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February 16, 2011

Dr. Andrew Rawicz
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8888 University Drive
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Re: ENSC 440 functional specification for a remotely controlled home care robot

Dear Dr. Rawicz

Enclosed is our *Functional Specification for a Controlled Home Assistive Device*, which describes a remotely controlled home care robot. Telemedix's goal is to design a robot that will be controlled over Wi-Fi, to aid the elderly and/or people with disabilities, and those who live in remote locations.

This functional specification describes the high level requirements of our product. It also discusses the testing methodology that will be used. This document will later be used as a guide for design and development of our device.

Telemedix is comprised of six senior engineering students from the systems, electrical and computing concentrations, with a broad range of skills and specialties. If you have any questions or concerns regarding our functional specification or product, please contact us by email at telemedix-440@sfu.ca.

Sincerely,

Robin Mahony

Robin Mahony
CEO
Telemedix

Enclosure: Functional Specification for a Controlled Home Assistive Device

Functional Specification for a Controlled Home Assistive Device

TELEMEDIX Functional Specification for a Controlled Home Assistive Device

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Submitted To : Dr. Andrew Rawicz - ENSC 440
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Issued Date: February 16, 2011

Executive Summary

Today we live in a society where the aging population will soon outnumber and come to depend on the younger generations. With increasing age comes declining health, and this means that more people will require supervised care in the future. Some people who are able to take care of themselves, but may require periodic supervision may not wish to be placed into a retirement or home care facility. This would mean leaving behind their homes and the life they have become accustomed to. The alternative, hiring personal nurses or home care professionals, is expensive and not realistic for everyone. There needs to be a way to provide this necessary supervised care in an affordable manor. This is where Telemedix's device, CHAD, can make a difference. It will allow for supervised care, without requiring anyone, the supervisee or supervisor, to leave the comfort of their own home. Through Wi-Fi, the supervisor will be able to routinely monitor the patient from wherever they are, allowing the patient to maintain their independence for an affordable price.

Telemedix's device will consist of a robot, remotely controlled by controlling software that uses the internet to connect to our device. Our product will consist of many features chosen to make our device easy to operate and interact with. Some of the critical requirements essential to the functionality of our product are:

- Robot will be able to easily maneuver indoors, fitting through doorways of average size
- A live, two-way audio feed between the robot and the controlling software
- The capability to send live streaming video from the robot to the controller
- The ability to remotely control the movement of the robot over Wi-Fi
- The capability to control the movement of the camera (over Wi-Fi) using our controlling software

Some of the non-critical features of our product include:

- Ability for the robot to receive and display live streaming video from the controller
- Ability to adjust the height of the robot
- A charging dock, allowing for the ability to move the device into its charging area remotely

In addition to the functional requirements listed above, safety and reliability are inherent to the Telemedix team. This is why numerous standards (CSA, FCC, etc) will be adhered to, and a rigorous test plan will be developed and executed to ensure a product that is secure and reliable.

The design and implementation of these features and procedures will be accomplished and integrated into our product with an expected date of completion of April 10, 2011.

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Glossary

CHAD	Controlled Home Assistive Device
GUI	Graphical User Interface
iOS	iPhone Operating System
USB	Universal Serial Bus
Wi-Fi	Wireless Fidelity, used in reference to WLAN (IEEE 802.11) technology. In simple terms, it is wireless Ethernet or internet.
Client	The person operating the controlling software
Patient	The person directly interacting with the robotic device

1 Introduction

The Controlled Home Assistive Device is a device for people who require a minor amount of supervision for their medical needs, but either do not wish to pay for the costs of a full time nurse, or live in a secluded community where nurses or home care specialists are not readily available. Our objective is to provide these individuals with a product that would allow visual and audible communication with a nurse, physician, or home care specialist at a remote location. While the patient administered some simple tests to check vital states - such as blood pressure or blood sugar levels - the nurse would be able to simply monitor the patient to ensure tests results are in a healthy range. This would allow them to maintain their independence, while at the same time ensuring their well being. The requirements for the robotic device are outlined in the following document.

1.1. Scope

This document describes the functional requirements for the Controlled Home Assistive Device. It provides a detailed description of the required functionality for a proof-of-concept model and partially describes the required functionality for the production model. The requirements laid out in this document will be relied on during the design and implementation of the proof-of-concept device, though minor modifications may be needed during development or after testing.

1.2. Intended Audience

The functional specification document is intended to be used by the members of the Telemedix team throughout the design and development stages to ensure that the design adheres to the required specifications. This document will also be used to measure project progress and to aid in user documentation and test plan creation.

1.3. Classification of Requirements

The follow convention has been established and will be utilized throughout this document to differentiate between different categories of functional requirements:

[R#-n p]

Where # denotes the section number
Where *n* denotes the requirement number
Where *p* denotes the priority of the specification and can have one of the following values:

> **P1 -** critical priority; must be adhered to in the prototype.
> **P2 -** secondary priority; will be adhered to if time permits.
> **P3 -** tertiary priority; completion not planned for prototype, but would be necessary for the production quality product.

2 System Requirements

2.1. System Overview

An overview diagram of Telemedix's home assistive system is shown in Figure 2.1 below.

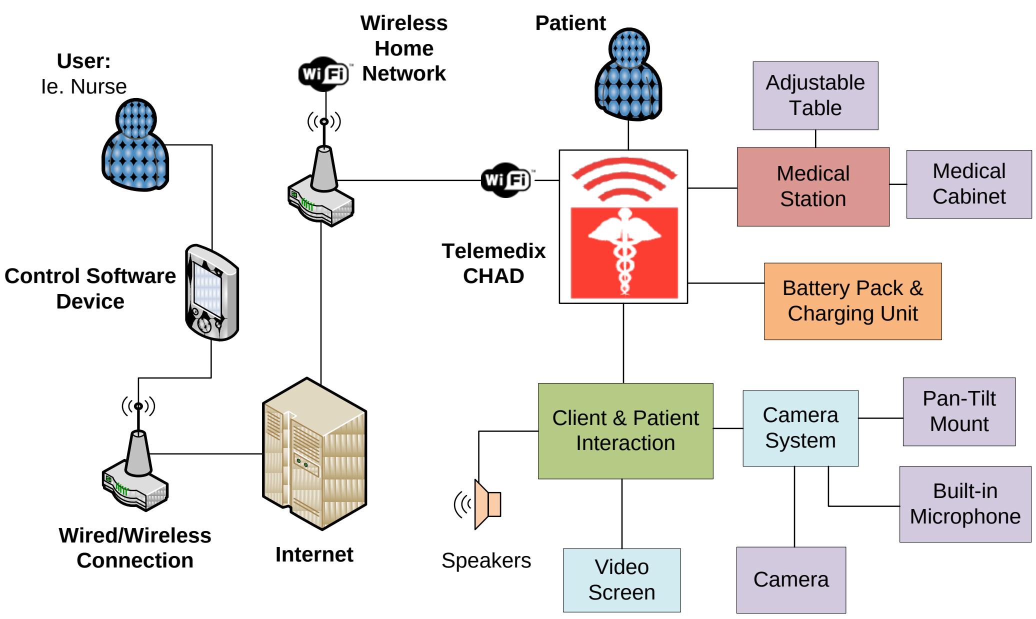

Figure 2.1: System Overview

As shown, the system consists of two main components: the robotic device (CHAD), and the remote controlling software, designed to run on Internet capable devices. These two components will communicate via connection to the Internet; with the robotic device utilizing a Wi-Fi connection.

The robotic device consists of a chassis with an attached webcam, a microphone, and speakers to capture audio and video in the patient's home (as well as produce audio). There will also be a large LCD screen to display video of the user on the final product, however only one way video (patient to controller) will be implemented for the prototype. The robot's chassis will also include a medical station consisting of a height adjustable table and a shelved cabinet to store items such as medication and small medical devices.

The remote controlling software will consist of a GUI allowing the user to control the movement of both the robotic device and the pan tilt camera system. This software will also display the video captured by the camera on the robotic device. Additionally, the software will capture video and audio to be sent back to the robotic device given that the controlling device has both video and audio recording capabilities. Our prototype system, however, will feature only one-way video (from the robotic device to the controlling software) and two-way audio transfer. Further features could also be implemented in software, such as being able to remotely update and fix software issues of the robotic device as well as receive self diagnostic test results from the robotic device, but these features will not be implemented on our prototype system.

This controlling software could be developed on a large variety of Internet capable devices including desktop and notebook computers, smartphones and tablets. For the purposes of the prototype system however, Telemedix will develop an iOS application for use on the Apple iPhone smartphone.

2.2. General Requirements

[R2.2-1 P1] The robotic device must be able to establish connection to the local Wi-Fi network.

[R2.2-2 P1] The robotic device must be able to communicate via the Wi-Fi connection to the remote controlling software.

[R2.2-3 P1] The robotic device must be able to maneuver through hinge doors 76 cm (30") wide and 203 cm (80") tall. [1]

[R2.2-4 P2] The robotic device will enter a low power standby mode after a period of 15 minutes of inactivity.

[R2.2-5 P3] The robotic device will remain connected to the local Wi-Fi network while in standby mode so that it may be brought out of standby by the remote controlling software.

[R2.2-6 P2] The robotic device will be able to pivot 360° in order to maximize maneuverability

[R2.2-7 P3] The retail price of the robotic device and controlling software will not exceed $1000

2.3. Physical Requirements

The following dimensional requirements are specified as to allow the device to move through standard household doorways and hallways. [1]

[R2.3-1 P1] The robotic device must have a width not exceeding 64 cm (25").

[R2.3-2 P1] The robotic device must have a height not exceeding 135 cm (4' 6") when fully extended.

[R2.3-3 P1] The robotic device must have a length not exceeding 9 6cm (38").

[R2.3-4 P3] The robotic device will have a weight not exceeding 23 kg (50 lbs), with the shelves and table unloaded.

[R2.3-5 P2] The robotic device will be visually appealing as to be unobtrusive in a household environment.

[R2.3-6 P3] The outer casing of the robotic device will be contoured, smooth and rigid.

[R2.3-7 P3] The robotic device will be designed to provide adequate airflow through the body without the use of fans to minimize noise.

2.4. Mechanical Requirements

[R2.4-1 P1] The robotic device’s tires must be able to provide adequate traction on indoor flooring surfaces (carpet, tile, laminate, hardwood, cement).

[R2.4-2 P1] The robotic device’s tires must not damage indoor flooring surfaces (carpet, tile, laminate, hardwood, cement).

[R2.4-3 P2] The robotic device will have a centre of gravity such that it maximizes stability during operations.

[R2.4-4 P2] All manually adjustable components will use simple mechanisms.

[R2.4-5 P3] The electromechanically adjustable components will have a manual override.

[R2.4-6 P3] The mechanical components will not be visually or physically obtrusive.

[R2.4-7 P3] The robotic device will not exceed a maximum speed of 1 m/s to be near typical human walking speed. [2]

[R2.4-8 P3] Will use sensors and accelerometers to determine the robotic device’s balance and orientation.

[R2.4-9 P3] Will use actuators to keep the robotic device stable and balanced, based on output of sensors and accelerometers

2.5. Electrical Requirements

[R2.5-1 P1] All electronic components must be mounted securely to the robotic device chassis.

[R2.5-2 P2] All electrical wiring will be well insulated.

[R2.5-3 P3] The robotic device will have a battery life sufficient to give at least 6 hours continuous operation.

[R2.5-4 P3] The robotic device will have a battery life sufficient enough to give standby time of at least 5 days.

[R2.5-5 P3] The robotic device will comply with FCC Part 15 rules. [3]

[R2.5-6 P3] The robotic device will not cause any harmful interference.

[R2.5-7 P3] The robotic device will comply with ICES-003 rules. [4]

[R2.5-8 P3] The robotic device will comply with RSS 210 rules. [5]

2.6. Environmental Requirements

[R2.6-1 P1] The robotic device must be used indoors only.

[R2.6-2 P3] The outer casing of the robotic device will be reasonably water resistant to protect from liquid spills.

[R2.6-3 P3] The robotic device will operate normally under humidity from 10% - 70% Relative Humidity. [6]

[R2.6-4 P3] The robotic device will operate normally over altitudes ranging from sea level to 1500 m above sea level. [7]

[R2.6-5 P3] The robotic device will have a normal operating temperature range of 5°C - 35°C. [8]

[R2.6-6 P3] The robotic device will have a storage temperature of -10°C - 60°C. [8]

[R2.6-7 P3] The robotic device will produce no more than 30 dB noise when in standby mode. [9]

[R2.6-8 P3] The robotic device will produce no more than 60 dB from movements alone. [9]

2.7. Safety Requirements

[R2.7-1 P1] The robotic device must not be able to be tipped on its side without the use of excessive force.

[R2.7-2 P3] The robotic device will utilize proximity sensors to keep a distance of 15 cm (6") from objects and persons in its environment.

[R2.7-3 P3] The robotic device will have a safety brake mechanism and will engage if the robotic device's velocity exceeds 1 m/s.

[R2.7-4 P3] The safety brake mechanism will include a manual disengage lever so the device can be moved manually if desired.

[R2.7-5 P2] The robotic device will have a smooth outer case to prevent personal injury.

[R2.7-6 P2] The robotic device will have no exposed electrical wires or circuit components.

[R2.7-7 P3] The internal components of the robotic device will be easily accessible only with the use of specialized Telemedix service tools.

[R2.7-8 P3] The safety brake mechanism will be engaged while the robotic device is in standby mode, preventing movement.

[R2.7-9 P3] The robotic device will issue a clear, audible message from the speaker system when the camera system is activated, alerting the patient that the robotic device is now active.

[R2.7-10 P2] A large blinking LED will indicate that the device is not in standby mode.

[R2.7-11 P3] Upon resuming from standby mode the robotic device will run a self-diagnostic test and send a brief status report to the controlling software.

[R2.7-12 P3] The self-diagnostic test will complete or report errors within 20 seconds.

[R2.7-13 P2] If communication is lost with the controlling software a warning light will flash indicating this to the patient.

[R2.7-14 P3] If communication is lost with the controlling software, the safety brake mechanism will engage to prevent movement.

[R2.7-15 P3] The robotic device will be able to detect mechanical failures and engage the safety brake mechanism to prevent movement if a mechanical failure is detected.

[R2.7-16 P3] A warning light will flash if the robotic device has detected any mechanical failures.

[R2.7-17 P3] The robotic device will send notification to the remote controlling software if a mechanical failure is detected.

2.8. Reliability and Durability Requirements

[R2.8-1 P2] The robotic device will be serviceable by trained Telemedix technicians.

[R2.8-2 P2] The robotic device will be able to be disassembled for servicing without damaging any components.

[R2.8-3 P3] The battery pack will be operational for 1000 charging cycles at 50% depth of discharge. [10]

[R2.8-4 P3] The motors will have a lifespan of at least 5 years.

[R2.8-5 P3] The electronic circuit boards will have a lifespan of at least 15 years.

[R2.8-6 P3] The electronic peripherals will have a lifespan of at least 10 years.

[R2.8-7 P3] The robotic device will be able to remotely diagnose hardware and software problems with the robotic device or remote control software given that the device has access to the Internet.

[R2.8-8 P3] Will be able to remotely update and fix software issues with the robotic device given that the robotic device has access to the Internet.

[R2.8-9 P3] Will be able to remotely update and fix issues with the controlling software given that the device on which this software runs has access to the Internet.

[R2.8-10 P3] The robotic device will be modular such that each individual subsystem (camera, speakers, circuit boards, motors etc.) may be replaced separately.

3 Client & Patient Interaction

This section consists of five components which are essential for a client and a patient to interact via the robotic device. Generally these are requirements were chosen to provide at least a minimal acceptable quality level of interaction with an elderly patient.

The purpose of the camera is to provide an audio and video feed to the client controlling CHAD. The client will also be able to control the motion of the camera in addition to the motion of the device. The angle requirements specified have been chosen to maximize field of vision and reduce blind spots in an effective manner. Since the device itself also moves, the pan tilt system does not need full horizontal and vertical swing.

The purpose of the speakers and the video screen is to provide audio and video for the patient. The patient can view and listen to the client through these components.

3.1. Camera and Microphone General Requirements

[R3.1-1 P1] Camera must record a color image with resolution at least 640x480 (VGA resolution)

[R3.1-2 P2] Camera will have continuous autofocus

[R3.1-3 P2] Video feed will be at least 20 frames per second [11]

[R3.1-4 P1] Audio and video feed must be synchronized

[R3.1-5 P1] Microphone must be able to detect sound of at least 40 dB (volume of a quiet conversation) [9]

[R3.1-6 P3] Microphone will be sensitive for all frequencies of human speech

[R3.1-7 P3] Camera will have a night vision mode

[R3.1-8 P1] Microphone quality must be similar to that of a telephone

3.2. Pan Tilt System General Requirements

[R3.2-1 P1] Camera mount must have horizontal swing of at least 135°

[R3.2-2 P1] Camera mount must have vertical swing of at least 90°

[R3.2-3 P1] Camera mount must support a minimum of 500 g

[R3.2-4 P2] Camera mount will move from one extreme to the opposite extreme in under 2 seconds

[R3.2-5 P2] Pan tilt system motors will remain silent when not operating

[R3.2-6 P3] Pan tilt system motors will generate less than 60 dB of noise when operating (volume of normal conversation level) [9]

3.3. Speakers General Requirements

[R3.3-1 P1] The robot/device must consist of at least 2 speakers to provide stereo sound.

[R3.3-2 P3] Speakers will be able to produce greater than 60 dB of audio because some of the elderly suffer with hearing loss around 60 dB and require audio louder than 60 dB. [12][13]

[R3.3-3 P3] Speakers will be able to reproduce all frequencies of human speech [12]

[R3.3-4 P2] Speaker volume will be adjustable by both the client and the patient through the controller software and on the robotic device using a knob for manual adjustment.

[R3.3-5 P1] Speakers must be within the defined size and weight constraints of the robotic device.

3.4. Video Screen General Requirements

[R3.4-1 P3] Video screen will be able to produce at least 250 Nits of Luminance to provide enough lighting in indoor environments. [14]

[R3.4-2 P3] Video screen will have at least 4:3 aspect ratio and 500:1 contrast ratio. [14]

[R3.4-3 P3] Video screen will have at least 640x480 resolution. (VGA resolution)

[R3.4-4 P3] Video screen will not have narrow viewing angle such that the luminance and color contrast is not reduced more than half when viewing angle is 45° away from center of screen.

[R3.4-5 P3] Video screen will have a refresh rate of at least 75 Hz.

[R3.4-6 P3] Video screen size will be at least 20 inches.

[R3.4-7 P3] Video screen will be within the defined size and weight constraints of the robotic device.

[R3.4-8 P3] Video screen will display the client's face clearly and in real time.

[R3.4-9 P3] Video screen will display at least rec709 color gamut.

3.5. Standards

[R3.5-1 P3] Robotic device will comply with CSA standards Z323.3.1 – 1982 (R2008), Electrical aids for physically disabled persons

4 Medical Station

4.1. General Requirements

[R4.1-1 P1] Table must support at least 25 lbs

[R4.1-2 P1] Table and cabinet dimensions must not exceed footprint of the robot

[R4.1-3 P2] Table will be height adjustable between 90cm (3ft) and 152cm (5ft)

[R4.1-4 P3] Table height will be adjusted using a linear actuator

[R4.1-5 P1] Dimensions of medicine cabinet must not exceed 50 cm x 40 cm x 20 cm (20 in x 15 in x 8 in)

5 Charging Dock

The purpose of the charging dock is to allow the remote user to park the robotic device on the dock to charge the batteries so the home user does not need to physically interact with the robotic device.

5.1. General Requirements

[R5.1-1 P3] The charging base will be no wider than 12" (30.48 cm)

[R5.1-2 P3] The charging base will be no longer than 12" (30.48 cm)

[R5.1-3 P3] The charging base will be exactly 5" (12.7 cm) in height

[R5.1-4 P3] Each of the two charging contacts on top of the base will be 9" squared (58.06 cm^2)

[R5.1-5 P3] The charging base will have a NEMA 5-15 plug with a cord at least 3 meters long that retracts on a spring into the charging base

[R5.1-6 P3] The charging base will not weigh more than 20 lbs.

[R5.1-7 P3] The charging base will be secured to the floor to prevent being moved when coming in contact with the robotic device

[R5.1-8 P3] The charging dock will charge the batteries from empty to full in eight hours or less

5.2. Standards

[R5.2-1 P3] The charging base will adhere to all CSA-E60335-2-29 standards applicable to battery chargers.

6 Remote Control Software

6.1. General Requirements

[R6.1-1 P2] Will be able to check for internet connectivity, and give an appropriate error message when none exists

[R6.1-2 P1] Must be able to establish a connection with the robotic device

[R6.1-3 P1] Must be able to send information that will be used to control the movement of the camera system (in the directions left, right, up and down)

[R6.1-4 P1] Must be able to send information that will be used to control the movement of the robot itself (in all X-Y directions)

[R6.1-5 P1] Must b able to receive and display live streaming video from the robotic device

[R6.1-6 P3] Will be able to send live streaming video with resolution of at least 640x480 (VGA resolution) from the controlling software to the robotic device

[R6.1-7 P1] Must be able to receive live audio from the robotic device

[R6.1-8 P1] Must be able to record and send live audio to the robotic device

[R6.1-9 P2] Will be able to play the received audio at a volume in a range from 0 dB to 80 dB (10 dB above that of normal conversation to ensure it is audible to all possible users [9])

[R6.1-10 P1] On controller end, audio must be easily audible and understandable to someone with reasonable hearing abilities (someone who is not hearing impaired, but doesn't have extraordinary hearing abilities)

[R6.1-11 P3] Controlling software will not be larger than 20 MB

[R6.1-12 P3] Video and audio streams will be synchronous

[R6.1-13 P1] Video must be easily viewable for someone with reasonable sight (able to see close and far things without straining eyes; who is with or without glasses)

[R6.1-14 P2] Brightness of video will be adjustable

[R6.1-15 P3] Delay between user inputting instructions (such as inputting a direction to move the robotic device) and device executing instructions will not be more than 100 ms.

[R6.1-16 P3] Will not take longer than 10 seconds for software to start once run on supported hardware

[R6.1-17 P1] Must be able to terminate software without damaging hardware of robotic device

[R6.1-18 P1] Must be able to terminate software without damaging controlling device that is running the software

[R6.1-19 P3] Will securely transmit and receive data without risk of data being intercepted

[R6.1-20 P3] Will not interfere with any other electronic devices

[R6.1-21 P3] Will require a secure login and user verification before usage

[R6.1-22 P1] Must be able to connect to the Internet

[R6.1-23 P3] Remote control software will receive feedback from robotic device about current direction of movement

[R6.1-24 P3] Remote control software will receive feedback about speed of robotic device

6.2. Usability Requirements

[R6.2-1 P2] User interface will be intuitive and easy to use

[R6.2-2 P2] Will be usable without requiring any technical knowledge

[R6.2-3 P3] User interface will be visually appealing

7 User Documentation

7.1. General Requirements

[R7.1-1 P2] Device will include quick start guides for patients and controllers

[R7.1-2 P2] User documentation will be downloadable from the Telemedix company website

[R7.1-3 P2] Technical documentation will be provided to authorized technicians

[R7.1-4 P3] User documentation will be written in multiple languages

[R7.1-5 P3] User documentation will include pictures and wording to describe all features

[R7.1-6 P3] User documentation will include instructions for all functionalities relevant to the user of the controlling software

[R7.1-7 P3] User documentation will include instructions detailing all the functionalities relevant to the patient.

[R7.1-8 P3] User documentation and quick start guide will be written to accommodate users with no technical background

[R7.1-9 P3] User documentation will outline the usability and limitations of the device

[R7.1-10 P3] User documentation will describe safety precautions

[R7.1-11 P3] User documentation will contain warranty details

8 System Test Plan

8.1. Client & Patient Interaction Tests

The testing of the client and user interaction components will be split into four sections: camera with microphone, camera pan tilt mount, speakers, and the display screen. Each component will have its own testing procedure which will prove whether the device has adhered to its requirements.

The camera will be first tested on its video image quality. For the camera's resolution, we will record an arbitrary scene and store the data on a computer. From the recorded video, we will extract the camera's resolution size, its frame rate and whether or not the camera produced colour images. For testing the continuous autofocus requirement of the camera, we will move it under different speeds to see if the camera will still produce video images that are continuously focused. This test will also include the camera being stationary for lengthy periods of time under different lighting environments. Under low ambient lighting or dark environments we will test its night vision capability as well. The microphone will be tested on its sensitivity using a digital sound level meter and a speaker. The speaker will produce sounds at 40 dB, while the digital sound level meter will be connected to the microphone to record the sound level in decibels. This test will also give us an idea of the quality by extracting its bit rate. Lastly, using an audio video latency testing software we will test the synchronization between audio and video.

The camera's pan tilt mount will be tested on its range of motion using a microcontroller. The microcontroller will send signals to the pan tilt system, from which we will be able to measure the horizontal and vertical swing and their respective angular speeds. Simultaneously we will measure the noise level generated from the pan tilt movement. Furthermore, we will also measure the noise generated when the mounting system is not active. These tests will be repeated for different loads to ensure the mounting system can achieve the same performance when having a load of at least 500 g. Additionally, these tests will be done in a quiet and indoor environment.

The speakers will be tested using a multimedia device and a sound level meter. The multimedia device, such as an iPod, will play a recording containing different frequencies of human speech on the speakers. During this time, the sound level meter will measure the loudness of the audio coming from the speakers. Secondly, the speakers' adjustability will be tested from both the controller software and the volume knob located on the robot.

We will conduct a video screen examination using test images and a spectroradiometer to acquire the best possible quality for the device's monitor. The video screen will be tested on the image quality produced at different angles and distances. Using a luminance meter, we will measure the luminance produced from video screen when displaying a pure white. These measurements will help calibrate the colors, brightness, contrast, and sharpness using test images. Additionally these measurements will give a sense of the viewing angle and its colour gamut. Similarly, these test images will be used to detect dead pixels and its resolution.

8.2. Physical Tests

The physical characteristics of the device such as its structural strength and durability will be established through a series of tests. The strength of the overall robotic device will be determined from several types of drop tests including free-fall and tip-over tests. The loading strength, specifically of the Medical Station, will be tested by applying increasing levels of weight until signs of significant stress and damage are observed. Temperature tests will also be completed to determine its effects on the device's material composition. We will also conduct liquid spill tests to establish the effectiveness of the device's outer shell in protecting its vital electronics.

8.3. Motor Tests

Similar to the physical tests, increasing values of weight will be applied to the motors to determine their performance under load. We will also test the motors for extended periods of time, above the maximum continuous operation of 6 hours, and check if temperature levels are within running condition. The motors and wheels will be tested on a variety of floor types found commonly in households; with this we will be able to determine a standard configuration for the motor & wheel assembly that will provide maximum performance. The type of wheel material being used must also be tested to ensure damage is not done to the floors. Also, the robotic device will be loaded in ways that that set it off balance and the balancing system will be tested to ensure it maintains a stable and balanced robotic device.

8.4. Software and Integration Tests

Testing and development for the various software involved in our system will be done in several stages beginning with separate components and then moving to system integration. This approach has the advantage of allowing development and testing of each component to go in parallel. During each stage software will be tested for performance and reliability, making sure all corner cases are accounted for.

We will begin with testing communications from the controlling software over the Internet by first performing a series of ping tests to various Internet web servers. Once this is complete, we will then test the ability of the controlling software to connect to and send data to and from computer software running on a Linux computer, with the idea that we would progress to communicating directly to the main board of the robotic device. We will test the integrity of transmission by performing loopback tests, that is sending generic data from the controlling device and then having the robotic device send the same data back. The received data will be compared with the transmitted data to ensure there is no data loss during transmission. Once loopback testing is complete we plan to send simple data between the devices to simulate motor control commands. The controlling software will send data strings and the robotic device software will simply parse the command data and print the intended action to the screen, such as "Move forward". This will ease the task of actual motor control via the remote control software.

While testing and development are ongoing for the wireless communication between our devices, we will also work on developing and testing the robot movement and motor control software. The goal of this stage is to make sure all of the movement requirements are met for the chassis motors and the pan tilt camera mount system. We will begin by executing simple commands to test the movement of the robotic device and the pan tilt mount. These commands will then be automated with the use of scripts that will run locally on the main board of the robot. Each movement will be tested individually for performance and stability. Additionally we will ensure that each mechanical component can be started and shut down safely by software.

In addition to the lower level motor control functions, we will develop and test software control of the video and audio capture of the camera and microphone as well as the playback ability of the speaker and LCD on both the robotic device and the controlling device. We will use various test images and sounds to do this, and then progress to using live recorded video and audio streams. Each of these components will be tested individually to begin with and then will be synchronized.

The next stage of testing will involve integrating the work of each of the previous development and testing stages. We will begin by testing robot movement control via the remote software in which we will verify the timing and speed requirements laid out in the above requirements section. Once this is complete we will add the combined audio and video feeds and test their quality as outlined in the requirements.

Lastly, to test the user interface of the controlling software we will perform a series of usability and human factors tests to ensure our software meets the usability requirements we have laid out. We will have a real user test the user interface, and have them give us feedback on its usability. This will allow us to fine tune the controller software to be easy and reliable for the end users.

Once all of the above testing is complete, we will do a final check of each and every requirement. This will consist of going through each requirement that has been completed, and testing its functionality, performance, and reliability. This will be the final check to ensure our prototype device has met all of the aforementioned requirements.

9 Conclusion

The functional specifications described in this document outline the performance, safety, and reliability requirements of CHAD. Product standards are also addressed as well as the device's user documentation and test plan. A prototype meeting the primary specifications will be completed by April 10th 2011. If the project is finished ahead of schedule, the Telemedix team will attempt to accomplish secondary objects specified in the document.

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