PosiTrack School of Engineering Science • Burnaby • BC • V5A1S6

January 18th, 2010

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

Re: ENSC 440 Project Proposal for a System to Track Athlete Performance

Dear Dr. Rawicz:

Attached is our team's proposal for a system to track athlete performance, in the context of the ENSC 440 project course. With our proposed design, we expect to build a product (the *PosiTracker*) that will allow coaches to monitor player statistics, such as XY position, distance traveled, speed, acceleration, and heart rate. The PosiTracker will help coaches to better analyze each player's physical condition and it will help customize training to suit each player's needs. The PosiTracker can also be used in-game, to help bring fans closer to the game with broadcasting of live statistics, as well as to help coaches better decide when to make player interchanges.

The purpose of the attached proposal is to provide you with an overview of the design as well as the proposed funding, budget, project scheduling and team organization. We believe our system has market potential.

PosiTrack Systems consists of four hard-working and motivated team members: Andreea Hrehorciuc, Jeff Anderson, Jaime Valdes and Ryan Lynne. Should you have any questions about our proposal, please feel free to contact me by phone or email.

Regards,

Ryan Lynne
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PosiTrack Systems

Enclosure: *Proposal for a System to Track Athlete Performance*

Proposal for a

System to Track Athlete Performance

PosiTrack Systems

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Submitted to: Dr. Andrew Rawicz-ENSC 440
School of Engineering Science
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Executive Summary

Each year sports teams spend millions of dollars to have the best players, equipment, coaching staff, and training facilities just to gain the slightest competitive edge over other teams. We believe that even the best players can become better, through innovative and cutting edge training.

For this reason, we propose to make an athlete performance tracking system that will allow coaches to monitor player statistics such as X-Y position, distance traveled, acceleration, speed, and heart rate in real-time. This information will be gathered from a small lightweight module located on the back of each athlete and the data will be communicated back to a main computer or laptop over a wireless connection.

This device, called the PosiTracker, will help coaches to better analyze each player's physical condition and to create customized training to suit each player's needs. The PosiTracker will do this by providing information in real time to coaches and broadcasters during a game. Undoubtedly, this will help coaches to make better informed decisions on player interchanges and give broadcasters a means to bring fans closer to the game.

Our competition, GPSports [1] is currently selling a product that provides all of this functionality but it relies on GPS signals in order to function. Likewise, it cannot be used indoors or anywhere else with poor GPS coverage. Our product will solve this problem and fill this market gap by using a simple Wi-Fi triangulation technique of the signal strength.

This proposal provides an overview of the system, potential design solutions, and details of our proposed design; it also outlines the organization and the profile of our company. We expect to have an operational prototype of the PosiTracker built by April 16th, 2010. The entire project is tentatively budgeted at $612.54, which we expect to obtain from a variety of funding sources.

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1. Introduction

Each year sports teams spend millions of dollars to have the best players, equipment, coaching staff, and training facilities just to gain the slightest competitive edge. Last year the average salary of a player on the Vancouver Canucks was $1.7 million dollars [2] which represents a massive investment into the training and health of each individual player.

We propose to make an athlete performance tracking system that can increase and protect this investment into each player by creating more effective training regiments and injury rehabilitation programs. The system will record the location, speed, acceleration, and heart rate of each individual athlete in real-time. This information will be gathered from a small lightweight module located on the back of each athlete and the information will be communicated back to a main computer or laptop over a wireless connection.

With the data gathered by our system, coaching staff will be able to better develop training regiments that objectively measure each player's workout. Also, using the same data coaches can make better in-game player interchanges by objectively measuring the fatigue of each player. Similar systems have already gained large popularity in professional soccer and Australian football.

The acceleration data recorded can also be used by the team physicians to detect any potential injuries and to create innovative rehabilitation programs. This will allow doctors to ensure the player in not pushing themselves too hard. Since player salaries make up such a large investment into any team, it is vital to prevent and rehabilitate injuries as soon as possible.

The last application of our system is using it to broadcast live statistics to the viewers at home allowing them to get "right inside" the game. Announcers can also use the statistics to add further commentary to the game especially with regards to the impact data, speed and heart rate of each player.

An Australian company called GPSports is currently selling a product that provides all of this functionality but it relies on GPS signals in order to function. This means that all of the sports that use indoor arenas can not use their product due to the poor quality of GPS signals indoors. Our product will solve this problem and fill this market gap by using a simple indoor localization technique.

This proposal provides an overview of the system, potential design solutions, and our proposed design. The sources of funding along with our budget are also briefly discussed and the organization and profile of our company is outlined.

2. System Overview

To track an athlete's performance the system needs to accomplish functions such as finding the position, speed and acceleration of the athlete. The system must also analyze and prompt the information effectively to the user. Below in *Figure 1,* the system is outlined to show the desired functionality.

The system that we will be creating will consist of three main components including the triangulation antennas, the worn device, and the data analysis program. *Figure 1* below shows the basic flow of signals transmitted and received by the proposed devices. The three or more antennas will each individually generate a signal which will be received and measured from the device that will be worn by, in this case, the hockey player. The device could be worn on the back by using a simple strap on system or by incorporating the device into the player's equipment.

The measured signal strength will be used to calculate the position of the player and the device will also incorporate an accelerometer and gyroscope to measure linear and rotational acceleration. In addition the device could measure physiological information such as heart rate. The device will communicate to a rink side computer that will provide an interface to the measured data.

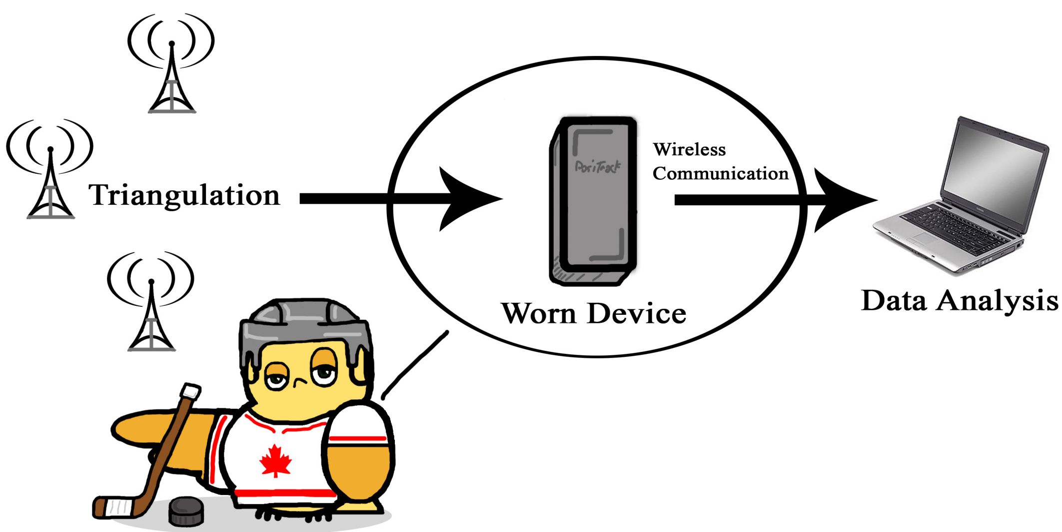

Figure 1: Basic flow of transmitted and received signals [3]

Figure 2 shows the flow of information within the system. The measured data can be used to determine the player's position, velocity, acceleration and heart rate at any time during a game. This data can then be used to derive more useful data such as workload, impact data, and jump heights.

A relative workload index can be established for each player by using the acquired data and this workload index could be used for objective training and player shift changes. In objective training, the system can quantitatively justify when an athlete has trained to the correct limit allowing for proper recovery in the time allotted until the next training session. The system can also justify the substitution of players during game play. Knowing when an athlete has performed to the proper limit for athletic gains and injury prevention is key.

Large sudden acceleration can give impact data. The impact data can be used by physicians to quantify the injury. This quantification can improve diagnoses of injuries, as well as provide enhanced justification of the timeline for recovery.

Data such as jump heights can be used in fitness testing. Accurately and consistently quantifying physical abilities is important when measuring the effectiveness of a training program. The data generated will validated the athlete's level of progression.

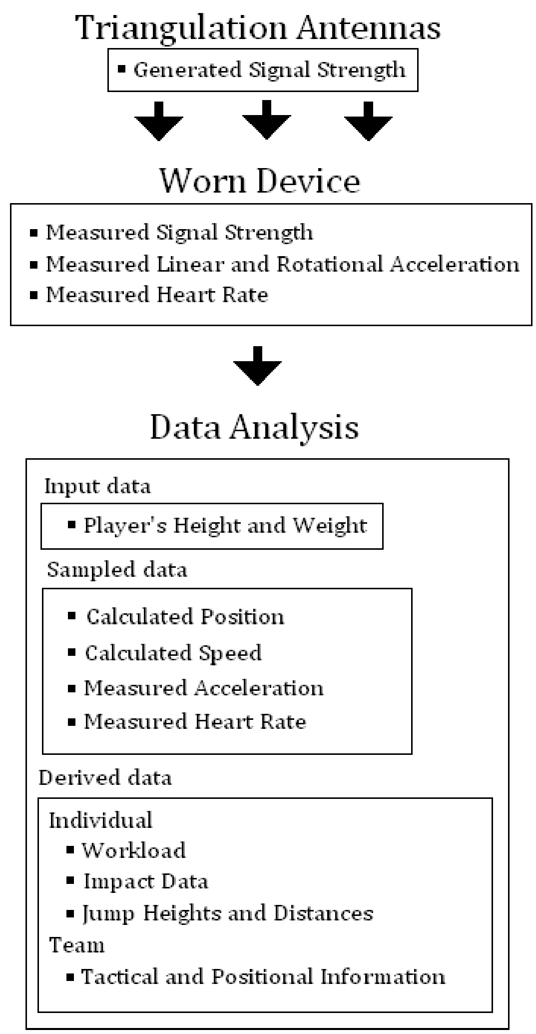

Figure 2: The flow of data on derived from the athlete's performance.

A team using multiple worn devices can analyze their tactical performance and a graphical position map created by the data analysis system can aid in coaching positioning and new strategic plays.

This data can also be used by broadcasters to provide additional statistics to the fans. Academics can also use the data generated in a range of studies.

3. Possible Design Solutions

There are currently several technologies which can achieve GPS like localization and tracking. These systems have their respective advantages and disadvantages. For the application of tracking athletes, we considered the following criteria: independence from line of sight, the ability to track multiple moving targets at once, and a reasonable accuracy of one meter. Some of the devices which are used for tracking purposes are listed below.

3.1. Global Positioning System

Global Positioning System uses time of flight triangulation between a device on earth and global navigation satellites. This system is being used currently by a company of the name GPSports [1] to provide athlete tracking for large scale outdoor sports such as football, soccer, and kayaking. GPS provides the characteristics required for our system; however it cannot be used indoors. Likewise, this system will not provide the resolution or accuracy required for sports such as hockey and basketball.

3.2. Ultrasonic Localization

Ultrasonic localization is a very accurate method of localization and results can be obtained within a few centimeters of accuracy. [8] However, the trade off is that as the coverage area is increased the accuracy decreases dramatically. The transducers required for this system are also very directional which can create small dead zones in the coverage area.

3.3. Signal Strength Localization with Bluetooth

Using Bluetooth technology is a low cost and low power method to achieve localization and it is easily expandable with a great variety of Bluetooth devices. Using a method of triangulation with Bluetooth technology yields acceptable accuracy. [9] Unfortunately, Bluetooth does not have the range needed for the size of a hockey rink or basketball court.

4. Proposed Design Solution

The above section revealed that there are many ways to track an athlete's position using the triangulation of either electromagnetic or sound waves. For our main market of indoor team sports, such as hockey and basket ball, we propose a solution that uses Wi-Fi signal strength triangulation to achieve the position of the athlete. Our solution will also use inertial measurement devices such as accelerometers and gyroscopes to increase positional accuracy along with giving acceleration measurements. In advanced versions of this product a microphone will be used to measure the heart rate of the athlete.

Wi-Fi was chosen over other technologies because of the nature of the desired task. GPS technology does not work well indoors. Ultrasonic triangulation is very dependent on the directionality of the transmitter and receiver. And Bluetooth is too low power for this application. A custom electromagnetic solution was also discussed however within the short time frame of this project Wi-Fi was a natural choice to provide functionality and rapid prototyping capabilities. Using Wi-Fi for triangulation also provides a communication link to upload the player's data to a remote desktop or laptop for analysis. Wi-Fi provides the balance needed in this project to develop a product quickly but with important functional qualities.

To improve upon the positional accuracy of the signal strength triangulation, dead reckoning will be used. Dead reckoning is the process of using current direction, and speed to estimate the next position. The acceleration technologies used will be an important addition to satisfy practical requirements.

This designed solution has to contend with the short time frame allotted for the completion of this project. With this in mind, our group will focus on developing a system to find the position, speed and acceleration of the athlete as well as provide an effective graphical interface that provides useful analysis. The integration of a heart rate monitor will occur in later version of this system.

The system to be developed has application outside of tracking athletic performance. The device could be used to help robots determine their position. A simplified version could be used in warehouses or hospitals to keep track of inventory or supplies. The developed system has the potential to be put in shopping carts to track the flow of shoppers to give data on shopping habit's and traffic flow.

Our proposed design solution has been chosen to provide desired functionality of tracking athlete's performance. The solution should allow for rapid prototyping and expandability.

5. Sources of Information

For a project of this size, problems are eventually bound to appear. Perhaps some team members argue that a particular solution is better than the other, and the rest of the team disagrees, or perhaps our team will feel that we're stuck at a particular step in the engineering process; we plan to resolve such problems by researching extensively in order to make informed choices.

We will obtain valuable information from multiple sources: course textbooks and related publications in the SFU library will undoubtedly prove to be of use. Sometimes we will have to choose a particular component from a multitude of possibilities – in such cases the specification sheets of various components will prove useful. Moreover, the Internet will prove to be a valuable resource; however, due to the vast amount of information posted online, one has to be very selective, and use only trustworthy websites. The reference section in this document contains scholarly papers that have helped us arrive at conclusions to difficult dilemmas.

The SFU staff involved in the field of antenna design and localization will undoubtedly be invaluable resources for our project. In addition, some graduate students at SFU have previously worked on related projects. Ash Charles, a SFU Masters student, has extensively used the Gumstix in order to build small robots driven by the Gumstix boards, under the supervision of Professor Vaughan. Having used the same hardware for his project, Ash Charles has a vast amount of knowledge in this field.

6. Budget

The total budget to create the system is $612.54 and the breakdown of each cost is outlined below in *Table 1*. In the table, each component is grouped into a category and its source is included along with its unit cost. Shipping and handling has also been included except for the components from NCIX as they can be picked up locally. An additional 10% contingency fee has also been added to allow for potential cost overruns.

Table 1: Cost Breakdown for Components

Equipment List	Source	Unit Cost
Microcontroller:		
Overo Air Gumstix	www.gumstix.com	$199.00
Summit Expansion Board	www.gumstix.com	$49.00
WiFi Antenna	www.gumstix.com	$10.00
5V AC Wall Adaptor	www.gumstix.com	$10.00
MicroSD Card 2GB	www.gumstix.com	$20.00
Gumstix Shipping Costs	www.gumstix.com	$41.41
Subtotal:		$329.41
Wireless Network:		
Wireless Router Cisco WRT54GL	www.ncix.com	$59.99
Wireless Router Cisco WRT54GL	www.ncix.com	$59.99
Wireless Router Cisco WRT54GL	www.ncix.com	$59.99
Subtotal:		$179.97
Dead Reckoning System:		
Z-Axis Gyroscope ADXRS613	www.digikey.com	$31.47
3-Axis Accelerometer BOSCH BMA020	www.digikey.com	$6.00
DigiKey Shipping & Handling	www.digikey.com	$10.00
Subtotal:		$47.47
Total Cost:		**$556.85**
10% Contingency Fund		**$55.69**
Final Cost:		**$612.54**

7. Sources of Funding

The three main sources of funding that we will pursue are the Engineering Student Society Endowment Fund (ESSEF), The Wighton Development Fund, and the Department of Engineering Science. The application for the ESSEF funding has already been completed as well as a short presentation to its board members. It is expected that the majority of the funding for the system will come from the ESSEF but additional funding will still be sought from the Wighton fund as well as the ENSC Dept.

We do not anticipate approaching sports teams or any industry members until we have a proof of concept with a significant "wow" factor. The actual cost of developing the system is very low and consists mainly our time. Likewise, at this point in time it is best to not make at financial commitments that would prevent us from freely developing our product. At the end of the course if we believe we have a commercially viable product we will first write a formal business plan then approach members in the industry to secure financing. Some of the local sports teams that we potentially could approach are the Vancouver Canucks, The BC Lions, The Vancouver Whitecaps, The Vancouver Giants. Additionally, we could sell our intellectual property to our competitors GPSports.

Any additional costs that are not covered by the funding received will be equally shared by all of the group members.

8. Schedule

Figure 3 below shows a Gantt chart of the proposed time line over the 13 weeks of this systems' proof of concept development. Since this project uses Wi-Fi protocols, it is possible to begin software development right away using desktop computers or laptop computers. After the parts arrive, the software will then be moved onto the embedded system platform. Some of the parts will be ordered immediately to reduce the effect of shipping times.

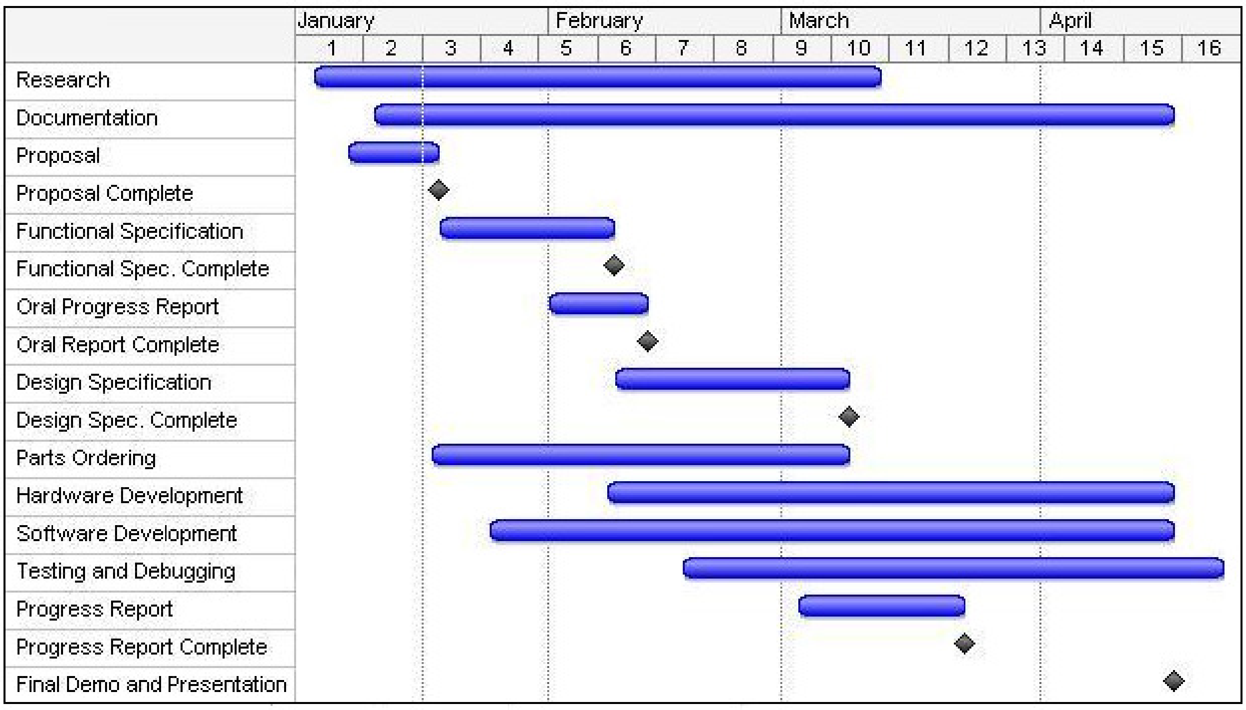

Figure 3: The flow of data on derived from the athlete's performance.

9. Company Profile

Andreea Hrehorciuc

I am a 5th year Computer Engineering student at Simon Fraser University; due to my Computer Science specialization, I have extensive programming experience in C++, Java, Assembly, and Visual Basic. My skill set lies predominantly in the fields of software and digital processor design. I am also doing a minor in Business at SFU, and currently working for Glentel Inc., holding the position of System Administrator. My 2+ years of working at Glentel has taught me, above all, that interpersonal skills and team-working skills are crucial to the well-being of a team.

Jaime Valdes

I am a 4th year Electronics Engineering student at Simon Fraser University with a skill set composed of interpersonal skills, hardware design, and software development. I hold knowledge in analog and digital circuit design, real-time embedded system design, and programming in C/C++, MATLAB, and VHDL. I have had prototyping experience in analog design through numerous labs (the latest being an NTSC decoder circuit) and I was a member of a software development team during an 8 month work term with Safeway Inc.

Jeff Anderson

I am a 5th year Engineering Physics student at Simon Fraser University who's interested in an array of technologies including, antenna design, internet protocols, and biomedical imaging. While completing an 8 month co-op term at Broadcom I extensively learned internet protocols and programming skills. Participating in a four month co-op at SFU I worked under Dr. Markino Sarunic and I developed a biomedical imaging system which introduced me to a full system design perspective.

Ryan Lynne

I am a 5th year Electronics Engineering student at Simon Fraser University specializing in Microelectronics, Digital Design and Embedded Systems. I am very experienced at programming and my project from Advanced Digital Design gave me extensive experience designing a complicated embedded system. My previous 8 month co-op term at PMC-Sierra taught me extensively about digital design and exposed me to the business side of a large corporation.

For our corporate structure we have decided to have a flat organization with each group member having an equal vote in every matter. We believe that you must be able to convince the group of your idea and or decision.

10. Conclusion

PosiTrack Systems hopes to give its' potential customers a valuable product and fill this market need with our design solution.

This athlete performance tracking system will give players meaningful statistics which were never conveniently recorded in the past. This new system will be able to change and enhance the way people participate in indoor sports, from coaches' right down to the viewers.

Furthermore, the data which is planned to be recorded from this system isn't just specific to indoor sports. The system can be adapter to satisfy numerous applications for a long list of potential customers.

The proposed budget and schedule will be the guide through the development of the PosiTracker. With clearly defined goals and thorough planning, PosiTrack Systems is confident that we will succeed on delivering a low-cost and efficient solution that satisfies all of our proposed requirements within this thirteen week development cycle.

11. References

[1] PosiTracker Competitor, Jan 18th 2010
www.gpsports.com

[2] Vancouver Canucks Player Salaries, Jan 18th 2010
http://www.nhlnumbers.com/overview.php?team=VAN&season=0910

[3] Laptop image source, Jan 18th 2010
http://www.mobilewhack.com/images/toshiba_satellite_a105_s4284_laptop.jpg

[4] J.M. Lee, "Indoor Localization Scheme of a Mobile Robot Using RFID", presented at the 2005 International Symposium on Humanized Systems, Wuhan, China

[5] V. Olivera, J. Cañas Plaza and O. Serrano, "WiFi localization methods for autonomous robots" in Robotica, vol. 24. UK: Cambridge University Press, 2006, pp. 455-461

[6] C.-H. Lim et al., "A Real-Time Indoor WiFi Localization System Utilizing Smart Antennas", *IEEE Transactions on Consumer Electronics*, vol. 53, No. 2, May 1997.

[7] M. Ocaña, L.M. Bergasa and M.A. Sotelo, "Robust Navigation Indoor using WiFi Localization", Universidad de Alcalá, Madrid, Spain

[8] Jang Myung Lee, "Indoor Localization Scheme of a Mobile Robot Using RFID", Department of Electronics Engineering Pusan National University, Busan, Korea

[9] G. Fischer, B. Dietrich and F. Winkler, "Bluetooth Indoor Localization System", presented in 2004 for "Innovations for High Performance | microelectronics"

