal shall reach 150 inches.
[F38-II] The receiver shall receive the signal within 200 inches at least.
[F39-II] The receiver shall filter out most of the noise.
[F40-II] The accuracy of output signal shall be within 0.5v per meter

3.4 Power Management Circuit

3.4.1 General Requirements

[F41-II] The batteries should be easily accessible and replaced

3.4.2 Physical Requirements

[F42-II] The size of the power management circuit shall be small enough to fit on the frame

3.4.3 Functional Requirements

[F43-II] The power management circuit shall supply stable power to each part of robot car.

3.4.4 Performance Requirements

[F44-III] The batteries should last for at least 3 hours

[F45-III] The batteries should be rechargeable

3.5 General Requirements

[F46-II] The frame should be able to carry the microcontroller broads, the battery pack, and the camera

[F47-III] The frame of the robot should be large enough to carry medical supplies

[F48-III] The robot should have low centre of gravity so it doesn't tip over easily

[F49-III] The exterior case of the robot should be strong enough to withstand minor impacts

4. Test Plan

Testing is separated into 2 parts: unit tests and integrated tests. This makes it easier to isolate problems.

4.1 Unit Tests

Each circuit is tested independently to ensure it is functional.

4.1.1 Imaging Circuit Unit Test Plan

- Check if it can host a webpage.
- Check if the webpage first authenticates the user before displaying anything.
- Check if the webpage streams a real time video from the camera.
- Check if the video quality meets the requirement.
- Check if the video shows the whole body of the chasing human or object.
- Check if the imaging circuit does not affect the robot's movement performance.

4.1.2 Action Control Circuit Unit Test Plan

- Check if motors can rotate properly
- Check if the robot can move in a straight line
- Check if the robot can turn on its axis
- Check if the robot can move in reverse
- Check if the robot can avoid obstacles

4.1.3 Wireless Communication Circuit Unit Test Plan

- Check if Ultrasonic Transmitter can send stable signal over 30 minutes.
- Check if Ultrasonic Receiver can receive the signal within 200 inches.
- Check if Ultrasonic Receiver output a High square wave.
- Check if it can filter out most of noises in different situation.
- Check if the detail of output signal from the Ultrasonic Receiver is accurate enough in different distance.

4.2 Integrated Tests

If all units are tested and all units are functional, then test the integrated system to ensure it is functional as well.

4.2.1 Automated movement test

- Check if the robot can find the target by itself
  - Check at least 4 positions: front, behind, left and right
- Check if the robot can stop a fixed distance behind the target
- Check if the beacon is out of range
- Check if the robot can follow the target
  - Check follow the target forward, backward, turn left, turn right
  - Check follow fast-moving target

4.2.2 Scaled model test

- Check if the video from the robot shows on the webpage
- Check if the robot can avoid obstacles while following the target
- Check if the total system works at the required environment such as hospital

5. Conclusion

In this functional specification, the system requirements are defined. The system is divided into four parts: imaging circuit, action control circuit, wireless communication and general requirement. In each part, physical requirements are defined and also the functional requirements.

Given this specification, we will try our best to satisfy all the requirements by the completion date. To ensure all the requirements are met indeed, we have included test plans in this document. All units test plan are provided, as well as the integrated model test plan.