

IPRO 310-Fall 2007

Assisting Blind and Visually Impaired Swimmers

Final Paper

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Introduction

This objective of this IPRO is to develop devices to aid visually impaired persons swim. The team has chosen to work on two separate devices to accomplish this task. One approach is to use a passive device, which is located in the pool, to guide the swimmers through the lane. A picture of the latest version of the device is pictured below in figure 1 with several key features identified.

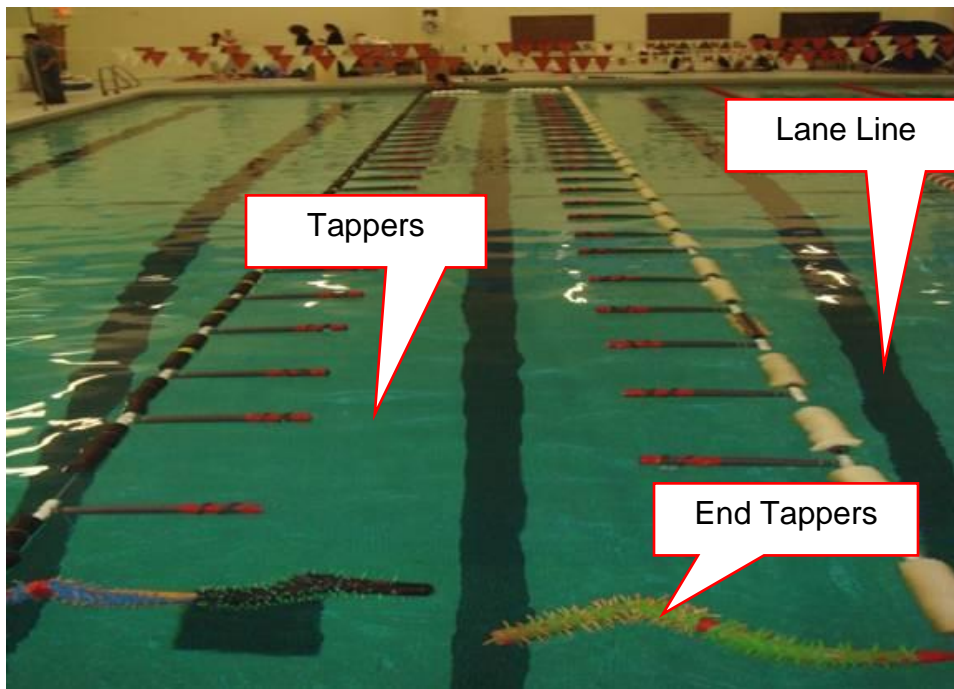


Figure 1: Version 6 of the passive device

The other approach is to use an active device, a sonar device, attached to the swimmer, which notifies them of an approaching obstacle.

Background

It has come to the attention of various people in the IPRO program of a problem with blind persons and the availability of aids for athletic activities, most pertinent to IPRO 310, blind swimmers. IPRO 310 has been working with the Chicago Lighthouse and the Notre Dame Masters Swimming Program to understand the problems of visually impaired swimmers, and try to provide devices to make them feel safe in the water.

Blindness can happen in many different ways ranging from injury and disease, where the effected persons once had sight, to those being blind from birth. The Chicago Lighthouse helps people who have become blind recover and cope with their handicap. This is one of the main sources for IPRO 310 as we can talk to people who are visually impaired and try to understand the challenges they face.

There are 180 million visually impaired persons in the world, of these 40 million are completely blind. Due to the restrictions of the visual impairments only 5% of these people participate in sports or physical activity of any kind. This IPRO has set the scope of aiding blind swimmers, a smaller problem in the grand scope but one that will have a great effect on a number of people.

This is the third semester for this IPRO. Previous teams have had success in developing the mechanical, passive device. This semester, the work of previous IPRO successes with this device were built upon and the device was modified and adapted to better suit the visually impaired swimming community. Previous teams have attempted the build an active, sonar device, with little success. This semester's team has attempted to reverse engineer a working sonar device to suit the needs of the visually impaired community.

Purpose

As described above, we chose to approach this problem in two ways, through sonar (active device) and an in-pool mechanical device (passive device). We considered other technologies, such as infrared, radio frequency control and audio feedback. Infrared required equipment deployed in the pool and we felt that something simply on

the swimmer would be easier. Radio frequency does not translate well from air to water and therefore was not very effective for our purposes. Audio feedback is not allowed in competitive swimming and was therefore not used.

We hoped to accomplish two working devices, one active and one passive, which successfully worked with a blind swimmer. The goals for each sub-team were as follows.

Active

The main objectives were to redesign the Dive Scan device circuit in order to give a vibration output instead of a display output. We also planned to make new vibration devices and a belt to attach the device to the swimmer. After this, we still needed to design and machine a new casing to hold the device in. Another one of our main goals was to provide the team from Rose-Hulman all of the information that they need in order to develop the first working device from scratch.

Passive

The main objective of the passive device sub-team was to design and modify the work of previous IPRO's and test a passive device on blind swimmers. This semester the team was to design and test two different passive devices, and then provide suggestions for the next semester's team.

Research

The objectives of the Research sub-team have changed significantly since the initial project plan and the mid-term report. These revisions were made based on the observations the team members had on the feasibility of the initial objectives. In the final analysis, we decided that our main objectives were to find, interview and recruit blind and visually impaired swimmers to work with us in our research and development of the active and passive devices. We were also supposed to identify possible sources of funds and material donations in order to control the high manufacturing costs that were needed to produce our devices. Lastly, the research team was to look into the prospects of filing provisional patents for both the active and the passive devices and fill out patent

application accordingly. This would involve doing a complete patent search, collecting documentation from the active and passive team engineering notebooks and putting this all together according to the US patent office regulations.

Research Methodology

Active

Our team has built a device that can be attached to the swimmer that will tell them when they are approaching an obstacle to ensure that they do not hit the end of the pool. To do this we had to take a scuba device used to find the range of obstacles underwater and modify it for our purpose. The key element of this was to make it output a signal to the swimmer, will physical vibration as opposed to a display. In addition, in order to make it not cumbersome to the swimmer we have to develop a hydrodynamic casing and develop a way to secure it to the swimmer.

The device was tested extensively in order to get the desired results. The most important tests were that of the physical response to the swimmer. Another crucial test was that of the ranging from the transducers. We had to continuously test the device to make sure that we have the outputs to the swimmers turn on or off correctly. We also had to test the method of strapping the device onto the swimmer. If the device is not comfortable for the swimmer to wear, they are not going to want to use the device. In order to perform all of these tests we had to have to reserve time in the pool and take constant records of our results, especially to get the ranging of the device down. As for the strapping of the device and the physical output, we had to test as many people as possible to see how it may affect them swimming and whether or not the output of the device was effective.

The results of the research and testing is documented in an engineering notebook listing all of the important factors that each test is designed to be testing. There will be three main testing guides; one based on the devices range, one on how well the output to the swimmer works, and another on how comfortable the strapping of the device is.

We analyzed each result based on what our expectations were for each test. As for the output to the swimmer, we had to see how well each output works and then build on

them to keep improving on them. The same was done for the strapping, in order to find what is most comfortable for the swimmer; we will have to keep modifying the device in order to get the right match for the average swimmer.

The team's work breakdown worked well and remained primarily the same through out the semester.

Passive

The main problem being addressed by this team is providing aid to blind swimmers. The passive device team modified and created a new device that is in the pool, not attached to the swimmer. It guides the swimmer through the lane lines by feel, a softer touch that will cut down the amount of zig-zaging through the lane.

The first steps in solving the problems have already been taken the previous IPRO's did a phenomenal job of jump-starting the process. For this semester, the passive team targeted areas of the current device that need to be redesigned and then made changes to those areas. For the current version, the passive team designed new connectors and new end of lane tappers. The team then analyzed the design and made changes based on the results of experiments with visually impaired swimmers.

Version 6 of the device was based off the connectors designed and built for Version 5. Version 6 addresses problems that were noticed during the previous pool tests and recurring problems from past versions. The main targets of redesign for V.6 will be the tappers, the end tappers, and the lane lines themselves. One of the main complaints of the previous designs was a lack of different tactile sensation between the tappers and the lane line, which is also covered in the same material as the tappers. The team also designed a few new tapper models to compare with the ones already in use on the device. Once again, end tappers were identified as problematic due to the lack of differentiation to the other tappers; they are made of the same material as the rest of the device. Extensive research was conducted to and several materials were identified and tested as end of lane tappers with much success and positive feedback from swimmers during experimentation.

The new device was tested with three visually impaired swimmers. This gave us a chance to see how the new parts responded to a test and get the input of blind swimmers

for the next design cycle. The test included two lanes, where the team tested blind swimmers both with the device and without the device. The test consisted of video documentation, to document both for the teams testing for insurance with the IRB certification; the test also timed the blind swimmers both with and without the device. This will prove to the team the analytical benefits of the passive device. The team also interviewed the swimmers with a series of pre-constructed questions to get their reactions and comments on the new device, these comments are used to help guide the next design cycle of the device.

Currently the team is in possession of an Engineering Notebook, a compilation of every design idea and design change to the passive device for the entire life of the project. This notebook contains a section dedicated to documenting the tests that have been and will be performed on the passive device. A sub-section includes the consent forms from the participants, and then a section documenting the post test interviews. This can be augmented after watching the video of the test to fill in any areas that were overlooked during the testing process.

The analysis will be mostly based on the response from the swimmers participating in the test. After the swimmers have completed a certain stroke the team asks questions of the swimmer based on the laps just swam. Once these questions have been answered and documented the team uses these answers to redesign the current device. The team will also observe other areas while the test is proceeding to make further changes for ease of use and functionality.

The IRPO deliverables will be documented as they occur. The builds and tests will both be included in the engineering notebook that will be kept by the team. The reports will document a summary of the build of the device, and will summarize the testing procedure. These documents will be useful to the continuation of the IPRO.

Research

One of the main problems that our IPRO faces is that the team members are still not clear on the needs of the visually impaired because we have not had a lot of contact with people who are blind or visually impaired. In order to better enlighten ourselves, we have organized a trip to the Chicago Lighthouse for the blind with a team of students

mostly comprising of students who are new to the IPRO (i.e. not continuing from the summer or the spring).

In order to have a small feeling of what it is like to swim without sight, an experiment was conducted at the Keating swimming pool with all the members from IPRO 310. Two of our students attempted to swim a full lap with blacked out goggles. This helped us experience some of the obstacles that blind/visually impaired swimmers have come in contact with and help us understand the full extent of their situation.

Our sub-team principally focused on primary research, specifically interviews, to gather our data. We conducted several interviews throughout the semester. Each interview was conducted with two or more interviewers and, for the most part, one interviewee at any one session. The questions that were in the interviews were carefully designed by the Summer IPRO research sub-team to gather answers related to what we needed to learn from the individual being interviewed. We will be making additions as we see fit. Each interview was digitally recorded, with their permission and then transcribed later in the week for a more careful final analysis. In addition, if the interview was conducted with a blind or visually impaired individual a consent form will be signed with a witness signature as well.

We also were able to recruit some of these people (or people they refer us to) for the pool tests that the active and passive teams held over the course of the semester. The focus of the research sub-team did not changed much since the preliminary project plan.

Assignments

Please refer to the sub-team Microsoft Project Plans in iKnow.

Obstacles

Active

Through testing, we have found it very difficult and time consuming to analyze every function of the dive-scan circuitry. After repeated tests, we decided not to continue analyzing the outputs to the LCD screen but rather find an easier way to recognize the signal. We found that the dive-scan device can only consistently read distances within 6-7 feet of the pool wall while moving, and from this decided that instead of interpreting exactly how the signal changes within that distance to the pool wall, we would simply have it turn the vibration on whenever we received a reading. With this, we have had the device working in the pool with sighted swimmers, but we faced another challenge when we tried testing it with blind swimmers. Due to the time we had to build the casing for the second pool test, we were unable to manufacture a streamline and waterproof case. While the case that we built functioned well under little use, with the blind swimmers present we were unsuccessful in showing the swimmers how it can work. This makes our biggest obstacle to this date to be waterproofing the device to ensure no water can reach the circuit components.

Passive

The team had to push through many obstacles, some of which included space for manufacturing, budgeted money and time, and availability of the materials needed for the device. The team was given a small room in which to work, much too small for the magnitude of manufacturing needed for building this device. Manufacturing of the device consumed most of the teams recorded hours for this semester, just less than 500 hrs to give a better idea. The equipment available for building and assembling the device were not all adequate and created another time obstacle for the team to overcome.

Cost budget was also an obstacle for the team. Some materials that may have been ideal for our purposes were too expensive and were implemented because of this.

Research

We faced several obstacles as a team. First off, since there are very few blind/visually impaired individuals that swim, we found it very difficult to find suitable candidates for our interview and for participation in our pool tests. This caused us to reduce the number of swimmers we intended to interview from six to four. In addition, we had several members of our team that were commuter students and hence were not available to help as much as they were needed. This made the rest of the sub-team struggle at times in order to cover for members that were not performing at the level they were expected to be performing at. The team also found it difficult finding potential individuals or organizations to solicit funds from. We did not fully know how to go about the fund raising process and so our efforts were largely unfruitful. This caused us to revise our initial expected amount from \$1500 to only about \$300. However, we did receive several donations and pledges of donations. Finally, since the team did not fully understand the patent process we had difficulty filling out the patent application.

Results

Active

From our first pool test we found that using the vibration device was very effective in letting the swimmer know when they were approaching the wall. The blind swimmer that we tested it with liked it because it allowed him to feel and hear the vibration. He said that he would not like using headphones because it would take away one of his senses. Therefore, this showed us that the vibration output would be very effective for our device. We also tested location of the vibration on the body and from this, we have found that it is easier for the swimmer to feel it on their upper back compared to their lower back, although further testing is necessary.

We have also established a relationship with cypress software; they develop microcontrollers and all of the software to program them. We were able to get them to donate 15 PSoC Microcontrollers of a retail value of over \$7500. With these, we will be

able to take that output signal and vary when we want to turn the vibration on. We can also use these controllers to do many other functional requirements that we may have later in the device. This relationship is very valuable to the further development of the device, offering support of the programming and circuitry.

We also analyzed the existing circuit of the dive scan device. Although the device is complicated and the manufacturer would not share information on how the system works we were able to establish a method of comparing the distance returned by the device and output the signal to a swimmer. The output of the dive scan device sends a signal to a LCD screen through twenty pins. The waveform present at each of these pins changes with changing distance from an obstacle. Several pins were chosen that cross a voltage threshold at approximately five feet from the pool wall. These were connected to the input pins of a Cypress Semiconductor Programmable System on Chip (PSoC), generously donated by Cypress. The PSoC was programmed using PSoC Express to compare these input voltages to a preset level. Once the device reached a distance of approximately seven feet from the wall, the voltage threshold was crossed and the PSoC output a voltage, which triggered a transistor switch and activated the vibration motor.

The team constructed a functioning device, which was our main objective at the beginning of the semester. The device was tested in the pool and as it approached the wall, a vibration feedback signal was triggered. The device needs to be further developed, but after two previous semesters of unsuccessful attempts, the current team has created a solid prototype for subsequent teams to develop further.

Passive

Through testing and development, the passive device team produced two new versions of the passive swimming aide. The team targeted two areas for redesign, the connections of the tappers to the main line, and the problems of the end tappers. The second redesign addressed several areas considered problematic during the first pool test.

The team tested two different tapper connections, both of which proved better than the first ones. However, the PVC “T” connectors seemed to be work better. They also eliminated all of the problems identified with the previous version. They were more

stable in the water, which means that the swimmer could swim through them with no trouble at all, and then the tapper would return to place at 90 degrees from the lane line.

The end of lane tapper designs developed for the second pool test proved to be more effective than those used previously. These end of lane tappers use materials of different texture than the tappers in the rest of the device. The swimmers were able to notice these much more than previous designs. Future teams should build upon these results.

The team has developed a solid design. The swimmers who tested the device responded positively. The device progressed throughout the semester and the team made positive changes to the previous IPRO team's work. It is felt that the design is practical and useful to the visually impaired swimming community. To further develop the device additional tests should be conducted to widen the number of variables of those testing the device and extended testing should be conducted to determine how the device functions over a longer period. From these duration tests a viable, marketable product can be developed.

Research

The research sub-team's main function was to find and interview blind and visually impaired swimmers and recruit them for our swim tests during the semester. We conducted several interviews this semester. Additional design criteria were gathered from these interviews for the active and passive devices (i.e. size dimensions, preferred location on the body to install the device, preference of a tactile interface over an audio interface and a preliminary pricing). A significant result/deliverable from our sub-team is the production of thorough reports of all the data that was collected over the semester. Each interview was transcribed and then analyzed and compared to the others to find similarities between answers.

Another interesting aspect of our sub-team was that we helped the active and passive teams with some of their research so that they could better focus on the major problems they needed to overcome. In other words, the other sub-teams outsourced their indirect research to us. By doing this, we were able to contribute more directly to the making of the devices.

Recommendations

Active

The first and most important next step will be to make a new casing that is waterproof and more suitable for the swimmer. The case will also have to be easily accessible to get at the batteries and adjust the circuitry as needed. Another big improvement would be to add multiple transducers to the design in order to allow the swimmer to know where objects are to their sides. These transducers could pick up the lane dividers and allow the swimmers to adjust themselves to stay swimming in a straight line. Other improvements could be to make the device smaller, and make the strapping more comfortable and adjustable. In the future, we also need to replace the three nine volt batteries with an easily interchangeable battery pack separate from the circuit components. Other improvements could be done to the circuitry itself, it might be helpful for the swimmer if the force of the vibration increased as they are nearing the wall to allow them to get a feeling of exactly how far away from the wall they really are. In addition, the range of the device could be improved, especially for in the pool. Some ways of doing this would be to use transducers with a narrower cone angle or modify the existing transducer by adding a cone to focus the transmission in a straighter line. In addition, there is a great deal of user features that could be added, primarily an on/off switch on the outside of the casing. Other functions could be added such as variable output strengths or vibration patterns, variable distances from the wall that the swimmer is alerted at, and a low battery alert. Through all of these improvements and new design ideas we hope to produce a product that blind swimmers will be enthusiastic about and feel safe using.

Passive

The team kept an engineering notebook that contains any design ideas, documentation on these ideas and recommendations for future semester teams. A few of the recommendations include purchasing clamps for the Tapper connections. This will

make the device much sturdier and someone will not have to be in the pool to reattach any parts that fall off the device. The team is also recommending a few different end of lane tapper ideas to the spring 2008 team. The spring 2008 team has a great start on a device that could be ready for endurance testing by the end of next semester.

Research

For the next semester, there are several responsibilities that the research sub team will have to be in charge of. These include, finding more blind swimmers to interview and to participate in our pool tests. This will enable the team to get a better understanding of the problems they are working on and give them more insight on what preferences the blind and visually impaired swimmers have for the devices. In addition, the team will start looking into the prospects of compiling a business plan for the two devices. We have put together a team of four business majors at IIT to adequately take care of this responsibility. In addition, the team will explore other fund raising options because of the high cost of building the passive as well as active device.

References

- Cypress Software (Corey Wilner)
- All of the blind swimmers
- RJE International (Dive-Scan)
- Physics 300 book
- Online Data Sheets

Acknowledgements

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