Auto Tech

TRACKER BY DESIGN

September 17, 2012

Dr. Andrew Rawicz

School of Engineering Science

Simon Fraser University

Burnaby, British Columbia

V5A 1S6

Re: ENSC 440W Project Proposal: Human Chasing Robot by Auto Tech

Dear Dr. Rawicz,

Please find the attached proposal for our project Human Chasing Robot by our company Auto Tech. It is a tracking robot that follows and monitors patients. Our product can be widely used in hospitals, mental institutions and nursing homes to track patients.

The proposal is intended to provide an overall view of our product. It includes possible solutions, estimated budget, timeline, and also team organization for the project.

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: Proposal for Human Chasing Robot

Auto Tech

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PROJECT PROPOSAL FOR HUMAN CHASING ROBOT

Project Team

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Submitted to

Dr. Andrew Rawicz

Steve Whitmore

School of Engineering Science

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Issued Date

September 17, 2012

EXECUTIVE SUMMARY

The labor force of Canada is shrinking as the population continues to age. The demands for nursing care increase as more and more people enter long-term care facilities. The current strategy employed by the Canadian government is continuous injection of technical immigrants into the labor market. However, this solution is not sufficient to fill the gap in our work force. Instead of increasing the number of human workers, an alternative solution is to introduce new technologies to lessen the burden of care-givers.

Here at Auto Tech, we believe robots are the solution to Canada's labor shortage. Robots can be used to perform labor-intensive or mundane tasks and freeing professionals to focus on more technical tasks. Many industries can benefit from using robots and there is a great potential for robots in our society.

Nursing has one of the highest demanded for skill workers in Canada. In nursing homes, robots can free care-givers from their daily chores so they can focus on more technical or complex operations. Technologies also allow professionals to perform their jobs more efficiently. We propose to use robots to monitor patients, which can be used at hospitals, mental institutions and nursing homes. Robots can track patients close to monitor them and carry medical equipment and supplies.

We plan to use tracking beacons with ultrasonic transmitters that are attached to high-risk patients. A robot equipped with ultrasonic receivers 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.

We estimate this project will take three month, which includes planning, research, implementation, and testing our project. The budget is estimated to be $500 and we have applied and approved for funding from ESSEF.

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INTRODUCTION

Canada's top problem is filling labor shortage. Canadian Prime Minister Stephen Harper said: "within a decade or two, there simply will not be enough workers in the country." Human Resources Minister Monte Solberg also gave out some data to back up Harper's opinion: British Columbia will be short 350,000 workers over the next 12 years. Alberta will require 100,000 workers over the next 10 years. Ontario will need 560,000 more workers by 2030. Quebec will have 1.3million job openings by 2016. Those data shows that we have a significant shortfall of workers in Canada.

Government could fix this problem by increasing the number of technical immigration, decreasing the number of investment immigration, making some limit such as age limit to let people who have strong ability in work come to Canada and so on. However, this problem hasn't been fixed.

The objective of our product is to develop a robot, which could replace human workers to do jobs. And we focus our robot's working area on healthiness. It can be used in hospital, mental institutions and nursing homes. The robot follows and monitors patients. There are two part of our product: the body of the robot and a beacon that will be carried on patients. An ultrasonic transmitter will be used on the beacon and two receivers on the robot. The ultrasonic transmitter send signal to the receivers, once the receivers receive the signal, our program will execute the signal. Then the robot follows the target.

By tracking patients, our robot will store their state of health and send these data to computer so doctor or nurse can monitors patient or use them for record. Because our robot follows patients and keep a certain distance, it can carry things for patients such as infusion bottle, bags and so on.

According to Children's Hospital in Vancouver, the hospital has forced the postponement of 50 surgeries in 3 months and 14 cancellations in just two weeks because of a lack of nurses for post-operative care. By using our robot, its can significantly save human resource and let our human resource play a role in the most important places such as operating room in hospital.

This document is a proposal that providing an overview of our product, funding, design methods, sources of information, time schedule and company profile. Alternate solutions are also discussed.

SYSTEM OVERVIEW

Our system has three distinct components: a robot that can move around, a camera that enables video streaming, and a main processor unit that can track a human and control the robot. The moving robot can be built easily using motors, wheels and frames. The camera can be attached to a Wi-Fi card to transfer the video data trough Wi-Fi. The last component, however, is not as simple as the other components. We have done an extensive analysis on the possible design solutions and came up with the following hardware design.

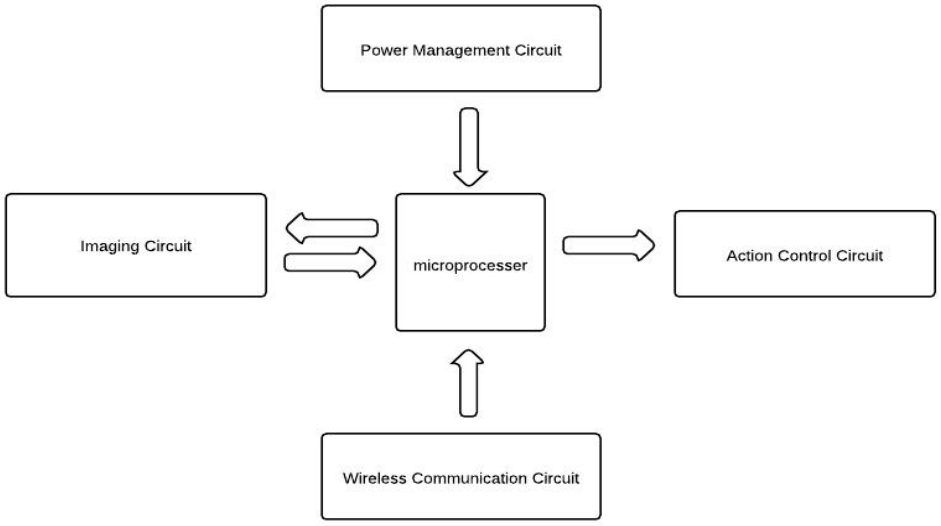

Figure 1 – Main Processor Hardware Overview

Figure 1 demonstrates the hardware overview of our main processor hardware parts. It has four parts as shown below:

1: Power Management Circuit

- It is the heart of our design; it provides 5V voltage to the other circuit

2: Action Control Circuit

- It is the brain of our design; it will location the object of chasing and controls all action of the car, such as, move forward and back, turn right and left.

3: Imaging circuit

- It is the eyes of our design; it will capture the view in front of the car. Also, it will save the data for locating the object if we use image processing for our software solution.

4: Wireless Communication Circuit

- It is the ears of our design; it contains two sonic sensors for receiving the sign from the transmitter. It will be used if we use ultrasonic signals for our software solution.

DESIGN SOLUTION ANALYSIS

With the available hardware parts, we have analyzed the possible design solutions for the human chasing robot. To chase a human, the robot first needs to detect a human and find out the location of the human. There are several methods that can be used to do this and we would like to propose two of them: image processing and radio signal.

Image Processing

One way to track a person is using the camera. Since our robot has a camera implemented, the images or the video from the camera can be used for tracking the human. Human tracking from images has been studied in many places and therefore, various resources and algorithms are available. Among the diverse solutions, we would like to propose a solution introduced by Jianpeng Zhou and Jack Hoang from I3DVR International Inc. The algorithm starts with background subtraction following the shadow detection. This can produce a foreground mask image that is used for the blob segmentation. Then, the human can be tracked next. After the human is detected, false object detection step is followed to increase the accuracy. According to the paper, "Real Time Robust Human Detection and Tracking System", the system built using this algorithm provides a robust system that can detect and track human in real time [1]. Once the human is detected from the video, it is easy to chase the human. Using the location of the human in the image, it is possible to figure out where the human is relative to the camera. Also, using the size of the human, it is possible to determine the relative distance between the person and the camera. The limitation with this implementation is that it will only work when there is only one human present in front of the robot. The robot would not know which one it should follow if more than one human are present.

Radio Signal

Another way to track a person is using a radio signals. There are some systems such as local positioning systems which use radio signals to track the position of a device with unknown position [2]. Similar mechanism can be applied to our robot. The robot can have two sensors that behave as reference beacon nodes and the person can carry a radio signal transmitter. This way, the relative position of the person to the robot can be calculated. To do this, the distance between the transmitter and each of the receivers needs to be known first. This can be done using the received signal strength indicator (RSSI) [3]. RSSI values indicate how much power is present in a received radio signal. With the RSSI values and proper formulas, it is possible to calculate the distance between two nodes. Once the distances between the sender and the receivers are determined, it is now feasible to find the relative position of the sender to the robot. To calculate

this, we propose an algorithm called Weighted Centroid Localization. It is an algorithm that has been proven to provide accurate location detection when used in positioning systems [4].

Although it has been studied that a positioning system can be built using RSSI of radio signals, it will not fit to our design model because the two receivers on our robot are very close and RSSI of radio signals is not sensitive enough [5].

PROPOSED DESIGN SOLUTION

As explained in the previous sections, our system is consisted of three distinct components. The robot that is capable of moving is built using motors, wheels and frames. The robot has a camera implemented so it can stream video through Wi-Fi network. The last component is the main processor unit that can track a human's relative location and control the robot. After doing detailed analysis on the possible solutions for the main processor unit, we would like to propose a solution using ultrasonic signal. The person carries a device that can transmit ultrasonic signal constantly and the robot has two ultrasonic sensors that receive the signal. This solution is same as the radio signal implementation discussed in the previous section except that it uses the ultrasonic signal instead of the radio signal. Even though ultrasonic devices are generally more expansive than radio signal devices, we are only using two receivers and one transmitter so the overall cost for the design is not much different from the design using radio signals. In addition, much more accurate distance values can be achieved from the ultrasonic signals compare to RSSI of the radio signals. The distances between the sender and each of the receivers can be calculated using a simple Physic formula. By constantly sending ultrasonic signals within fixed intervals, distances can be calculated because the speed of the sound is known. Once the distance is available, the algorithm WCL which was described in the radio signal solution can be used to decide the relative location of the person to the robot. To improve the accuracy of the system, we will use an advanced version of WCL called Adaptive Weighted Centroid Localization for the actual system [2].

BUDGET AND FUNDING

Budget

The cost breakdown required to design and implement our Human Chasing Robot is based on researches via the internet for different essential components.

Table 1 – Cost Breakdown

Equipment List	Estimated Cost
RC Car with Camera	$200
Proximity Sensor	$50
Chips and other basic circuit components	$50
Small LCD Display	$50
Microcontroller Kit	$150
Total Cost	$500

Funding

Our company is fully supported by the Engineering Science Student Endowment Funding (ESSEF) for our payments. The requested amount of $500 has already been approved. The Wighton Development Fund is another source of funding.

In case of insufficient funding or any contingencies, all of our team members are willing to cover any additional costs for the project. Little sacrifices would lead to big achievements.

SCHEDULE

Gantt Chart

The figure below demonstrates the planned schedule for the next few months. Our company will mainly focus on designing and programming in the next two months. We will move on to the implementation and testing in November.

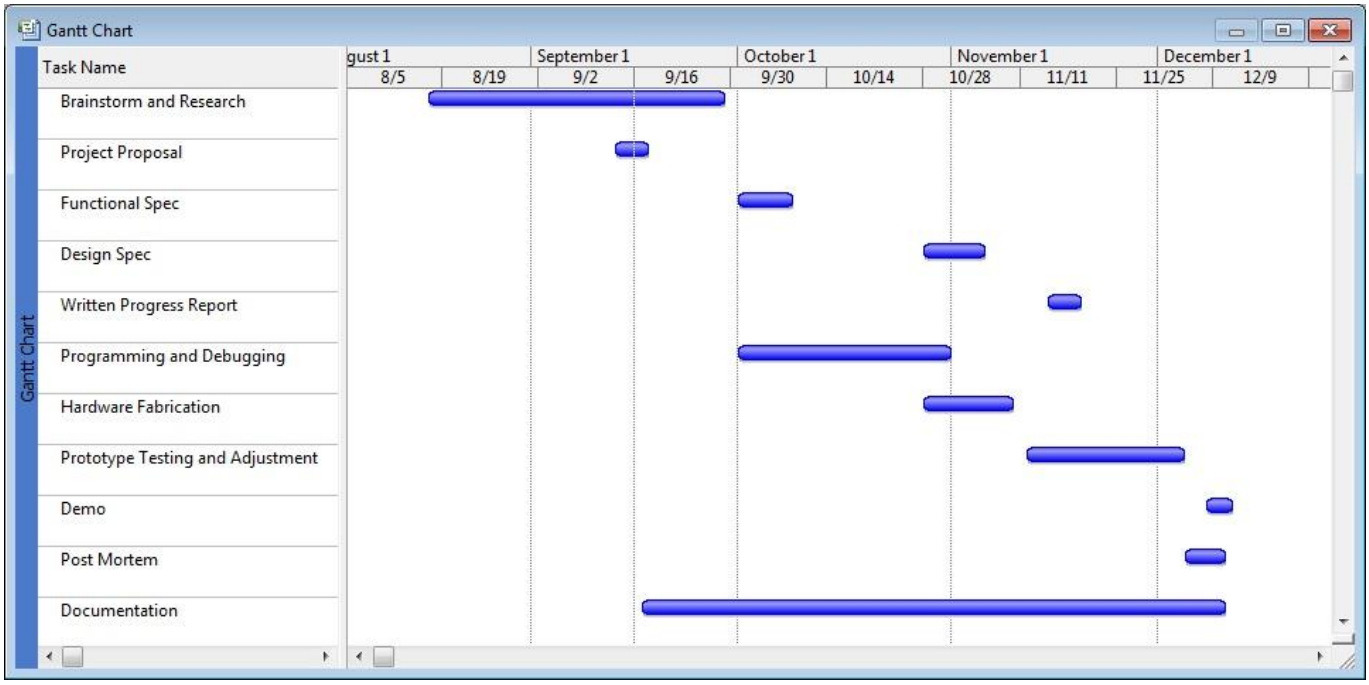

Figure 2 – Gantt Chart

Milestone Chart

The milestone chart pinpoints any important dates for this project.

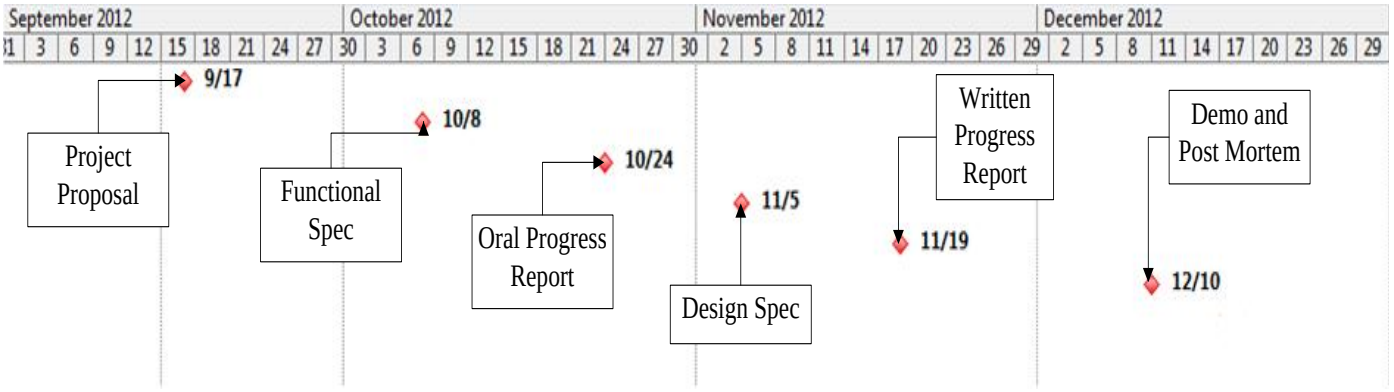

Figure 3- Milestone Chart

TEAM ORGANIZATION

Auto Tech consists of five talented engineers: Johnny Leung, Michael Leung, Eric Zhao, Alex Jiang, and Ken Nam. All members are either on their fourth year or the last year in the program. Our team is comprised of four electronics and one computer engineers. The specific skills and experience of each individual are very helpful to the company in achieving the goal.

Auto Tech is divided into three different departments, which are hardware, software, and the research department. In the first month or so, the research department would mainly focus on researching the components of the robot and also different methods to implement the robot. At the same time, the software department will work on programming the movement of the robot. The hardware department would design the circuits for communication between microcontroller and the sensors or image processor. At the end, the different departments would share their work and focus on the final implementation of the robot.

The official titles of the members of Auto Tech are as follows. Johnny Leung, Chief Executive Officer (CEO), is in charge of overall progress of the project and is responsible to lead the company. The most important role of the CEO is to make sure everything is never behind the schedule. Michael Leung, Chief Financial Officer (CFO), is in charge of the budget. Eric Zhao, Chief Hardware Officer (CHO), is responsible to the hardware development including designing and testing. Ken Nam, Chief Software Officer (CSO), is responsible of all programming in the company. Alex Jiang, Chief Communications Officer (CCO), is responsible maintaining good communications between departments.

To ensure proper team dynamics and to stay on schedule, the team has decided to meet up twice a week, mostly after 440 and 305 lectures, to discuss the progress of each task. Team members also share their work progress through the team email. Each member is willing to help out the others if anyone has trouble or behind the schedule.

COMPANY PROFILE

Johnny (Ho Cheung) LEUNG – Chief Executive Officer

Johnny is a fourth year Electronics Engineering student at Simon Fraser University who has developed a strong background of hardware circuitry and also software programming. During his co-op work term at KaShui International Holding Ltd as an engineering trainee, he has developed strong interpersonal skills like teamwork, communication, and also time management by leading team projects. He has also done circuit testing and debugging in his co-op. His good communication skill and time management skill would be ideal to make sure the project is on schedule.

Michael (Ko Yung) LEUNG – Chief Financial Officer

Michael is a fourth year Electronics Engineering student at Simon Fraser University. He has completed a co-op work term at Nokia as a technical support engineer. During his time at Nokia, he gained experience developing and maintaining an automated Python script. He was also introduced to Qt, a cross-platform application and UI framework. In addition, He has also done software testing and debugging for mobile phone applications. Besides technical experiences, working at Nokia had also allowed him to develop interpersonal skills, such as teamwork, communication, and time management. He is equally capable at handling software and hardware. His greatest asset is the ability to learn quickly.

Eric (Zhuopei) ZHAO – Chief Hardware Officer

Zhuopei Zhao is a fourth year electronic engineering student in Simon Fraser University. He has a strong skill in wireless communication protocol area, circuit design and debug. Also, he experienced embedded software design. He has a strong background in various software languages including C/C++, VHDL, assembly language and problem solving in the engineering context. Excellent teamwork and leadership skills developed from leading several team projects during study and three co-op terms.

Alex (Xu) JIANG – Chief Communication Officer

Alex is a fourth year Electronics Engineering student at Simon Fraser University with previous co-op term experiences at Huawei and Pawell. Through his work experiences, he hasmaintained GSM network, upgraded the devices such as BSC and developed procedures for field-testing. Through the courses at SFU, he has designed and developed a 3D robot arm by using Solidworks. He has worked in a cross-compilation environment and he also has a good understanding and application of Digital Electronics Circuits. Finally, he has good communication skill.

Ken (Kyoungwoo) NAM – Chief Software Officer

Kyoungwoo Nam is in his last semester of studying Computer Engineering at Simon Fraser University. He developed his technical skills greatly through his twenty months co-op experience at two different companies, Honeywell and Broadcom. He has strong software development and debugging skills, and has extensive knowledge on network protocols like TCP/IP, SIP and SDP. In addition, he is a team player who has led several team projects in school and groups such as music bands.

CONCLUSION

We live in an age of rapid technological advancement and every aspect of human lives continues to morph and shift as more technologies are introduced into our society. Robots have stepped through the veil of imagination into our reality. Robots are no longer subjects of science fictions but a new front in technological research and development. Robots will change the way we live, and potentially solve many issues in our society, such as labor shortages.

Auto Tech is taking its first step into robotics. Our proposed tracking robot is a simple yet significant project, aimed to address the shortage of care-givers in long-term care facilities. It is a great starting point for introducing our engineers to robotics. We hope our robot will assist care-givers in nursing homes, lessen their work-loan and improve their quality of service. By tracking patients and carrying emergency supplies, our robot will be a great addition to any long-term care facilities. In this proposal, we have outlined the purpose of our project and the plan to implement our product. We estimated the project will be completed early December of 2012. With a group of 5 motivated engineering students, I believe we can successfully implement our design and demonstrate a functional product at the end of the project.

REFERENCES

[1] Jianpeng, Z. and Jack, H. (2005) Real Time Robust Human Detection and Tracking System, *CVPR Workshops on IEEE Computer Society Conference*

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[3] Bachrach, J. and Taylor, C. (2005) Localization in Sensor Networks, In Stojmenovic, I. (1st ed), *Handbook of Sensor Networks: Algorithms and Architectures* (pp. 277-310). Hoboken (NJ): John Wiley & Sons

[4] Behnke, R., & Timmermann, D. (2008). AWCL: Adaptive Weighted Centroid Localization as an Efficient Improvement of Coarse Grained Localization. *Positioning, Navigating and Communication*, 243-250.

[5] Grossman, r., Blumenthal., J, Golatowski, F., & Timmermann, D. (2007). Localization in Zigbee-based Sensor Networks, In *IEEE International Symposium on Intelligent Signal Processing*, WISP 2007, Madrid, Spain.