IPRO 310 Final Report

Summer 2009

Devices that Assist Blind & Visually-Impaired Individuals in Swimming and Other Exercise Activities

Advisors: Frank Lane, Ken Schug & Phillip Troyk

1. **Abstract**
    a. The problem posed with blind and visually impaired (BVI) swimmers is one of safety and independence. BVI individuals need to be able to orientate themselves in a swimming pool and avoid obstructions like lane-lines, pool walls and other swimmers for a safe experience. Additionally, it is important to BVI swimmers to maintain their autonomy and low profile during this experience. The Buoy team focused on designing two prototypes using the two technologies recommended by the previous semester: electromagnetic field and laser. Two major groups were organized to design and build a prototype using one of the technologies while incorporating community feedback in their design. Surveys and interviews were also conducted with the BVI community to ensure that the Buoy team was meeting the needs of the market.
2. **Background**
    a. Sponsors
        i. Chicago Lighthouse for the Blind & Visually-Impaired was founded in 1960. Its main mission is to serve people who are blind or visually impaired with a broad array of innovative programs designed to assist them in leading richer, more independent lives.
    b. Customer: The blind and visually impaired community
        i. According to the U.S. Census Bureau News published in December 2008, there are nearly 7.8 million people age 15 and older who had difficulty seeing words or letters in ordinary newspaper print, including 1.8 million who are completely unable to see.
        ii. 609,000 children in the United States live with some degree of visual impairment and over 50,000 of them are legally blind.
    c. BVI persons unable to exercise on their own safely and independently
        i. Lack of facilities for BVI swimmers
        ii. In the past, most of the IPRO groups focused on technology before obtaining feedback from the BVI community. As a result, the devices that had been created were not very autonomous for the user. The prototypes were often bulky and caused impediments in the swimmers performance.
    d. Similar solutions
        i. EyeSwim passive device modified by previous IPRO semesters from the original device created by Notre Dame University.

ii. Some underwater swimming devices that are used by the swimmers: Life Buoyancy Device, Swimming Aid, Sonar Lifeguard and Easy Float.
iii. Devices that can be used underwater but not for swimming purposes; these devices may be adapted to our design: underwater phone, underwater iPod and underwater headphone.
iv. Devices using either sonar or ultrasound to guide the blind but they cannot be used underwater: Tongue Sensor and Electrode.
v. Several of the devices stated above are already being sold while the few others are only in the patent phase.

e. Technology
   i. It was determined that assistive technology techniques must be employed in the development of the devices involved in this project. Consumers must be kept in mind or involved in the creation of an assistive device.
   ii. Two technologies were suggested from the previous IPRO as potential solutions to the problem of location in pool environments. These technologies are an invisible fence concept (electromagnetic field) and a laser gate. The invisible fence concept works by creating a boundary with a wire and sending a radio signal through it that can be picked up when a receiver, worn by someone, nears the boundary. The lasers, which propagate through water, are designed to align with a light sensor such that when the beam is broken, a signal will be sent to the swimmer to alert them of their proximity to the end of the lane.

f. History
   i. Passive device showed signs of success by helping swimmers correct their direction if they were off track; however it did so at the cost of requiring a large, bulky device that stands out from conventional methods of swimming.
   ii. A vibration belt was attempted. This device was also large and stood out. It did not eliminate the need for an assistant to be outside the pool warning the swimmer when they were nearing walls or lane lines.
   iii. A snorkel device was created. This stood out in the pool because most swimmers do not use snorkels when swimming laps and the mouthpiece was rather large. Additionally, it required an assistant to be outside the pool giving directions.
   iv. SONAR was used before as well, however in previous attempts the groups tried to mount the sonar source

on the wall instead of on the swimmer. Mounting it on the wall lead to a lot of noise and false signals getting picked up and misleading the swimmer.

v. Both an electromagnetic field and laser technologies were investigated

g. Ethical Issues
   i. Beneficence
      1. Different BVI swimmers would need different assistance while swimming according to their age and swimming experience.
   ii. Non malfeasance (Do no harm)
      1. . Quality and safety of the prototypes
   iii. Autonomy
      1. The appearance of device
      2. Self-image of the users
   iv. Justice
      1. Price
      2. Patent and copyright
   v. Fidelity
      1. The safety of the testing environment

3. **Objectives**
   a. Our mission is to develop, test, and implement assistive technology with the community that promotes safety and improves independence of blind and visually impaired (BVI) swimmers.
   b. Team objectives
      i. Design and develop a cost effective assistive technology prototype using current laser and/or electromagnetic field technology
         1. Verify the application of laser technology for underwater use.
         2. Incorporate device into environment in a discrete manner.
         3. Identify ways to communicate usable information between the technology and the swimmer.
      ii. Include the BVI community in the design process using surveys, interviews, and BVI facility visits.
      iii. Modify the Buoy website so that it is accessible to the BVI community through existing screen-reader software.
      iv. Create a cooperative, motivational and innovative team environment using team-building techniques.
      v. Research user markets to maximize consumer benefit and marketability of potential device(s).

vi. Enhance continuity between semesters by utilizing past resources and continuing effective documentation methods.

4. **Methodology**
    a. According to survey data from previous semesters, existing assistive technology does not allow BVI swimmers to swim as independently as they would prefer.
    b. The Buoy team researched devices that have already been developed by this IPRO and other organizations to determine the market that exists for such devices.
    c. The team members were divided into two major development teams geared towards utilizing specific technology in designing of the applications of these devices in a pool environment.
        i. Electromagnetic field technology
        ii. Laser beam technology
    d. Team members were further broken down into sub-teams that focused on IPRO deliverables.
        i. Documentation team
        ii. Media team
        iii. Survey team
    e. The team initiated the involvement of the market BVI community through surveys and interviews.
    f. The team was diligent about documenting their research and results that will be easy to follow by future IPROs, including keeping minutes of every team meeting.
    g. The survey team was responsible for creating the surveys and respective consent forms for the semester. Additionally, they were responsible for reporting on the results of any surveys administered during the semester. The entire class needed to approve all documents created by the research and survey team and the IRB has final approval authority prior to administration. For the complete survey, see Appendix A.
    h. The documentation sub-team was responsible for the written deliverables due during the semester. Their rough drafts of the deliverables were presented to the entire group and a final draft was developed through class feedback.
    i. The media sub-team was responsible for the brochure deliverable due during the semester as well as modifying the Buoy website and maintaining the iGroups site. The entire team approved all deliverables prior to their submission.

	June 1 to 6	June 7 to 13	June 14 to 20	June 21 to 27	June 28 to July 4	July 5 to 11	July 12 to 18	July 19 to 25
IPRO overview	X							
Defining the Problem	X	X	X					
Research/Surveys		X	X	X	X	X		
Identifying possible Solutions		X	X					
Teambuilding session				X				
IPRO Team Meeting Minutes	X	X	X	X	X	X	X	X
Project Plan (6/16)	X	X	X					
Ethics Framework Module		X						
Design/Build prototype			X	X	X	X	X	
Mid-term prep			X	X	X			
Mid-term reviews (6/30)					X			
Midterm peer evaluation					X			
Testing			X	X	X	X	X	
Communication Experience & IPRO Day preparation						X	X	
IIT course evaluation								X
Exhibit/Poster						X	X	X
Abstract/Brochure						X	X	X
Presentation (7/23)						X	X	X
IPRO Projects Day (7/24)								X
Final Report								X
Team Work Product								X
IPRO Stuff Hand-Off								X
Final peer evaluation								X
Individual team								X

member project analysis report								
IPRO Project closure								X
Website development			X	X	X	X	X	X
Time Sheets	X	X	X	X	X	X	X	X

5. **Team Structure and Assignments**
   a. Faculty roster

Faculty	**Email**	**Specialization**
Frank Lane	lane@iit.edu	Rehabilitation Psychology
Dr. Ken Schug	kschug@msn.com	Biology, Chemistry, Physics
Dr. Phillip Troyk	troyk@iit.edu	Biomedical Engineering

   b. Team member roster

Team Member	**Email**	**Major, Year**	**Skills/Strengths**
Baar, Coleman	cbaar@iit.edu	ME, 4th Year	Experience with the physically and mentally disabled Computer Proficiency (Word, Excel, Basic C++, and Basic AutoCAD, Basic MATlab) Political Background
Dykeman, Kimberly	kdykeman@iit.edu	PSYC, 2nd Year	Proficient at Microsoft Office (Word, Powerpoint, Publisher, Excel). Basic experience with C++ and Visual Basic programming languages. Psychology experience.
Hotz, Thomas	thotz@iit.edu	ME, 4th Year	Leadership experience. Communication proficiency. Word, Excel, and PowerPoint Programming in C++.

Kruse, Kevin	kkruse1@iit.edu	BME, 4th Year	Extensive use of Microsoft Word, Excel, and PowerPoint Programming in C++, HTML, PHP, MYSQL, Actionscript 3, XML, some Spanish speaking and writing skills
Kwiatkowski, Lisa	lkwiatko@iit.edu	BME, EE, 3rd Year	Proficient at the Microsoft Office Suite, including Word, Excel, and PowerPoint, experienced in formal scientific research and statistical analysis, Java programming language, and MATLAB, leadership experience
Lane, Brendan	blane2@iit.edu	AE, 3rd Year	Team member experience, experienced with MATLAB, proficient in MS Word and Excel, also used Maple
Lopez, Roman	rlopez6@iit.edu	ARCH, 5th Year	10 years of restaurant management experience, basic knowledge of web design, communication and leadership skills
Sarkar, Smita	ssarkar8@iit.edu	BME, 4th Year	Leadership skills. Research experience in BME, computer proficiency (Microsoft Office, MATLAB, C++).
Sowiak, Joanna	jsowiak@iit.edu	ME, 4th Year	Polish fluent in reading and writing, Windows Vista /XP/ 2000/ Microsoft Word, Excel, PowerPoint, and MATLAB
Stelcel, Carl	cstelcel@iit.edu	BME, 4th Year	Computer proficiency (Word, Excel, Powerpoint, basic C++, basic Java, some Autocad, basic PSpice, MATLAB)
Winston, Nithin	nwinston@iit.edu	BME, 4th Year	MATLAB, Eclipse, MS Office (Word, Excel, PowerPoint), AutoCAD, Basic understanding of PSpice, Bilingual: English and Malayalam.
Zhou, Raymond	rzhou1@iit.edu	EE, 4th Year	Computer proficiency (Word, Excel, PowerPoint, basic C++ and Java, some Autocad, basic PSpice, MATLAB)

c. The major teams were organized based on member skills and field of expertise to ensure equal distribution of talent. The minor teams were organized to include two members from each major team to ensure that both major teams have equal influence over the minor team's respective responsibilities and deliverables.
d. Major teams
    i. Electromagnetic field technology
        1. Thomas Hotz (ME) (Continuing with Buoy in fall 2009) TEAM LEAD
        2. Coleman Baar (ME)
        3. Kim Dykeman (PSYC)
        4. Roman Lopez (ARCH)
        5. Smita Sarkar (BME)
        6. Nithin Winston (BME)
    ii. Electromagnetic field contributions
        1. Designed Prototype I, which is able to detect electromagnetic fields, but not in a range that would be suitable for pool testing; however, it was modified such that the feedback increased in volume as it approached the perimeter.
        2. Discovered the signal generated by the transmitter is encrypted.
        3. Determined that the reciever's performance is partially due to the optimal frequency it detects. Using the concepts of a band pass filter, the optimal frequency can be calculated and implemented.
    iii. Laser technology
        1. Kevin Kruse (BME) (Worked on laser in Spring 2009) TEAM LEAD
        2. Lisa Kwiatkowski (BME/EE)
        3. Brendan Lane (AE)
        4. Joanna Sowiak (BME)
        5. Carl Stelcel (BME)
        6. Raymond Zhou (EE)
    iv. Laser contributions

1. Discovered the maximum tested ranged of a green laser underwater was 51 feet and that splashing does not interfere with the laser beam.
2. Designed a working prototype using four lasers aligned with photocells. When one of the laser beams is broken, the LED corresponding to that photocell turns off. When any beam is broken a vibrating motor turns on to alert the swimmer of their proximity to the end of the lane.

e. Sub-teams
   i. Documentation
      1. Lisa Kwiatkowski (Team 2) (Management experience) TEAM LEAD
      2. Coleman Baar (Team 1)
      3. Joanna Sowiak (Team 2)
      4. Nithin Winston (Team 1)
   ii. Documentation team contributions
      1. Midterm/final report
      2. Agendas
      3. Meeting minutes
      4. Budget management
      5. Timesheets
   iii. Media
      1. Smita Sarkar (Team 1) (Interested in web design) TEAM LEAD
      2. Roman Lopez (Team 1)
      3. Carl Stelcel (Team 2)
      4. Raymond Zhou (Team 2)
   iv. Media team contributions
      1. Pictures of events, pool tests, designs, etc.
      2. Website
      3. Brochure/Abstract
      4. Poster
      5. PowerPoint Presentations
      6. Deliverables CD
      7. iGroups
   v. Survey

1. Kim Dykeman (Team 1) (PSYC) (IRB experience) TEAM LEAD
2. Thomas Hotz (Team 1)
3. Kevin Kruse (Team 2)
4. Brendan Lane (Team 2)

vi. Survey team contributions

1. Survey development, administration, and results reporting
2. IRB approval
3. Contact lists
4. Community coordination

f. Designation of roles

i. BOUY overall team leader: Coleman Baar

ii. Weekly Timesheet Collector/Summarizer: Documentation Team

iii. Minute Taker: Nithin Winston

iv. iGroups Facilitator: Media Team

v. Website Creator and Facilitator: Media Team

vi. Agenda Maker: Documentation Team

vii. Timekeeper: Joanna Sowiak

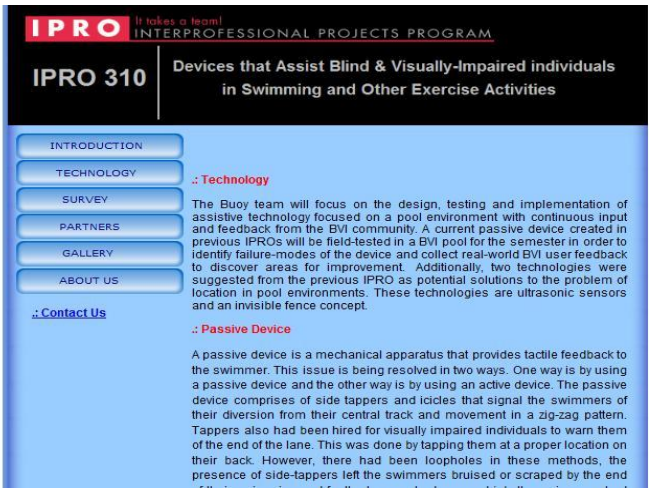
6. **Budget**

Category	Requested	Approved	Explanation	Status
Supplies	$100 2/6/09	Approved	Wires, building materials, solder, and other miscellaneous items for modifying equipment	Pending
Equipment	$385 2/6/09	Approved	$75 - 5 Green Laser pointers $100 - 2 End switches $40 FM Transmitter $20 FM Headset $150 Innotek replacement receivers	Pending
Services	$25 2/6/09	Approved	Printing etc.	Pending

Travel	$100 2/6/09	Approved	Trips to stores for equipment and facilities to administer surveys, interviews and product testing.	Pending
Participant Support	$25 2/6/09	Approved	Used for pool test participants if needed.	Pending
Team Building	$100 2/6/09	Approved	Used for team building exercises to be determined	Pending
TOTAL	**$735**	**$0**		

7. **Results**
    a. Laser beam technology:
        i. Testing
            1. Pool test to find max range of red and green lasers.
            2. Functionality testing of various circuits.
        ii. Results
            1. Green Laser is optimal and was successfully tested up to 51 ft.
            2. Found optimal circuit for laser detection.
            3. Water turbulence doesn't affect laser beam
    b. Electromagnetic field technology:
        i. Testing
            1. Range test of receiver
            2. Frequency test
        ii. Results
            1. Prototype 1 worked up to 1ft
            2. Frequency of transmitter was 8.192 kHz
    c. Bouy webpage
        i. http://www.iit.edu/~ipro310f09
        ii. The website is intended to network with the BVI community; allowing for the outreach and receipt of ideas and progress. The user needs survey as well as the passive device surveys will be more assessable to a larger community, increasing their amount of influence and feedback.
        iii. Topics involved in the web page:
            1. Introduction: Description of the overall background of this project. Team construction, history, detail, mission.
            2. Technology: Introduction to the existing product, exploring potential technologies that can be applied to our products.

3. Survey: Results of surveys taken by the previous and current IPRO team, online survey is also provided in this section.
4. Partners: Collaborator of the team.
5. About us: Group personnel introduction.



8. **Obstacles**
    a. Lack of expertise in circuit design
        i. The laser team struggled to create a working circuit due to the lack of expertise in circuit design on their team.
        ii. The electromagnetic field team, after discovering the transmitter had an encrypted signal, was unable to design a new transmitter in the time remaining the semester. Additionally, getting a vibrating motor to work in a DC circuit when it need AC current was a challenge that has not yet been solved.
9. **Future Applications and Recommendations**
    a. Laser future applications
        i. Further develop the prototype device.
        ii. Build a wireless wristband receiver.
        iii. Waterproof device and wristband.
        iv. Mount and install device in a pool.
        v. Conduct user testing.
    b. Electromagnetic field future application
        i. Troubleshoot Prototype 2
        ii. Develop a transmitter
        iii. Integrate receiver into a wrist band
        iv. Waterproof receiver
    c. Sub-team conclusions
        i. The major accomplishments of our semester was our outreach to the BVI community through visits to the

Chicago Lighthouse, IRB approval of a revised survey and consent form, and the design and production of a functional website. Additionally, the documentation of our progress for future IPRO's has dramatically improved over previous semesters.

d. Sub-team next steps
    i. Maintain involvement with the BVI community
    ii. Maintain BVI accessible website
    iii. Promote documentation for future IPRO teams to ensure continuity

10. **Acknowledgements**

a. Contact list
    i. The Chicago Lighthouse for the Blind and Visually Impaired
    1850 W. Roosevelt Road
    Chicago, IL 60608-1298
    Tel: (312) 666-1331
    Fax: (312) 243-8539
    www.thechicagolighthouse.org

Appendix A
2009 Assistive Device User Needs Survery

IPRO 310 *is an InterProfessional project at the Illinois Institute of Technology aimed at enabling blind and visually impaired individuals to swim safely and independently. The team aims to fill the void in assistive technologies present for blind and visually impaired swimmers by designing, documenting, testing and marketing a prototype.*

General description: *The purpose of this survey is to solicit the needs of blind and visually impaired individuals relative to swimming. A multidisciplinary design team will use the results of this survey in the development of assistive technology*

Skill Level

1. *Do you currently swim?*

If answer YES, how would you describe your skill level out of the following options?

   a. *Needs assistance*

   b. *needs supervision*

   c. *no supervision required*

- *Do you mainly swim for exercise (laps) or recreational (fun) purposes?*

- *How often do you swim (per week / per month)?*

- *Where do you normally swim (public or private facility)?*

If answer NO:

- *Have you ever tried swimming?*

- *If YES, reason for decline:*

   a. *Other: _____*

   b. *Safety*

   c. *Time*

   d. *No assistance*

e. *Lost interest*

f. *Pool availability*

□ *If a device was built to improve the BVI swimming experience by aiding in the navigation of the pool would you be interested?*

Device Characteristics:

If a device was built to improve the BVI swimming experience by aiding in the navigation of the pool…

2. *Device Location:*

a. *Cap*

b. *Goggles*

c. *Swimsuit*

d. *Wrist bands (both wrists)*

e. *Other:*_____

3. *Alert Type:*

a. *Tone*
b. *Vibration*

4. *Cost: What is the MOST amount of money you would be willing to spend on this type of device?*

a. *$100+, Max Amount:* _____

b. *$75-$100*

c. *$50-$75*

d. *$25-$50*

e. *Under $25*

5. Rank each of the following based on the scale: (least important, less important, very important, most important)

a. *Device location (least important, less important, very important, most important)*
b. *Cost (least important, less important, very important, most important)*
c. *Alert type: tone/vib (least important, less important, very important, most important)*
d. *Training time (least important, less important, very important, most important)*
e. *Ease of use (least important, less important, very important, most important)*

6. Would you prefer a device that provides you with constant information if you are headed on the right course or a device that only alerts you if you veer off course (approaching a wall or lane line)?

7. If the device had to be plugged into an outlet, would that cause you any concern?

8. We would like to design a vibrating wristband, that would signal to you when within a certain distance to the pool perimeter. On a scale of 1-10 how comfortable would you be using this device on your own?

9. How comfortable would you be, on a scale of 1-10, using the device if for the first time, somebody accompanied you? What would help to make you feel more comfortable?

10. Do you know of any organizations, institutions, or individuals that would fund this type of technology?

11. Can you give me an example of an assistive device you found very helpful? What features did you find most helpful?

12. Can you give me an example of an assistive device that you did not find useful? What features made the device unappealing?

13. Would you be willing to participate in a test of an assistive swimming device? If so, include contact information

a. *Name: _____*

b. *Phone #: _____*

c. *Email: _____*

d. *Would you need transportation?*

Demographic Questions

14. Age: _____

- *(5-11, 12-21, 22-35, 36-64, 65+)*

15. Gender

16. Level of blindness