PRAlpha Robotics Inc.

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Monday, February 18, 2008

Mr. Patrick Leung
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia.
V5A 1S6

Re: ENSC 305/440 Project, Home Care Robot functional specifications

Dear Mr. Leung,

Thank you for being interested in our idea of building a web-controlled robot for general home care purpose. Base on our marketing research, our team outlines the functional specification for our project, building a multi-functional home care robot, iBonni.

In the attached document, *Functional Specification for the Home Care Robot,* we describe the detailed requirements of our product. We carefully select the most useful features for our users within an affordable range of our system. Users shall be able to add extra personal defined function to the robot easily.

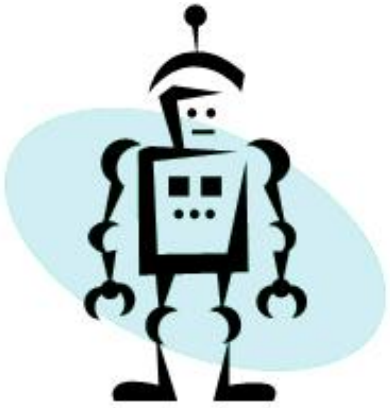
If you have any concerns or questions regarding to this project, please contact us by email, pr-440@sfu.ca, or visit our company website, http://pralpha.info.

Sincerely,

Rick Wong
Chief Executive Officer
PRAlpha Robotics Inc.

Enclosure: *Home Care Robot Functional Specifications*

PRAlpha Robotics Inc.



Functional Specification for the Home Care Robot

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1	ETC-002	Proposal for a Home care Robot, Jan 21, 2008

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Issue	Author(s)	Date	Description
0.1	Jessica Sun	2008/2/13	✧ Creation
0.2	Rick Wong Jessica Sun Ye Feng	2008/2/16	✧ Excutive Summary ✧ Introduction ✧ Physical Requirements ✧ Electrical Requirements ✧ User Documentation ✧ Conclution
0.3	Rick Wong Jessica Sun	2008/2/17	✧ System General Requirements ✧ Performance Requirements ✧ Known System Limitations ✧ Environmental Considerations ✧ User Training ✧ Sensor System
0.4	Rick Wong	2008/2/18	✧ Power System ✧ Reliability and Durability ✧ Safety Requirements
0.5	Ye Feng	2008/2/18	✧ Motion System ✧ User Inferface ✧ Standards
1.0	Rick Wong	2008/2/18	✧ Final review
1.1	Jessica Sun	2008/2/26	✧ Reference

Executive Summary

People concern about their home and pet in situation they need to be away for days, weeks or even months. Many devices have been developed for this issue like home security system, automatic pet-feeder and IP-cameras. However, we have to shop around for several devices and services and some of the existing devices do not work very well under variety situations.

The objective of our project is to build a multi-functional robot platform which will be capable of manipulating objects and allows future add-ons and user-definable functionalities. For home secure usage, house owners can remotely access robot from anywhere via internet and drive it to monitor their house through night vision camera. Using the powerful built-in sensor system, our robot can take the roles of smoke detector, flood detector, temperature detector, etc and generate alert in case of emergency. Besides security applications, our robot is also able to operate other home devices via IR transmission as a universal remote controller which can be accessed by house owners through network. Therefore, our product can achieve various functionalities. For instance, with speaker and MIC on robot, house owner can even talk and play with their pet.

Main features of our product iBonni are:

- **Mobility:** iBonni can move freely to each direction. The unit should last 3 hours of continuous usage.
- **Vision:** Though the vision system of iBonni, users can watch their home through the client program from us
- **Control:** A graphic user interface of the remote controller is provided, so that the user can remotely control the movement of iBonni via internet and control the corresponding device at home via the remote controller on iBonni.
- **Monitor:** With various sensors, iBonni can monitor your home situation and report them to users if required

To achieve our goal, our project will be divided into several sub-modules including Center Manager Module, Action Control Module and Sensor Control Module. The development process will also be divided into smaller phases.

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Glossary

Term	Definition
ACM	Action Control Module
CMM	Center Manager Module
I^2C	Inter-Integrated Circuit, a mutli-master serial BUS
PFM	Path Finding Module
PLM	Position Locating Module
PWM	Pulse-Width Modulation
SCM	Sensor Control Module
TWI	Two-Wire serial Interface
UDM	User Defined Module
USART	Universal Synchronous/Asynchronous Receiver/Transmitter
ANSI	American National Standards Institute
Wireshark	A free packet sniffer computer application for network analysis

1 Introduction

PRAlpha Inc. proposes developing a mobile robot, iBonni, which acts as an interface for household between home and remote site. iBonni can be controlled by an easy to use web GUI (Graphic User Interface) via Internet. User's command could be sent back home to control devices for watering plants, feeding pets, switching lights or opening windows. Furthermore, its sensor system can report the real time status of home, for example, the temperature. People can view their home though iBonni's eye, a night version camera or can even talk with their pets via speakers and MIC.

1.1 Scope

This document for iBonni home care robot outlines its proposed functionalities and lists a set of requirements which will guide our product design. A test plan has also been involved to ensure the development progress.

1.2 Intended Audience

This document is primarily created for the PRAlpha project team to provide direction in the design of the iBonni. Team members will use it as a framework for the project. Team manager will use it to check the development progress. Design engineers will use it to ensure their product design meets the requirements. Test engineers will use it to verify their testing goal. Sales person will use it as a user handbook.

1.3 Classification

Following convention will be used in this document to denote requirement levels:

[PR*x*-*y*] Requirement description

x is the requirement number, and ***y*** denotes the stage of production the requirement is applicable to, which can be of three options:

- **A** The functional requirement is only intended for the proof-of-concept device.
- **B** The functional requirement is only intended for the production device.
- **C** The functional requirement is intended for both the proof-of-concept and production device.

2 System Requirements

2.1 System Overview

This robot, iBonni, is a center command device which interface home and remote site. As shown in Figure 1, households can remotely control and monitor iBonni by accessing a web based GUI in favor Internet Brower. The sensor system and cameras installed on iBonni will provide the real time status and feedback to the user.

The user can choose to be text messaged on his cell phone in cases of fire, gas or water leaking emergency situations. On the other hand, iBonni can pass the command inputted in GUI to other home devices such as pet feeder, plant watering system and light switches via IR transmission.

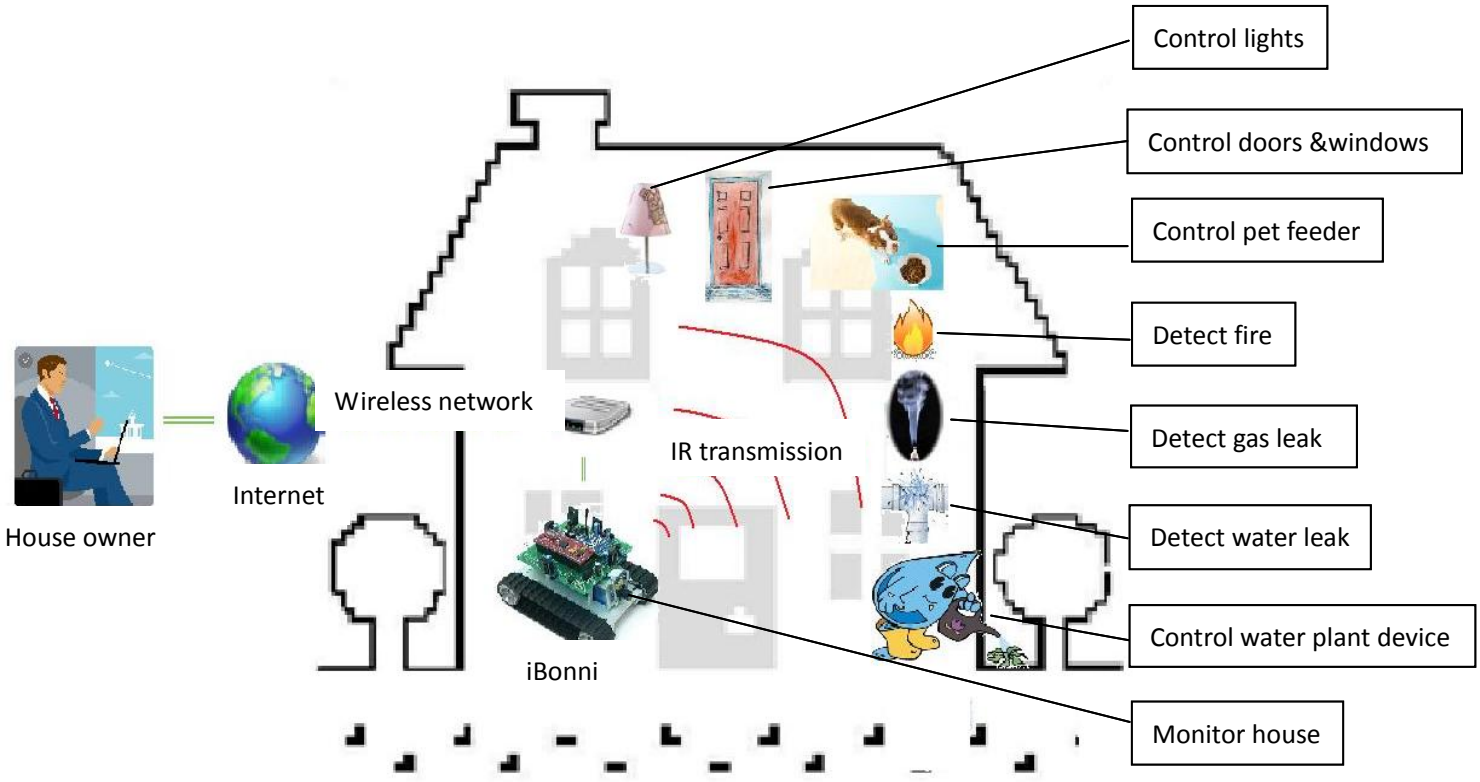

Figure 1: System Sketch [1]

2.2 General Requirements

The robot will to be designed to operate indoor with the below conditions:

2.2.1 Temperature

[PR1-B] The robot shall be able to operate at a temperature range between 0 °C to 50 °C, which covers the possible room temperature range. [2]

2.2.2 Humidity

[PR2-B] The operating humilities are limited by the PC mainboard, which are between 0% ~ 95% (relative humidity; non-condensing). [3]

2.2.3 Cruise duration

[PR3-B] The robot must be able to continuously operate for at least 2 hours with a full charge.

2.3 Physical Requirements

2.3.1 Size

[PR4-B] In order to archive a better portability and easy to avoid road blocks, the size of the robot shall be kept as small as possible. Dimensions of the robot shall be less than 30cm of height, 40cm of length and 20cm of width.

2.3.2 Weight

[PR5-B] The weight shall be as light as possible to save the power consumed by motors. Considering the weight load the motors can afford, the total weight of the robot, including batteries and shall be less than 5 Kg.

2.3.3 Outside Shell:

[PR5-B] The device shall be protected by the outside shell; therefore, the shell must be strong enough while also lightweight.

2.4 Electrical Requirements

2.4.1 Power

[PR6-B] The robot must have enough power to operate continuously for a certain length of time, at least 2 hours.

[PR7-B] Since the robot must have a good portability, power must be stored into batteries instead of using wall-plug.

2.4.2 Heat Dissipation

[PR8-B] The robot is designed to continuously operate for a long period of time, therefore the heat generated by PC, microcontroller, motors and battery must be dissipated properly.

2.5 Environmental Considerations

2.5.1 ROHS Compliant

[PR9-B] ROHS compliant components shall be used whenever apply.

2.5.2 E & M Interfere

[PR10-B] In order to reduce electromagnetic wave interferes to the environment, IR is chosen as the communication protocol. Moreover, the robot shall be covered by metal shell to father reduce the electromagnetic field.

2.5.3 Potential Damage to Room Floor

[PR11-B] The potential damage to room floor shall be as less as possible if cannot be zero. To archive this, the robot shall be lightweight and the motion system shall be floor friendly.

2.6 Standards

[PR12-C] Product version conforms to ANSI standards. [4]
[PR13-C] Product version meets requirements of CSA certification. [5]
[PR14-C] Product version meets requirements of IEEE standards. [6]

2.7 Reliability and Durability

2.7.1 Reliability

[PR15-A] All sensors shall have a maximum error of 5%.
[PR16-B] The robot shall provide the status of sensors for monitoring with minimum time delay.
[PR17-B] The robot shall provide feedbacks of the commands for validating.
[PR18-B] User must be able to reset all sub-systems remotely in cases of critical error or system hang.
[PR19-B] Robot must send warning message whenever attention is needed, for instant, the power is low.

2.7.2 Durability

[PR20-C] The robot shall operate normally for at least 3 years of daily use.

[PR21-C] The robot shall be able to withstand a reasonable drop or collision.

2.8 Safety Requirements

[PR22-B] The outside shell shall be made by biomedical friendly materials and have no sharp corners, edges or points which may cause a danger to the user.

[PR23-B] The power system shall be shielded and protected to ensure no harmful electrical leaking is possible. An over-current protecting circuit is desired.

[PR24-B] The robot must be able to detect and avoid collision with objects whenever possible to minimize danger to children or pets.

[PR25-B] An emergency bottom which stops all actions of the robot must be easy to access.

[PR26-B] Potential risk actions must be double confirmed by the user before executing.

[PR27-B] The heat sinks shall be isolated so users or pets will not be injured by the high temperature.

[PR28-C] Security login shall be employed to ensure the validity of user's identity.

2.9 Performance Requirements

2.9.1 Local Command Response Time

[PR29-B] The local command response time refers to the time delay between the commands generated by user on PC to be executed by the microcontroller. The microcontroller shall response to the local commands within 0.5 second.

2.9.2 Emergency Response Time

[PR30-B] The emergency response time refers to the time delay between the detection of emergency event by the sensor system to proper response. A proper action shall be generated within 100 microseconds.

2.9.3 Internet delay

[PR31-B] A broadband internet with a minimal delay is desired to ensure the quality of remote control and monitor services.

2.10 Compatibility with Other Systems

[PR32-B] Client program is running on both Windows XP and Linux platforms

[PR33-B] No installation is needed to run the client program

[PR34-B] Accessible and controlled through Internet

2.11 Known System Limitations

2.11.1 Manual Control

[PR35-B] The robot has to be controlled by human as user either locally or remotely. The automatic control ability requires positioning and path finding functions, which may be future add-ons in the next generation.

2.11.2 Handling Stairs

[PR36-B] This generation will not be able to climb up or down the stairs. The robot must stay on one floor otherwise handled by user oneself.

2.11.3 Internet Access

[PR37-B] Since this robot is to be controlled remotely via wireless connection, the internet access is essential. Moreover, the quality of service will depend on the internet bandwidth and delay.

2.11.4 In Door Only

[PR38-B] The robot is designed to be used in door only. It may not operate normally under outdoor conditions such as cold temperature, rain, bumpy road surface and lack of wireless internet access.

3 Sensor System

Our product, iBonni, is able to monitor several aspects of the house's situation through the sensor control module which can periodically collect data from sensor, store them into memory and alarm users if the sensor status is abnormal. Sensor system contains a sensor control module and several sensors such as vision sensor, block sensor, temperature sensor, fire sensor, gas sensor, flood sensor, etc. The block diagram of sensor system is showed below:

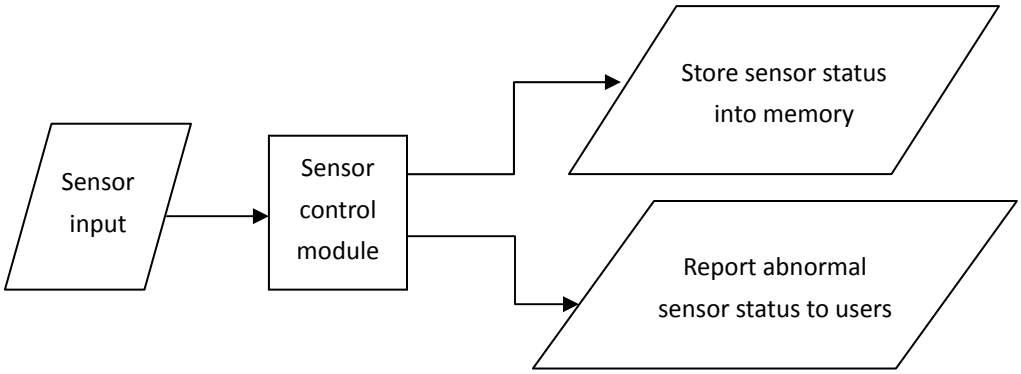

Figure 2: Sensor control module block diagram

The requirements for each sensor are:

3.1 Vision Sensor

[PR39-B] The resolution of the video shall be high enough to provide quality image for monitoring and also shall be low enough to minimize internet delay.

[PR40-B] The viewing angle shall be wide enough for monitoring.

[PR41-B] Users shall be able to monitor the house in dark, underwater or smoky conditions.

3.2 Block Sensor

[PR42-B] The sensor shall be able to detect the block within 2 meters ahead.

[PR43-B] The sensor module shall be able to report the distance from the block to users and auto stop the robot movement if the distance is minimized.

3.3 Temperature Sensor

[PR44-B] The temperature detect sensor shall be able to detect the environment temperature.

[PR45-B] The temperature detect sensor shall be suitable for monitoring extreme temperature conditions.

[PR46-B] The general contact temperature for human and pets is from -10 degrees Celsius to 40 degrees Celsius, therefore the sensor control module will send a notice to users if the temperature is out of this range. [7]

[PR47-B] The allowable temperature range can also be configured by user.

3.4 Other Sensors

[PR48-B] The fire sensor shall be able to detect the burning objects and report to users.

[PR49-B] The gas sensor shall be able to detect the gas in the air and report to users if it is in danger.

[PR50-B] The flood sensor shall be able to detect the water leaking on the floor.

4 Motion System

4.1 General Requirements

[PR51-B] The motion system carries the on-board PC, sensor system and power system.
[PR52-B] The robot shall be able to move forward or backward flat floor smoothly.
[PR53-B] The robot shall also be turn left or right flat floor smoothly.
[PR54-B] The robot shall stop automatically if no command is received.
[PR55-B] The robot must stop automatically before blockage without collision.
[PR56-B] The motion system shall provide stable movement for video capturing.

4.2 Physical Requirements

[PR57-B] The motion system shall provide a 5 Kg load capacity.
[PR58-B] The error of movement shall no more than 1 cm compare to the desired distance.

5 User Interface

5.1 General Requirements

[PR59-B] A command line interface shall be designed for early development phase.
[PR60-B] A graphic user interface shall be designed for product version.
[PR61-B] User authentication shall be designed for product version.
[PR62-B] Video stream from the vision sensor shall be transmit and displayed to the user.
[PR63-B] Sound from the vision system shall also be transmit and played back.
[PR64-B] User shall be able to subscribe monitor system to active/inactive sensors.
[PR65-B] The user interface shall display status of active sensor.
[PR66-B] The user interface shall display the key status of the whole robot system.
[PR67-B] The robot shall accept commands from remote controller.
[PR68-B] The robot shall be able to record and playback commands.
[PR69-B] User shall also be able to save and import command records

5.2 Physical Requirements

[PR70-B] Graphic user interface should be displayed clear enough for monitoring.

6 Power System

6.1 General Requirements

[PR71-B] As mentioned in section 2.4.1, batteries must be used to store power to ensure portability.

[PR72-B] High capacity batteries are required to provide enough power for the robot to continuously operate for at least 2 hours.

[PR73-B] Batteries shall be able to perform a full charge in a short period of time.

[PR74-B] The batteries shall be memory-less so that it does not loss capacity after repeated charging.

6.2 Physical Requirements

[PR75-B] The battery itself shall also be lightweight in order to save power consumed by the motors.

[PR76-B] The available space to store the power system is limited by the overall size of the robot. Therefore, the maximum dimensions of the power system must be 15cm of height, 20cm of length and 15cm of width.

7 Documentation and User Training

[PR77-C] User Documentation will include a website which contains all important documents for our project and all the discussion and progress our team made. Users also can post their questions on the BBS which will be replied by our engineers instantly.

[PR78-C] The user manual which includes a quick start guide, detailed operations and troubleshooting shall be created for users with moderate computer and internet skills. A quick safety and usage training will be offered to required users.

[PR79-C] A detailed installation guide, technology specification and service guide will be created for technicians. Sufficient technical training will be offered to required technicians.

[PR80-C] User documentation will be written in English and Chinese with future languages to meet the language requirements for growing international markets.

[PR81-C] Copyright and warranty information will be provided for users.

8 System Test Plan

A practical test plan is important for checking whether the product meets all the specifications successfully. Since our project contains several modules, all modules must be tested individually in their development phases. The test plans for each module are:

8.1 Sensor System

For the sensor system, the first testing object is to make sure the sensor control module can properly receive data from sensors and send them to other modules. For different sensors we will set some sample environment situations and check if these specified situations are properly reported by the sensor system.

8.2 Movement System

iBonni will undergo the test of moving forwards and backwards, turning left and right with 4kg test load. Test cases of stopping by not receiving commands and stopping by detecting blockage would be done.

8.3 User Interface

For testing user Interface about receiving and sending commands, we will write everything which is received or sent as a command to a text file and then verify the commands and the content of the input/output. For testing communication between computer and robot, we will use LEDs to verify sending and receiving data.

8.4 Power System

The maximum and minimum cut-off voltages and currents must be full tested. The capacity of the battery must be tested by perform fully charging and discharging. The charging time shall also be tested and compared to our requirements.

8.5 Overall System

Each module must be tested prior to integration and the overall system shall be fully tested throughout the integration phase. The overall specifications shall be verified to meet the requirements mentioned in previous sections.

9 Conclusion

The functional specification outlines the capabilities and requirements that should be met by the home care robot, iBonni. Our project will be designed based upon the functional requirements which are specified in this document which also helps the project team to better manage our development priority, progress, resources and budget. Our final product is expected to fulfill all the functional requirements listed above and will be completed by our final milestone date, April 6th, 2008.

10 References

[1] Robot ICO from the following reference and other ICOs from Microsoft Word Resources. Parallax Inc, *Rolling Robot*, 2007. [online]. Available: http://www.parallax.com/ProductInfo/Robotics/tabid/229/Default.aspx [Accessed: February 14, 2008]

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[7] G4.38 Extreme temperatures, *general contact temperature*, Sep 1999. [online]. Available: http://www2.worksafebc.com/Publications/OHSRegulation/GuidelinePart4.asp?ReportID=18787Crime&_from=regulation.healthandsafetycentre.org [Accessed: February 20, 2008]