Final Report

IPRO 310: Swimming Aid for Visually Impaired Swimmers

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1.0 Abstract

This project aims to help visually impaired individuals to exercise independently. While the primary focus this semester will be enabling visually impaired swimmers to swim independently, other physical activities will be researched for the purpose of choosing three activities to be considered for future projects. A passive device, which is a mechanically-based device that offers tactile feedback to the swimmer, and an active device, which is a sonar based device, will both be developed in parallel to aid the swimmers. This project, overall, could potentially increase the independence of blind and visually impaired individuals, as well as improve their quality of life.

2.0 Background

IPRO 310 is a continuing project focused on enabling visually impaired individuals to swim independently. While current advances in assistive devices have enabled people who are blind to be involved in more activities than previously possible, there are still areas that lack attention in applying assistive technology, specifically for blind swimming, which is our primary focus.

Current methods involve blind individuals hiring “tappers”, who are tasked with making sure the swimmers do not hit the pool walls. In addition to avoiding the pool wall, blind swimmers need to avoid the pool lane ropes on either side of the lane. Competitive blind swimming does not include the use of extra equipment to avoid the pool lane ropes. The use of tappers at the ends of the pool lane is the only current standard. The result is that the blind swimmer veers left and right in a zigzag pattern, constantly making contact with the pool lanes. It is not uncommon for the blind-swimmer to cut, scrape, and bruise their body while achieving the slower swimming lap time.

Previous IPRO teams have come up with two main methods to avoid this. These include a passive device, where a blind swimmer can freestyle and backstroke though a swimming lane built of injury safe materials, which act as an awareness system of where the swimmers are relative to their lane. Issues that currently need to be developed based on previous IPRO’s designs are:

1. Long-term endurance to pool conditions.
2. Effectiveness of certain device components (ex. Icicle buoyancy after extended periods of time).
3. Overall effectiveness of device during use.

The active team has been working, in parallel to the passive team, on an electronic system utilizing sonar (sound navigation and ranging) signals that will be utilized and coupled with either an aural or physical signal to inform the swimmer of their proximity to boundaries such as a wall or pool lane ropes. The previous IPRO device developed worked by utilizing a radio frequency signal to signal on/off commands to a receiver connected to a circuit board, which in turn were connected to vibration producing motors located within a waist belt. The signals sent to this waist belt were sent from a small remote, which was operated by human interaction. Issues that need to be further developed include:

1. Operability of Unit (current and new) in underwater conditions.
2. Signal transmission
3. Waterproofing
4. Physiological effects
5. Economic feasibility studies
   (Rose-Hulman Institute of Technology has engineered a system utilizing sonar, however at an unreasonable cost.)
6. Interoperability of Unit components (ex. Sonar to receiver)

The research team’s role is to support the other teams when needed, structure the pool tests, conduct interviews to gather information, and ultimately research to choose what the future I-Pro’s should work on. Throughout the semester, the team will assess numerous physical activities and choose three activities for future I-Pros to pursue. To fully understand the difficulties of being visually impaired, the research team plans to develop contact with individuals from The Chicago Lighthouse for the Blind, as well as other visually impaired individuals.

3.0 Objectives

Active Team

- Repair and implement the wired device, which is a device that has vibrating motors connected to a remote control with wires.
- Develop and test vibration language, which is set of commands that we come up with the different types of vibrations that we can produce to communicate with the swimmers.
- Determine which location on the body is best for the placement of the belt with the vibrating motors
- Figure out which intensity for the motors would be most universally accepted by swimmers

Passive Team

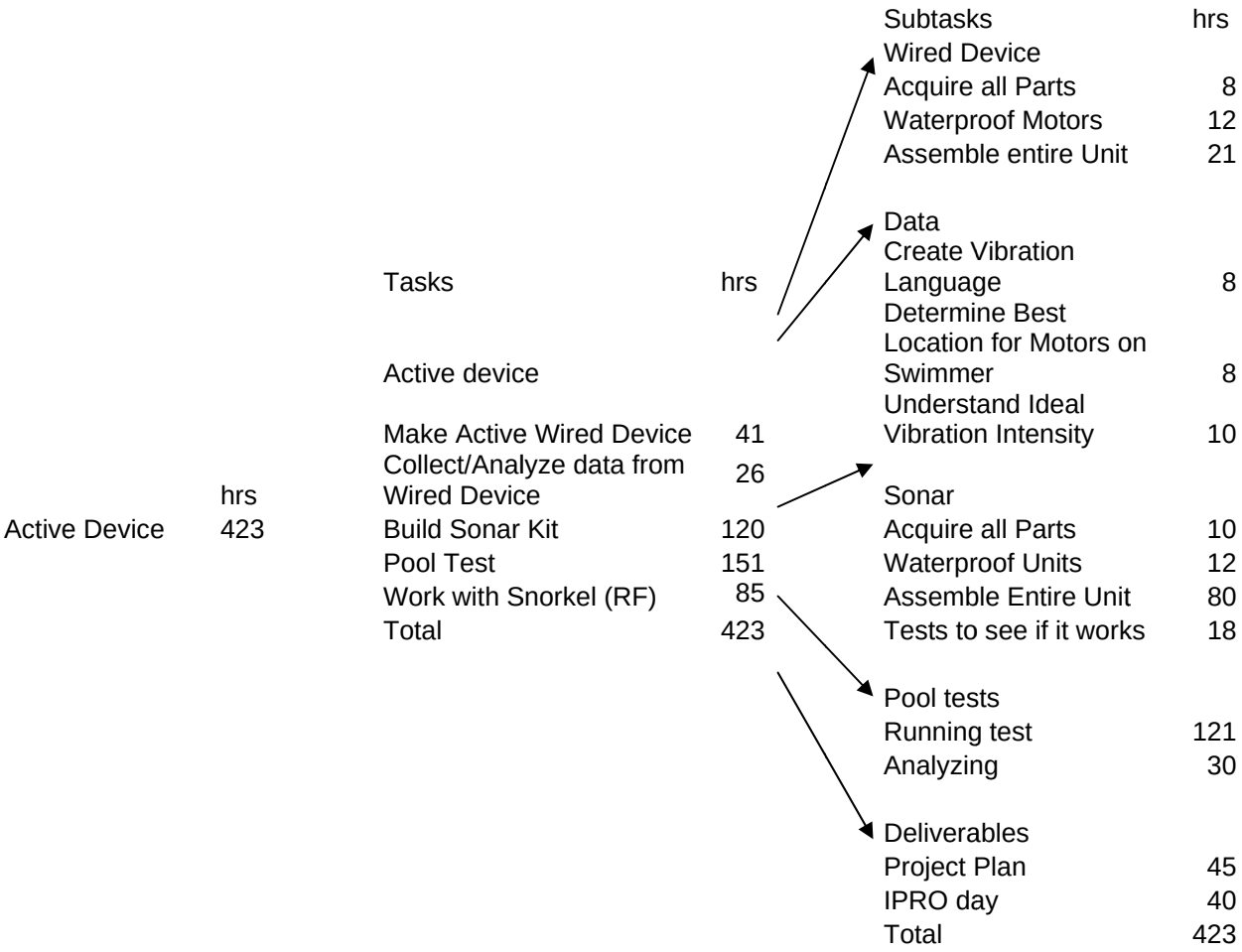
- Create a device for use in the pool for the Wisconsin Center for Blind and Visually Impaired.
- Perform extensive materials and durability tests to current materials used in passive device.
- Research alternate pool friendly materials and their costs (Co-op with research team)
- Redesign T-Connectors for easy mobility and for mass manufacture.
- Replace current nylon lane lines with official lane line components.
- Find a new type of material for ‘icicle’ that is more durable but not buoyant, and to apply it to lane line side icicles for breaststroke and butterfly.
- Find a new adhesive for tactile pad at ends of side tappers.
- Improve the storage device to cause less damage on passive device.

Research Team

- Examine current and future assistive technologies for possible application in our project.
- Educate sub-teams in these assistive technologies.
- Investigate/ identify specific areas of exercise for further research and development via feasibility studies.
- Provide research and analysis for passive/active teams.
- Build potential partnerships with institutions, active groups, and companies for further collaboration.
- Compile all research materials into a readily accessible format.
- Conduct oversight over all pool tests.

4.0 Methodology

Active Team



Active Team			
	Start Date	Duration	End Date
Tasks			
Project Plan	6/8/2008	8	6/16/2008
Mid-Term Reviews	6/22/2008	3	6/25/2008
Make Active wired device(st)	6/11/2008	17	6/28/2008
Create vibration language (st)	6/28/2008	1	6/29/2008
Sensor placement on the swimmer (st)	6/28/2008	1	6/29/2008
Vibration intensity (st)	6/28/2008	1	6/29/2008
Order and Build Sonar Kit	6/16/2008	14	6/30/2008
Test and Waterproof Sonar	6/30/2008	9	7/9/2008
Test and Experiment methods of fixing unit to swimmer	7/9/2008	9	7/18/2008
Exhibit/Poster	7/16/2008	7	7/23/2008
Presentation	7/16/2008	7	7/23/2008
Final Report	7/16/2008	7	7/23/2008
Team Work Product; Meeting Minutes	6/11/2008	42	7/23/2008
IPRO Day Conference (with deliverables CD)	7/20/2008	5	7/25/2008
Sensing device testing for swimmer path deviation	7/18/2008	7	7/25/2008
Pool Test	7/27/2008	1	7/27/2008
	Total Hours	139	

Passive Team

Work Breakdown Structure

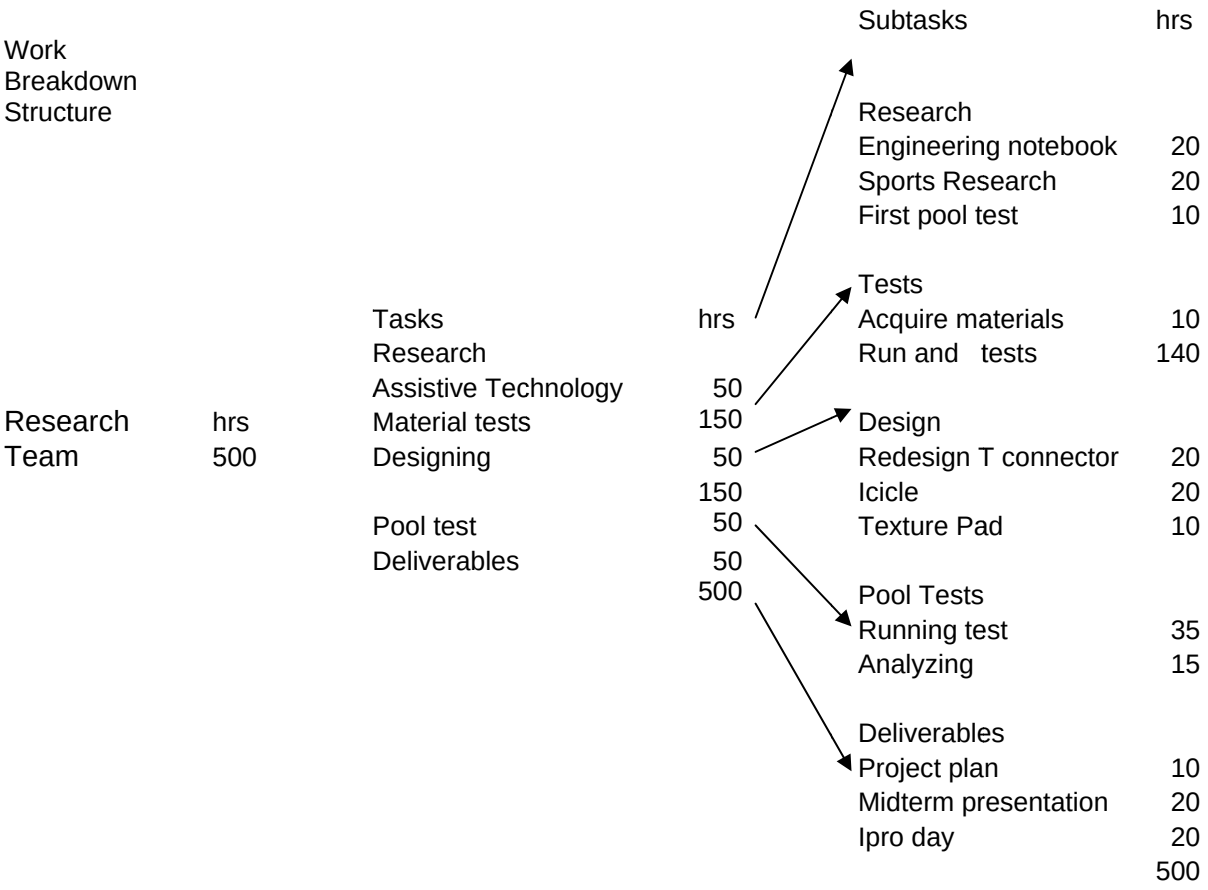
Passive Team	hrs
	500

Tasks	hrs
Research	50
Assistive Technology	150
Material tests	50
Designing	150
Prototyping	50
Pool test	50
Deliverables	500

Subtasks	hrs
Research	
Engineering notebook	20
Patent information	20
First pool test	10
Tests	
Acquire materials	10
Run and tests	140
Design	
Redesign T connector	20
Icicle	20
Texture Pad	10
Pool Tests	
Running test	35
Analyzing	15
Deliverables	
Project plan	10
Midterm presentation	20
Ipro day	20

Passive Team			
Tasks	Start Date	Hours	End Date
Practice pool test	6/9/2008	5	6/9/2008
Report on engineering Notebook and previous work	6/9/2008	16	6/10/2008
Collect materials required for testing	7/1/2008	4	7/1/2008
Setup experimental testing area and begin testing	6/16/2008	14	6/17/2008
report on findings	7/3/2008	12	7/3/2008
Engineering Notebook	6/11/2008	20	6/20/2008
Project Plan	6/15/2008	15	6/16/2008
Peer review	6/26/2008	10	6/26/2008
Midterm presentation	6/2/2008	25	6/3/2008
IPRO day stuff due	6/2/2008	30	6/4/2008
IPRO day	7/26/2008	9	7/26/2008
First Pool test	6/28/2008	6	6/28/2008
Second Pool test	7/19/2008	6	7/19/2008
Cypress semiconductor seminar	6/20/2008	4	6/20/2008
Chicago Lighthouse	6/13/2008	4	6/13/2008
Trip to school for the blind	TBD	15	TBD
Redesign icicles	6/27/2008	25	6/28/2008
Improve wind up spool	7/17/2008	27	7/19/2008
Building new passive device	7/2/2008	42	7/25/2008
Total Hours		289	

Research Team



Research Team Overall			
TASKS	Start Date	Hours	End Date
Research			
Engineering Notebook	6/13/2008	65	7/24/2008
Sports Research	6/5/2008	60	7/4/2008
Assistive Devices	6/12/2008	35	7/17/2008
Sonar Research	7/1/2008	20	7/17/2008
Pool Tests			
Planning	6/17/2008	25	7/19/2008
Execution	6/28/2008	50	7/20/2008
Networking			
Lighthouse	6/13/2008	55	7/26/2008
Assistive Device Companies	6/17/2008	25	7/18/2008
Swimming Equipment Companies	6/17/2008	25	7/18/2008
Sonar Equipment Companies	6/17/2008	25	7/18/2008
WCBVI	7/13/2008	80	7/28/2008
Deliverables			
Project Plan	6/10/2008	25	7/5/2008
Mid-Term Presention	6/19/2008	25	7/24/2008
IPRO Day	7/19/2008	25	7/26/2008
	Total	540	

5.0 Team Structure/Assignments

Active Team

Active Team	
Marta Alvargonzalez	Wired and Wireless Device
Team Leader	Oversight on whole team
	Sonar Research
	Vibration Research
David Malon	Wireless Device
Sub-Team Leader	Sonar Research
	Bone Conduction Research
	Motion sensor work
Jeffrey Lin	Wired Device
Sub-Team Leader	Vibration Research
	Motion sensor work
Robert Keane	Wireless Device
Team Member	Sonar research
	RF Research
Paul Cordogan	Wireless Device
Team Member	Sonar Research
	Exhibit Work
Hussain Biyawerwala	Wired Device
Team Member	Potentiometer

Passive Team

Passive Team	
Nick Pryzbysz	**Pool Materials**
Team Leader	Materials Listing
	Material Testing
	I-Connector Design and Build
	Repairing the Device
	Pool test trainer
Kevin Ragauskis	**Materials Testing**
Team Member	Icicle Design
	Texture Pad Adhesion
	IPRO video production
	Archiving digital files
	Pool test lane manager
McLain Hubbard	**Materials Design**
Team Member	T-Connector Design
	I - Connector manufacturing
	Material Testing
Mahdieh Salimi	**Materials Design**
Team Member	Re-design storage device, and testing
	Pool test trainer
	Repairing the device
	Abstract handouts
Ryan Dudek	**Materials Research/Design**
Team Member	Icicle Design
	Alternative Materials Research
	Repairing the device

Research Team

Research Team	
Joshua R. Cabrera	**Assistive/Other Devices**
Team Leader	Ultrasonic Technologies
	Robotic Sensor Technologies
	Applicable Technologies
Nicole Karns	**Pool Test Management**
Team Member	Setup Process
	Documentation
	Questionnaires/Surveys
	Data Tabulation
	Engineering Report
Andrew Lichaj	**Research Management**
Team Member	Video/Audio Documentation
	Collaborative Contacts
	Budget
Alex Leasenby	**Sports Research**
Team Member	Individual Sports Research
	Sports Criteria
	Sports Data Tabulation
Fiona Daay	**Swimming Equipment**
Team Member	General Swimming Equip.
	Swimming Company Research

6.0 Budget

Budget Update

Passive Team		Active Short		Research	
Wisconsin trip	$410.66	Pager motors	$24.00	Binder / Dividers	$11.56
Pool supply	$25.21	New Belt	$20.00	Binder / CDs	$7.79
Weights	$11.65				
Glue	$8.00	**Active Long**			
Machine shop	$120.00	Scuba gear	$181.14		
Pool tests	$320.60	Parallax Sensor	$38.00		
Springs	$16.71	Water proofing	$15.00		
		Motion sensors	$40.76		
budget allowed	$928.00		$423.00		$100.00
Total	$912.83		$318.90		$19.35
Amount left	$15.17		$104.10		$80.65

Total Allowed	$1,451.00
Total Budget	$1,251.08
Total Amount Left	$199.92

7.0 Results

Active Team

For the Active team's four goals as listed in the Objectives section of this report we have these following conclusions.

Wired Device

For the repairing of the wired device we were able to fix the device and reattach the potentiometer. The first test of this device showed that at its current voltage it did not give enough intensity to the motors so we attached more batteries to increase the intensity.

Body Location

In order to test the best location on the body we placed the belt on each swimmer's waist and lower back and asked which was most comfortable for them or which they preferred when they were swimming. From the data gathered from this test we found that eight swimmers preferred the motors on the front and ten preferred the motors on the back. From this we could not conclude that one was significantly better than the other so from this we could say that it is something that needs to be examined further.

Vibration Intensity

For the second test we allowed each swimmer to play with the potentiometer and asked them if they were any discomfort. We also asked them about the intensity of the motors after they swam. From the data here we found that most of the swimmers said that they had a hard time picking up the signal and that the motors needed more intensity. The swimmers that said the intensity was good enough said that they wouldn't mind having a little more intensity however. For this test the motors were receiving 4.5 V up from the previous 3 V each.

Vibration Language

Finally for the language test we only tested one language and then asked them if the opposite language would be easier to learn and use. All the swimmers gave the same basic answer which was that any language that we decided to use would take time to learn and practice was needed for it. However the useful information that we gathered was that Language 1 was the most natural to most of the swimmers, this was the language that was swim away from the signal.

Passive Team

Icicles

Research into alternative materials capable of replacing the old icicles had been done. The criteria for finding the alternative material were:

(1) Material should be dropping down in the water while floating from the side tapper.
(2) Material should feel harder than the previous version in order to be more sensible by the swimmers.
(3) Material should have a high durability due to its pool environment.

Following the research for such a material we have found dense rubber tubing to be the best alternative for the icicle. We had been able to test this new material in several pool tests, including the pool test in the Wisconsin Center for Blind and Visually Impaired, which included numerous visually impaired swimmers. Based on the feedbacks from the swimmers we have concluded that dense rubber tubing is a better solution for icicles.

T-Connector

By examining and testing the previous version of the passive device, we realized that we could come up with a better design for the T-connectors which could be more efficient in terms of its manufacturing and mass production, so that it is not made with off the shelf material. Based on our pool test T-connectors lost their flexibility over time, on the dual line stabilization system's string, where it would hardly adjust its distance from the other T-connector in lane.

We have designed and built the prototype for a new design which we have called I–Connector. I–Connector is a single piece design equipped with a Spring Lock System, linking side tappers together and is meant to be incorporated with the dual line stabilization system, making adjustments on the lane feasible.

Material Durability Test

Most of the materials used in the current device showed no change in appearance or mass during the test. The only component that changed mass through the test was the pipe insulation which actually gained mass. The Velcro strips, silicon tubing and puffer balls all showed physical changes. The Velcro strips became bleached, the silicon became softer and more flexible and the puffer ball discolored and the surface became tacky to the touch. The pool itself maintained the desired 5 ppb of chlorine; however the pH of the pool rose above the level that we could monitor. It is believed that the material the puffer ball is made of reacted with the chlorine in the pool, degrading the puffer ball and causing the rise in pH. The reactions of the other materials to the pool environment were not extreme and will not likely degrade overly quickly or cause a problem for pool chemistry.

End Tappers' Puffer Balls

As the material test shows the puffer balls will degrade over time in pool water. Therefore we had to research and test new materials that can have similar effect on swimmers. We have tested loaf and exercise golf balls to replace them. Based on swimmer's responses the golf balls were more successful.

Research Team

General Research

Research into general information on visually impaired individuals was carried out due to lack of documentation in previous engineering reports. Sources were cross referenced and checked to make sure the information gathered was of relevance to the IPRO. Preliminary research on the Americans with Disabilities Act as well as the Assistive Device Act were undertaken to provide some historical background to the efforts of visually impaired groups to gain more independence.

Throughout the semester, the research team was asked to respond to Requests for Information (RFI's). Research done for the active team included: finding waterproofing units/solutions for current active device, finding appropriate fish-finding (sonar) equipment, finding ultrasonic sensors, and investigating possible negative effects of vibration on the human body due to the use of vibrating motors on the active device. Passive team request included: finding alternative materials to use in place of existing materials, and finding better ways to attach the icicles to the scouring pads on the passive device.

Assistive Technologies

Research into assistive technologies during the semester yielded important observations on what types of assistive technologies are being widely used by visually impaired individuals, as well lesser known developmental technologies not yet being mass marketed. Technologies looked at ranged from computer assisted Braille devices, to smart cane technologies, to completely autonomous visual systems for the visually impaired. It was found that development in the area of GPS/GIS visual systems for complete spatial awareness of the environment is the next technological leap in the field of assistive technologies. Many of the newest assistive technology devices are hybrid systems incorporating different technology platforms to achieve completely independent awareness of surroundings. An extensive list of assistive devices and companies were compiled for future IPRO's to review. This information can be found in the engineering report compiled by the research team.

Other Technologies

Research into other technologies was undertaken to see if there were any possible applications in devising a solution. Areas of interest included fish finder equipment, laser technologies, RFID chip technologies, motion sensing equipment, as well as robotic sensor equipment, a prime example being ultrasonic sensory equipment. Technologies relating to robotics were found to hold the most promise, since these systems could easily be readapted to various applications, one of them being aiding blind swimmers navigate through the water. While ultrasonic sensors were explored by the active team during the semester, only preliminary experimentation was performed. Ultrasonic sensors seem to hold much promise in terms of a possible application in IPRO 310. Information relating to all these technologies was compiled by the research team for easy reference by future teams.

Pool Test Management

In regards to pool testing, it was found that the documentation forms utilized by previous IPRO"s were insufficient in terms of accurate data recording, as well as generally being outdated in terms of types of data needed for thorough analysis. New categories were added, including more information about test subjects weight, height, arm length, and lap timings. Also the datasheets themselves were streamlined for faster data recording, as well as ease of analysis after testing was done. Also, pool setup was streamlined for more consistent testing, as well as more manageable pool testing. Research team compiled all the pool setup, documentation forms in the engineering report, as well as on CD-ROM format.

Sports Research

The research team was tasked with looking into alternative activities for future development for visually impaired individuals. Ten key sports were initially chosen for research; skiing, judo, running, cycling, tandem cycling, wrestling, fencing, beep ball, and soccer. A set of criteria was chosen to narrow the list down to 3 potentials. The set of criteria included; calories burned per hour, cost , independence, difficulty/safety, and overall popularity. Using data charts for analysis via the criteria, the three potential activities for future IPRO development came to be: Running, Soccer, and tandem cycling.

Audio/Video Documentation

Throughout the semester, extensive audio/video was taken for the purpose of having a media formats that could be reviewed by future IPRO's, as well as for future collaborative efforts to attract companies and institutions. Audio/Video of pool testing done by the active and passive teams were recorded and edited to create informational videos. Copies of these videos are provided within the CD-ROM attached to the engineering report.

8.0 Obstacles

Active Team

- The motors on the wired device did not have enough intensity and we increased it once but it was still not enough
- The intensity issue caused more issues with the other tests that we did.

Passive Team

Some of the obstacles the Passive team encountered during the semester included:

Infinity foam / Dual Line Stabilization

- The Infinity foams on lane which holds the two strings together were seen to be falling apart after excessive use of the device. The glue's failed to hold the infinity foams in their place all time. We had to check them before every pool test and even between the tests. Eventually at the end we have lost couple of them because of their instability.
- The two lines which pass through the infinity foam tend to twist within the foam which causes us to fix it in the pool because of the storage procedure.

Icicles

- The old icicles started to bend and would not stand up right in the water. Swimmers expressed that they barely can feel and interact with them. Therefore we have researched the new material that can suspend in the water yet float. We also tested attaching weights to the old icicles. We had swimmers telling us that the rubber tubing was more efficient than the weights.
- The new icicles fell off once during the test. And the reason for its fall was that the little cut that had been made for its attachment to the side tappers had expanded all the way and caused the icicle to detach from its base.
- We have research another way of attaching the rubber tubing with an alternative material that does not require cutting in the tube. The information on the research is available in the research teams engineering notebook.

T-Connector

- After the first pool test we have discovered that the T-Connectors are not easily capable of moving along the lane for adjustments.
- A new design for the connectors had been made and the prototype is built which is following the same principal of the T-Connectors but is capable of adjusting itself with the spring lock system incorporated in it.

Puffer Balls / End Tappers

- Our material durability tests showed that the previous puffer balls, attached to the end tappers deteriorate over time in pool environment.
- Despite the fact that visually impaired swimmers very much liked their feel and color, we had to come up with new materials to replace them with the same effects.
- In the last pool test we tested two different alternative materials.
- End tappers sometime slide over the side tapper next to it. We tried to further distance the two to avoid it.

Storage Device

- From our first pool test we have realized that the storage device is causing some damage to the tappers. Although the system is very useful in making the device more manageable, signs of bent and lane marks had been observed on device.
- Transportation of the device became hard when the tappers and icicles start to fall off the storage device.
- The new design of the storage device had been suggested which is following the same principals of the older version. But it is rather holding the device downward, therefore causing less damage to them.

Research Team

Some of the obstacles the research team encountered during the semester included:

Assistive/Other Devices

- Difficulty in finding technical information concerning some of the sensory equipment we were tasked with researching. Some requests for information were obtained, but for the most part, technical information was lacking for many of these devices.
- Lack of an extensive source of information concerning assistive devices beyond the mainstream products. While not able to resolve

this, future collaboration with some of these companies may go much farther than research alone in acquiring more extensive information.

- Most promising hybrid solutions are either still in development at other universities, or are being done by private institutions. Therefore, acquiring information concerning these devices is extremely difficult unless contact is initiated with these institutions.

Pool Test Management

- Since human subjects are being tested, we must constantly be aware of how to ethically undertake the pool test with visually impaired swimmers. To prepare ourselves, all members of all teams were required to undergo IRB certification to help prepare for the pool tests.
- Actual pool setup was consistently subject to change, depending on the availability of individuals for the pool tests, which were done on weekends. After the first two pool tests, a series of tasks were structured so as to minimize disruption during the pool test due to lack of available members.

Sports Research

- Creating a set of criteria based on subjective data analysis was difficult, since the justifications for some of the criteria had to be well documented in order for outside parties to be able to understand why we arrived at some of the figures we did.

Audio/Video Documentation

- During pool test documentation, we had to be certain that individuals who did not wish to be recorded were not accidentally recorded during documentation. There was one recorded visually impaired swimmer who specifically asked not to be recorded at all. Steps were taken to adhere to the swimmers request.

9.0 Recommendations

Active Team

- Give the motors more intensity and retest the entire device
- Research and test which motion sensors work the best and are the most cost effective
- Reconfigure and reverse engineer the swimp3 to make it work with the antenna from the snorkel
- Modify the snorkel so the mouth piece is less uncomfortable

Passive Team

End Tappers

- Based on the reported material tests the puffer balls in end tappers have to be changed.
- Two alternative materials had been tested on few swimmers but more investigation and tests are needed to find a final solution.

Storage Device

- The new design had been tested on the old storage device by holding it vertical and rolling the passive device around it. The experiment was successful.
- The actual device in full scale has to be built and tested.
- It has to be decided whether or not we want to expand the design to hold both lines or should we have separate device for each side of the lane.

Infinity Foams

- Infinity foams on the dual line stabilization system come off the line. New design has to be made to keep them in their place.
- Research on type of glue which is durable in pool water is necessary.
- Part of the problem is resolved with the new T-Connector design, but the further improvements on infinity foams are necessary to make them integrated with T-connectors.

Icicles

- The new icicle material proved to be suitable, but their attachments to the side tappers are still under investigation.

- An efficient way of attaching rubber tubes without any cut on the tube itself is needed.
- More research is needed on finding a medium to attaching icicles.

Research Team

Assistive/Other Devices

- IPRO should purchase Assistive Technology Book outlined within the engineering report. It provides a good source of information for further research.
- With contact efforts to be undertaken, companies should be contacted for possible collaboration for further technical information on products.
- Contact with institutions should be arranged so as to keep up on the latest developments within assistive technologies.

Pool Test Management

- Utilize the Pool Test documentation set up done by the summer term.
- Contact visually impaired swimmers in well in advance, preferably at the beginning of the IPRO, as well as follow-up calls two weeks in advance to reconfirm their commitment.
- Thoroughly prepare pool tests, as well as leave contingency plans when in case things go wrong.

Sports Research

- Next IPRO should take a further look into running, soccer, and tandem cycling.

Contacts

- With the contact lists provided, as well as the videos compiled by all the teams, contacting companies/institutions should simply be a matter of going through the lists and contacting the companies via phone/email, with a preference towards a phone contact. For email contacts, utilize the videos provided to aid in explaining the project the IPRO is currently doing. This will go much farther in getting a positive feedback, then solely explaining the project in words.

10.0 References

Active Team

See Engineering Report

Passive Team

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Research Team

Note: All references utilized by Research Team are located in the Engineering Report within appropriate subjects.

11.0 Resources

Active Team

User	6/24 - 6/30	7/29 - 8/4	6/1 - 6/7	6/8 - 6/14	6/15 - 6/21	6/22 - 6/28	6/29 - 7/5	7/6 - 7/12	7/13 - 7/19	7/20 - 7/26	Semester Total
Jeffrey Lin			5.0	9.5	12.5	8.5	11.5	21.5	15.0	15.5	99.0
Paul Cordogan			6.0	8.5	5.5	8.0	10.5	16.5	12.5	9.0	76.5
Dave Malon			5.0	14.0	12.5	5.5	14.5	6.0	19.5	15.5	92.5
Robert Keane			7.0	3.5	16.5	16.5	2.0	9.0	8.0	5.5	68.0
Hussain Biyawerwala			5.0	10.0	7.0	9.0	8.5	4.0	18.0	0	61.5
										Team Total	397.5

Passive Team

User	6/24 - 6/30	7/29 - 8/4	6/1 - 6/7	6/8 - 6/14	6/15 - 6/21	6/22 - 6/28	6/29 - 7/5	7/6 - 7/12	7/13 - 7/19	7/20 - 7/26	Semester Total
Nicholas Przybysz			3.5	12.3	7.1	14.3	5.5	16	7	6.3	72.5
Mahdieh Salimi			8.5	8.5	1.5	7	5	34	8.5	17	90
Kevin Ragauskis			8.8	8.5	8.5	8	13	30	17.5	8.5	102.8
McLain Hubbard			7.5	7.5	12	7.5	10.5	4.5	13	8	70.5
Ryan Dudek					16	19	6	7	8	5	61
										Team Total	396.8

Research Team

User	6/24 - 6/30	7/29 - 8/4	6/1 - 6/7	6/8 - 6/14	6/15 - 6/21	6/22 - 6/28	6/29 - 7/5	7/6 - 7/12	7/13 - 7/19	7/20 - 7/26	Semester Total
Joshua Cabrera		3.0	8.5	17.5	15.5	11.0	12.5	26.5	13.0	18.5	126.0
Nicole Karns			5.5	8.5	13.5	9.0	11.5	29.0	10.5	12.5	100.0
Andrew Lichaj			4.0	5.5	10.5	11.3	16.0	27.0	23.0	20.0	117.3
Fiona Daay			1.5	16.0			9.0	18.0			44.5
Alex Leasenby			4.0	7.0	6.5	8.5	13.5	7.5			47.0
										Team Total	434.5

12.0 Acknowledgments

See Engineering Reports for respective teams.