IPRO 310: Swimming Aid for Visually Impaired Swimmers

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Abstract

The main focus of this project is to help blind and visually impaired individuals obtain an opportunity to exercise by swimming independently. The team is creating two devices to help. A passive device is a mechanical apparatus that provides tactile feedback to the swimmer and the active device uses contains special electronic capabilities like sonar to help guide the swimmer. In addition, a strong connection to the blind community will be made through surveys and frequent trips to blind shelters in order to help mold the direction of future projects that will ultimately satisfy visually impaired swimmers to the highest degree, help them exercise, and help further improve their quality of life.

Background

IPRO 310 is a project aimed at enabling the blind and visually impaired individuals to swim at ease without any of their physical disability hampering their activity. World Health Organization (WHO) estimated that in 2002 there were 161 million (about 2.6% of the world population) visually impaired people in the world, of whom 124 million (about 2%) had low vision and 37 million (about 0.6%) were completely blind. This type of serious visual impairment has left merely 25% of the population to participate in various activities. Though there are instructors for the blind and visually impaired to aid them in their endeavors, there is a dearth of non-invasive technology that can be provided to them for additional support and assistance. IPRO 310 aims at filling the void in assistive technologies present for blind and visually impaired swimmers by designing, documenting, testing and marketing the prototype. The team is comprised of students from different fields of engineering and science to make the goal achievable. This IPRO also has collaborated with the Chicago Lighthouse, enabling us to have a deeper understanding of the common and basic problems faced by the visually impaired individuals and what they expect from our outcome in order to feel independent in water. The Chicago lighthouse for Blind people supports us in our mission by encouraging interaction among the Blind individuals.

Passive Team

This issue is being resolved in two ways. One way is by using a passive device and the other way is by using an active device. The passive device comprises of side tappers and icicles that signal the swimmers of their diversion from their central track and movement in a zig-zag pattern. Tappers also had been hired for visually impaired individuals to warn them of the end of the lane. This was done by tapping them at a proper location on their back. However, there had been loopholes in these methods, the presence of side-tappers left the swimmers bruised or scraped by the end of their swimming and for the tappers to do a good job, the swimmers had to be trained efficiently. To overcome these problems, the passive team has decided to modify the previous versions and design new assistive devices that could eliminate the problems faced by the blind and visually impaired people.

Active Team

Active devices deal with the electronic devices and wireless communication through RF signals. Visually impaired people while swimming put on these devices. These are smaller, more versatile and do not deprive the swimmers from their independence. Sonar devices technique being one of the very effective technologies used previously. Previous IPRO team used Sonar Underwater Personal Anti-Collision Device (SUPAD), which uses Sonar technology. It helps in orient blind swimmers in the pool and helps them to compute distance while approaching the wall. The last IPRO Team Members used ‘Snorkel Devices’, which was found really effective. Snorkel in some extent has taken place of ‘End Tappers’ by giving signals to the blind swimmers with the help of receiver, process known as ‘Bone Conduction’. Main issues which needs to be fixed from last few semesters will be: We should make device simple in operation and smaller in size. After looking through few tests held last semester, it shows that size of the device could have been further decreased.

Objectives

The goal for IPRO 310 is to create a device to assist the blind so that the blind can have an opportunity to swim. Presently there is no device on the market to help a blind swimmer. There have been devices made for a blind swimmer formed by students, but haven't gotten any further than their schools pool.

Passive Team Objectives

- Redesign storage device
    - To increase durability of passive device. Preferably, no tight strings to tie the device so it does not bend the side tappers.
    - Make the device lighter so it can be more easily transported (short distance)
    - In addition, the storage device needs to be smaller so it can be shipped if needed (long distance)
- Rebuild entire passive device to be used for pool tests
    - Replace bent and worn out side tappers
    - Replace scouring pads, rope, and Velcro straps
- Redesign I-connector
    - Giving firmer hold on lane line.
    - Must be more easily adjustable than T-connector
- Redesign End tappers
    - To make them more distinguishable from side tappers
    - Incorporate sound (in the form of ringing bells)
- Make the entire passive device Modular
    - If time permits, for future transportability of device.
    - Would require all new storage device as well

Active Team Objectives

- Improve on past device by researching new technologies and ideas for active device.
    - Choose two most promising solutions to develop.
        - RC/RF
        - LVDT
        - Other alternatives
- Develop and test methods of communicating with swimmers.
    - Sound
        - Tones
        - Voice commands
    - Vibrations
        - Intensity
        - Location
- Design new housing for equipment that utilizes equipment non-blind swimmers use to prevent putting the swimmer at a disadvantage.
    - Swim cap
    - Goggles
- Test and calibrate new equipment to determine the best solution.
- Move toward a more independent device that does not require another person for assistance.
- Conduct multiple surveys with blind shelters to increase awareness of blind needs and establish strong bond with the blind community.

Methodology

- Project management
  - Research of previous IPRO semesters **177 HOURS**
    - Class presentations 30
      - Prep 50
      - deliver 22
    - Engineering notebooks 25
    - Pool test 20
    - Assessing current devices 50
  - Research and Design **127 HOURS**
    - Active 64
      - Technologies 50
      - Devices 14
        - Hydrophone 4
        - Modified snorkel 10
    - Passive 63
      - End tappers 22
      - Storage device 35
      - I connectors 6
  - Prototype **161 HOURS**
    - Active 63
      - Building 29
        - Hydrophone 4
        - Modified snorkel 25
      - Testing 9
        - Hydrophone 5
        - Modified snorkel 4
      - Material acquisition 23
        - Hydrophone 3
        - Modified snorkel 20
    - passive 98
      - Material acquisition 34
        - Storage device

○ New tappers	6
	28
● Preliminary material test	8
○ Storage device	6
○ New tappers	2
● Building	56
○ Storage device	26
○ New tappers	30
○ Testing	**110 HOURS**
■ IIT pool test with team members	55
■ IIT pool test with blind and visually paired	55
○ Surveys	**45 HOURS**
■ Pre-test:	25
■ Post-test:	20
○ Deliverables	**416 HOURS**
■ Project plan	40
■ Midterm	40
■ IPRO day	120
■ Presentation	45
■ Abstract	40
■ Poster	40
■ Preparation	24
■ Final report	40
■ Weekly reports	27

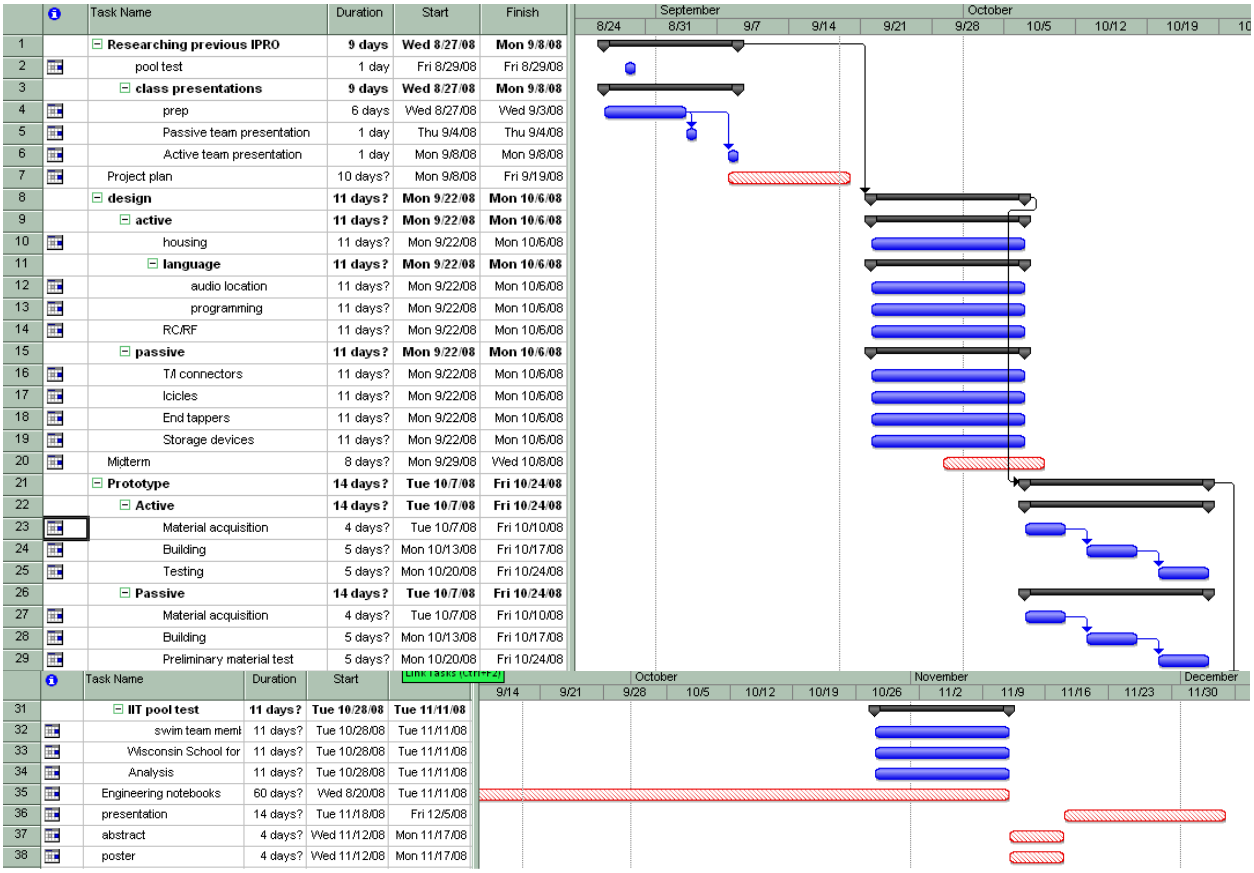
Changes

Our IPRO team was highly encouraged to involve the human factor into our research and design for the different devices. This did not allow for the time predicted for building new- or modifying old devices. More time was spent on surveys, presentations and reports.

Task Durations

8/29/08 to 8/29/08 Pool Test
8/29/08 to 9/24/08 Analyze Previous IPRO information
8/27/08 to 9/3/08 Passive Team Presentation
8/27/08 to 9/8/08 Active Team Presentation
9/8/08 to 9/19/08 Project Plan
9/12/08 to 9/12/08 Chicago Lighthouse Trip
10/06/08 to 10/08/08 Midterm Review
9/24/08 to 10/6/08 Design of Prototype (Active and Passive Team)
10/6/08 to 10/13/08 Engineering Notebook
10/07/08 to 10/28/08 Prototyping
10/28/08 to 11/11/08 Testing
11/11/08 to 11/18/08 Analysis and Engineering Notebook Update
11/18/08 to 11/26/08 Posters
11/18/06 to 12/05/08 IPRO Presentation Practice
11/24/08 to 11/26/08 Future plans and suggestions of next IPRO

Gantt Chart



	Task Name	Duration	Start	Finish
1	**Researching previous IPRO**	**9 days**	**Wed 8/27/08**	**Mon 9/8/08**
2	pool test	1 day	Fri 8/29/08	Fri 8/29/08
3	**class presentations**	**9 days**	**Wed 8/27/08**	**Mon 9/8/08**
4	prep	6 days	Wed 8/27/08	Wed 9/3/08
5	Passive team presentation	1 day	Thu 9/4/08	Thu 9/4/08
6	Active team presentation	1 day	Mon 9/8/08	Mon 9/8/08
7	Project plan	10 days?	Mon 9/8/08	Fri 9/19/08
8	**design**	**11 days?**	**Mon 9/22/08**	**Mon 10/6/08**
9	**active**	**11 days?**	**Mon 9/22/08**	**Mon 10/6/08**
10	housing	11 days?	Mon 9/22/08	Mon 10/6/08
11	**language**	**11 days?**	**Mon 9/22/08**	**Mon 10/6/08**
12	audio location	11 days?	Mon 9/22/08	Mon 10/6/08
13	programming	11 days?	Mon 9/22/08	Mon 10/6/08
14	RC/RF	11 days?	Mon 9/22/08	Mon 10/6/08
15	**passive**	**11 days?**	**Mon 9/22/08**	**Mon 10/6/08**
16	T/I connectors	11 days?	Mon 9/22/08	Mon 10/6/08
17	Icicles	11 days?	Mon 9/22/08	Mon 10/6/08
18	End tappers	11 days?	Mon 9/22/08	Mon 10/6/08
19	Storage devices	11 days?	Mon 9/22/08	Mon 10/6/08
20	Midterm	8 days?	Mon 9/29/08	Wed 10/8/08
21	**Prototype**	**14 days?**	**Tue 10/7/08**	**Fri 10/24/08**
22	**Active**	**14 days?**	**Tue 10/7/08**	**Fri 10/24/08**
23	Material acquisition	4 days?	Tue 10/7/08	Fri 10/10/08
24	Building	5 days?	Mon 10/13/08	Fri 10/17/08
25	Testing	5 days?	Mon 10/20/08	Fri 10/24/08
26	**Passive**	**14 days?**	**Tue 10/7/08**	**Fri 10/24/08**
27	Material acquisition	4 days?	Tue 10/7/08	Fri 10/10/08
28	Building	5 days?	Mon 10/13/08	Fri 10/17/08
29	Preliminary material test	5 days?	Mon 10/20/08	Fri 10/24/08

	Task Name	Duration	Start	
31	**IIT pool test**	**11 days?**	**Tue 10/28/08**	**Tue 11/11/08**
32	swim team meml	11 days?	Tue 10/28/08	Tue 11/11/08
33	Wisconsin School for	11 days?	Tue 10/28/08	Tue 11/11/08
34	Analysis	11 days?	Tue 10/28/08	Tue 11/11/08
35	Engineering notebooks	60 days?	Wed 8/20/08	Tue 11/11/08
36	presentation	14 days?	Tue 11/18/08	Fri 12/5/08
37	abstract	4 days?	Wed 11/12/08	Mon 11/17/08
38	poster	4 days?	Wed 11/12/08	Mon 11/17/08

Budget

Over the course of the semester for the IPRO, the budget changed according to specific needs of the group. The group decided on a few categories at the beginning of the semester that would require financing. The initial budget is shown below in Chart X.

Category	Requested	Approved	Explanation
	9/19/08	9/26/08	
Supplies	$300	$300	150 - passive team 150 - active team
Equipment	$900	$0	400 - passive team 500 - active team
Travel	$50	$50	transportation
Participant Support	$80	$80	volunteering incentive
IIT pool tests	$100	$100	life guard, pool reservation, etc.
Wisconsin Pool Tests	$250	$250	
TOTAL	$1,680	$780	

Table 1: Proposed/Approved Budget

The initial budget included the following. “Supplies” dealt with the building materials that would be used to construct the various devices. “Equipment” included the technology or materials spe-

cific to the active and passive devices. “Travel” covered the expenses of going to stores to pick-up any materials purchased. “Participant Support” involved providing incentives to any person who took part in a test or survey. “IIT Pool Tests” covered the costs of reserving the lifeguard and pool for any tests necessary. “Wisconsin Pool Tests” dealt with the costs related to the potential trip to the Wisconsin School for the Blind.

Due to the careful planning expenditure, we only spent 50% of our approved budget.

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Team Structure and Assignments

Name	Major	phone number	Year	Subteam	Skills
Sunny Sajjad	Biochemistry	[redacted]	4th	Passive	Biochem lab tech experience, MS Office, Sales, Manager
Hsuen Yew	BME	[redacted]	4th	Active (leader)	Ms Office, Basic C language, Matlab, Bio lab technique, Foreign Languages
Jodi Warns	BME	[redacted]	4th	Passive (Team Leader)	MS Office, matlab, chem & bio lab techniques
Arun Sood	Biochemistry	[redacted]	4th	Passive (leader)	Microsoft Office, C++, Organized, chem & bio lab techniques
Neha Padwal	BME	[redacted]	4th	Passive	MS Office, chem & bio lab techniques
Lorne Turrentine	ME	[redacted]	4th	Active(leader)	Matlab, AutoCAD, Basic C++, Maple, MS Office
Sikander Soleja	ME	[redacted]	4th	Active	Mechanical design, MS office, AutoCAD, Matlab
Jan Teves	ME	[redacted]	3rd	Active	AutoCAD, Pro Engineer, MATLAB, Maple, MS office, Access, C++, Labworks, Solidworks
Daniel Chiu	AeroE	[redacted]	3rd	Active	C++, Qbasic, Woodworking, Riveting, Matlab, MS office, AutoCAD, Cad Key, Manual drafting
Lisa Reed	Psychology	[redacted]	3rd	Passive	MS Office, C++, Physic, Bio & Chem lab
Vaibhav Gupta	EE	[redacted]	4th	Active	MS Office, Matlab, Macintosh, electrical concept
Fiona Daay	Architecture	[redacted]	5th	N/A	
Shital Patel	EE	[redacted]	4th	N/A	
David Gatchell	BME	[redacted]	ph.D	N/A	
Frank Lane	Psychology		ph.D	N/A	

Ken Schug	Chemistry	[redacted]	51st	N/A	

Ipro 310 is organized into two major subteams, working on different facets of the project. The "Active" subteam is devoted to working on a real time solution that accomplishes the goal of enabling blind swimmers to be self-dependent, while the "Passive" team works in an effort to engineer a stationary solution with the same goal in mind. Subteam leaders for each group delegate responsibilities to each team in accomplishing their subset of tasks to improve upon or otherwise alter the existing models that represent the culmination of their research, testing, and development. The subteam leader s report to the team leader, who coordinates with IPRO supervisors/consultants to keep each subteam organized and best equipped to complete the IPRO successfully. The team meets twice weekly to discuss current affairs on the project and mark forthcoming milestones .

Team Schedule

ACTIVE	am			pm												am
Monday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Daniel Chiu							Class Meeting									
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																
Tuesday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Daniel Chiu																
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																
Wednesday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12

IPRO It takes a team
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Daniel Chiu							Class Meeting									
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																
Thursday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Daniel Chiu																
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																
Friday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Daniel Chiu																
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																
Saturday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Daniel Chiu																
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																
Sunday	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Daniel Chiu																
HK Yew																
Jan Teves																
Lorne Turrentine																
Sikander Soleja																
Vaibhav Gupta																

	Available
	Tentative

	Not available

Team Responsibility

Administration & Deliverables

Mid Term Review

-HK

-Lisa

Updating and organizing Engineering Notebook

-Vaibhav

-Fiona

-Sunny

Minute

-Sunny

Agenda

-Jodi

Igroups Organization

-Lorne

-Dan

Budget

-Jan

-Sikander

-Jodi

-Arun

Timesheet

-Arun

-HK

Pool Test: Organization

-Lorne

-Neha

Pool Test: Contact

-Arun

Final Report

-Arun Sood

-Sunny Sajjad

-HK Yew

Final Deliverable CD

-HK Yew

Passive Device

End Tappers

-Neha

-Lisa

I-connectors and rebuild

-Jodi

-Arun

Storage device

-Sunny

-Dan

-Lorne

Active Device Research

Parking Sensors

-HK Yew

Hydrophone

-Lorne

Snorkel Device

-Vaibhav

Invisible Fence

-Sikander

Results

Active Device Team:

Research

The active team developed and distributed a survey to the blind and visually impaired community with assistance from the Chicago Lighthouse for the Blind. The team interviewed seventeen (17) individuals and obtained the following data:

Swimming Capabilities

Classification	
Swimmer	Non-Swimmer
9	7

Time-Self	
Yes	No
4	8

Communication

Type			
Sound	Touch	Voice	Vibration
10	3	2	3

Feedback		
Positive (+)	Negative (-)	Both
6	4	7

Device Characteristics

Placement						
Choice	Wrist	Head	Shoulders	Hands	Feet	Other
Primary	6	8	1	1	0	3
Secondary	0	3	4	5	1	1
Last	1	5	5	2	2	0

Size		
Small (Watch)	"Little Bigger" (Cellphone)	Big (Box)
9	8	0

Maintenance

Replace Batteries	
Yes	No
13	4

Charge Batteries	
Yes	No
16	1

Scheduled Calibration	
Yes	No
13	4

Cost

Cost			
<$25	$25-$50	$50-$100	>$100
4	6	5	1

Funding		
IIT	Other	No
1	7	8

These data show that blind and visually impaired persons prefer to have a device that is small, worn on the head, and transmits information via audio communication. The preferred type of feedback is a combination of both positive and negative. These data also show how much effort one is willing is to put forth into a device. The majority of people would both replace batteries or charge a battery pack. The majority of persons surveyed also said they would take devices

Helpful, Enjoyed Features
Talking dictionary, computer, calculators
Device which helps one to communicate properly (voice cleaning device)
CCTV, tent zoom
paddle board
stuff thats talk
zoom text
programming device, makes fully independent, talking device
cordless phone

into a store for scheduled calibration to ensure quality of the device.

Passive

After each test run through the passive device, the team administered a survey to the subject. From the feedback, the team found that modifications to the end tappers proved to have no affect on the swimmer's swimming.

	Question #	1	2	3	4	5	6	7	8	9		11		13	14	15	16	17
Test #																		
1		N	Y	Y	N	Y	Y	Y	N	Y		Y		Y	N	N	Y	N/A
2		Y	N	Y	N	N	Y	N	N	Y		Y		Y	Y	N	Y	N/A
3		Y	N	Y	N	Y	Y	Y	N	Y						N	Y	N/A
4		Y	N	N	N	Y	Y	Y	N	Y		Y		Y	N	N	Y	N/A
5		N	N/A	N	Y	Y	Y	Y	N	Y		Y		N	N	N	Y	N/A
6		Y	N	N	Y	Y	Y	Y	N	Y		Y		N	Y	N	Y	N/A

The surveys showed that the subjects could not hear the new attached bells on the end tappers. The surveys also showed that the inflatable arm bands on the end tappers induced panic in the swimmer. They thought that the arm bands made the end tappers too large and would often stop, treating the end tapper as the wall. Subjects' tactile perception of tappers varied greatly between different strokes. With this in mind, the future passive device should include adaptability for individual swimmers.

Accomplishments

Overall, the IPRO team accomplished several objectives. The team involved the blind and visually impaired community in the development process. The team also completed a new storage apparatus for the passive device.

Obstacles

Active team

Snorkel device

- The speakers were not loud enough under water for the blind and visually impaired swimmers in order to follow the instructions.

Snorkel using waterproof earphones:

- The size of the circuit casing was large as compared to the suggestions from the blind and visually impaired swimmers as concluded from the survey.
- Problems in making the circuit casing completely waterproof.
- The perfect location to wear the device on the body is yet to be determined.
- The water proof head phones got back ordered and as result the installation of the device got delayed.

Hydrophones:

- The feedback it gave was really vague and hard to interpret.
- The volume of the speakers was really low and has to be amplified.

Parking sensors:

- The parking sensors got back ordered and did not reach in time for us to work on it.

Passive Team:

Storage Device:

- The new storage device was not able to support the weight of side and end tappers when built.
- The two vertical poles of the storage device did not have any support at the bottom.
- Y-shaped part of the storage device was not long enough to store both end tappers and side tapers at the same time.

End Tappers:

- New end tappers padded with inflated tubes having bells inside, were not able to serve the purpose of alerting blind and visually impaired swimmers of the end pool walls.
- Sounds produced by the bells, which are placed inside the inflated tubes were not loud enough.
- It was difficult for Blind and visually impaired swimmers to reach the end pool walls as intended due to large distance between the pool walls and the end tappers.

I-connectors:

- Design of the new I-connectors has been made but not yet built and used due to lack of adequate information and specifications.

Recommendations

Active Team

The largest initiative of this semester was to organize the IPRO group and help provide direction to the course of the project. It is highly recommended that future groups continue to use the appropriate documentation templates in order to keep all research, ideas, weekly status reports, and meeting minutes in a format that is easy to follow and use. Basically, it allows for standardized documents to be produced ensuring all the necessary information is included.

The next main recommendation would be to keep the community involved along the path of the design of the device. Make use of the resources of information the devices the BVI population currently uses to help add or remove features to cater to the needs of the potential users. Also, use the feedback that the BVI community can provide and has provided to guide the devel-

opment of an active device. This was lost in the technological focus of previous IPRO groups and should be strongly reinforced. It is easily accounted for through surveys and trials that involve the potential users. Obtain feedback and redesign frequently.

As far as technology, many concepts were proposed. From these technologies, it was determined that the best paths to pursue were ultrasonic sensors, an "invisible fence" concept, and continued use of radio frequency and bone conduction for communication. The ultrasound sensors should be the first of the paths explored because it offers many benefits and shows a lot of potential to work well with the task at hand. These can be found in today's society and are typically known as "parking sensors." The range or sensitivity of the sensors should be carefully examined to ensure the correct distances are calculated under water. Other modifications should be considered as well, but the general technology behind the setup should be examined further.

Overall, the group should be sure the consumer is kept in mind while the device is being developed. So far the community has expressed that the device should be compact and carried in a way that it does not stand out more than typical swimming gear. This includes ideas such as incorporating the device into goggles or a swim cap. The community also suggested using positive audio feedback, a device the size of a cell phone or smaller, and to carry the device on the head or in a swim suit.

Passive Team

1. **End tappers:** The size of the present end tappers with floaties and bells needs to be narrowed down and at the same time made sure that they seem distinguishable from the side tappers. This could be made possible by use of slightly smaller and slender floaties than the fat and puffy floaties currently used. During project research, it was found that long slender floaties, in the shape of a tube that make a sound of approximately three second duration on touch, are available in the market. It is recommended that the present end tappers be replaced by such kind of end tappers. Also while placing the end tappers in the pool, the distance between the pool wall at the end and the end tappers must be reduced.

2. **Side tappers**: The side tappers need to be arranged at a distance greater than their current distance. This would enable the swimmers to feel unobstructed during swimming. Also, the point at which the side tappers connect with the T connectors need to be bracketed so that the tappers do not flip over while swimming.

3. **I- connectors:** The team was considering of replacing the current T- connector with I-connectors for sturdier connection, ease of sliding along the lane line and easy manipulation among the components of passive device. Though the team had a good head start on this issue, lack of appropriate guidance from sources dealing with such connectors caused

the team to consider this change for next semester.

4. **Storage Device:** Though the current storage device has minimized the bending of side tappers, it is still not portable. The storage device needs to be flexible so that it can be efficiently used during the pool test and also easy for transportation.

5. The pool tests conducted during this semester involved only blind swimmers. Thus the data obtained from the surveys pertained to changes experienced only by the blind swimmers. If we could have some visually impaired swimmers try out our device, one could make an analysis of changes that needs to be considered for both, blind and visually impaired swimmers. Also, the distance between the lane lines needs to be wide enough for allowing more comfort while swimming.

Acknowledgments

We would like to thank the Light House for the tour and the survey questions that they answered. We would like to also thank our professors for the knowledge and experience that they shared with us. Finally we would like to thank the participants that participated in the pool test.

Reference

Chicago Light House for the Blind

Yale University – Cr. Roman Kuc

Duke University

American Foundation for Blind

Notre Dame University