Vision Impair Swim Aid

Design Document

Team 5
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Executive Summary

Development Standards & Practices Used

- For prototyping
  - Arduino (Programmed in C)
  - IR sensors
    - Sharp GP2D12
  - Ultrasonic
    - Parallax PING)))™
    - MaxBotix MB7072-200
  - Vexilar sonar

Summary of Requirements

- All components waterproof
- Device should be completely operable by blind and vision impaired users
- Device should detect the user when they are near the end of the
- Device should warn the user when they are near the end of the pool

Applicable Courses from Iowa State University Curriculum

- CPR E 288
- EE 224/324
- EE 201/230
- EE 321
- EE/CPR E 185
- COMS 327

New Skills/Knowledge acquired that was not taught in courses

- Using sensors in water
- Researching commercially available parts/devices

Table of Contents

List of figures/tables/symbols/definitions (This should be the similar to the project plan)

1 Introduction

1.1 Acknowledgement

Our advisor, Lee Harker, is the overall manager of the project and all the products being purchased have to be confirmed and funded by the ETG.

1.2 Problem and Project Statement

Problem

Swimmers who are visually impaired cannot see the lines at the bottom of the pool to tell a lap swimmer when they are close to the wall. Because of this, those who cannot see the lines are forced to have assistance from another person who taps them on the head with a stick when it is time to turn around. This forces the visually impaired to have to work around other's schedules to find time to swim.

Project Statement

To allow visually impaired people to be able to swim without other's assistance, we set out to create a device that would allow the swimmer to go on their own time. This device will tell the swimmer when they are getting close to the edge, so they know to turn around. We plan to create a device that will be easy to set up and takedown, and accommodated for visually impaired people.

1.3 Operational Environment

– The headphones and radio receiver on the swimmer will be used for extended periods of time it the chlorinated pool water. They will need to be completely sealed and waterproof. They will need to be able to withstand the effects of any chemicals in pool water. They will need to be powered by a rechargeable battery that can power them for the duration of a swim.

– The control box(es) and sensors will be placed at the ends of the pool. They may be used in both indoor and outdoor pools. They need to withstand splashes from the pool, the humid climate of an indoor pool,

1.4 Requirements

- All components waterproof
- Device should be completely operable by blind and vision impaired users
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1.5 Intended Users and Uses

The intended user would be vision impaired lap swimmers. We are designing this product to help vision impaired lap swimmers know when they are getting close to the edge of the pool so they

could turn around before hitting their head while at the same time not having two other people tap their shoulders when they get close.

1.6 Assumptions and Limitations

Assumptions

- The product will only be for vision impaired lap swimmers
- The product will have two sensors on each side of the pool
- Product is used in an indoor swimming pool

Limits

- Vision impaired and blind people will need to be able to use it
- Need sensor on both ends to detect swimmer, otherwise pool length is too long
- The system needs to be wireless and operate in wet conditions
- The system needs to be battery powered

1.7 Expected End Product and Deliverables

The end products are going to be:

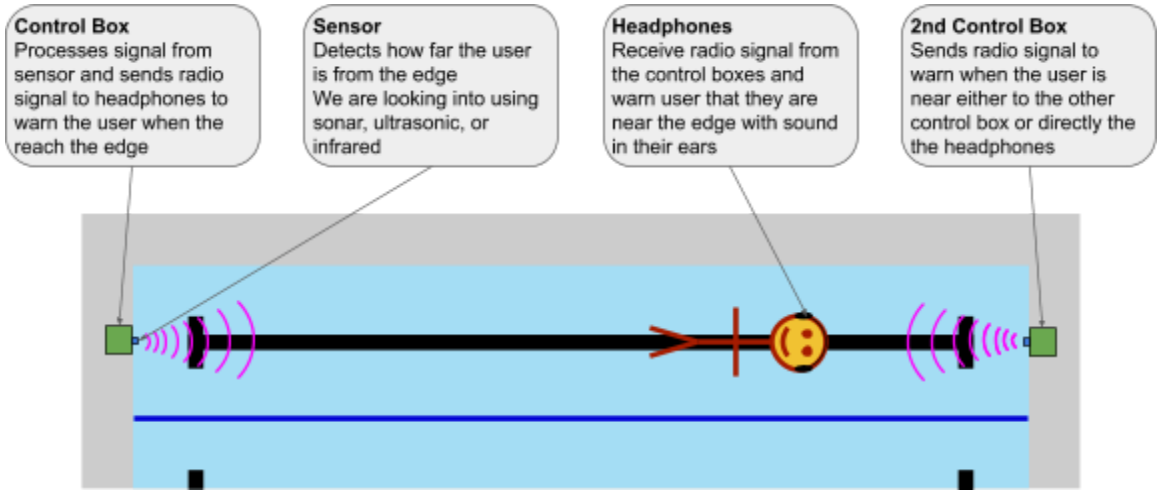
- 2 Control Boxes with sensors attached
- Wireless headphones for the user
- Sensor Selection
    - For this project we will need to find a sonar that is compatible with water and also has a range far enough to sense the swimmer before they are too close to the wall.
- Control Box
    - Once we have the sensors that we want we are going to use, we will start to build and program a control box that will communicate to the device on the swimmer and the sensor at the other end of the pool.

2. Specifications and Analysis

2.1 Proposed Design

The first thing we did in our design process was to come up with a high level overview of the whole system. The overview is shown below in Figure 1.

Figure 1: Overview of the System



The two control boxes will all the signal processing and communicate to the swimmer via headphones.

2.2 Design Analysis

– We started off by going to the pool to test the different sensors

– Different types of sensors like IR and Sonar are used to test how they react to the swimmer on the surface of the water

– The first sensors we used from the ETG

– The microcontroller that is being used is the Arduino Uno

– After we get a good tracking of the swimmer, then we can focus on the communication from the control box to the swimmer

2.3 Development Process

It is hard to imagine how disabled people go about their everyday needs. We met with the Student Accessibility Services office here at Iowa State to reach out to members in our community that are disabled. We want to determine some norms that vision impaird swimmers might follow. Our goal is to make our product as user friendly as possible. After we establish some procedures that need to be followed, then we just need to get the system to work.

2.4 Design Plan

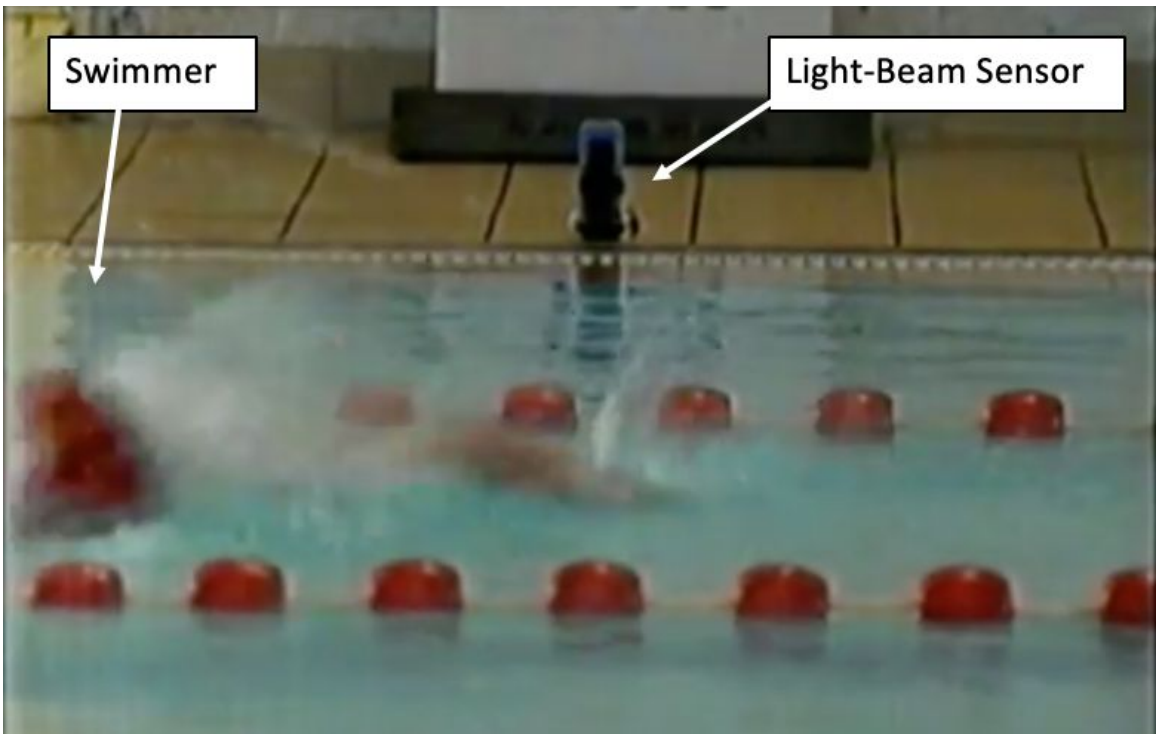
Describe a design plan with respect to use-cases within the context of requirements, modules in your design (dependency/concurrency of modules through a module diagram, interfaces, architectural overview), module constraints tied to requirements.

We plan on designing this product to have a control box on one end of the pool and it will communicate with another sensor box and the device on the swimmer.

3. Statement of Work

3.1 Previous Work And Literature

In all of the research we have done, we have only found one product that has a similar concept as ours. In 2009 a group created a device called AquaEye. The device has the same idea of tracking a vision impaired swimmer and then sending them a signal via headphones so that they know where they are located in the pool. The way that they track their swimmer is with a light beam, and when it gets broke the digital signal is sent back to the processor. In our product we are trying to get the specific distance of the swimmer away from the wall. With the light beam, it limits which lane the swimmer can use because it has to be placed on the outside of the pool lane. Figure 2 below shows the limitations of their device.



If their product is used as shown above then no one would be able to swim in the lane closest to the sensor otherwise it would alter the performance of the device.

3.2 Technology Considerations

The strength of our device is that it will be able to function no matter what lane the user is in. With this advantage given to the user, it makes tracking the swimmer more difficult. We need to be able to detect the swimmer no matter where they are at in the lane, but we can't get any interference from the neighboring lanes, otherwise it will alter the performance of our device. There are always negative side effects to improving the functionality of an already thought of idea.

3.3 Task Decomposition

For this project we have split it into tasks which include: find sensor and find communication. Within the find sensor we want to research, test, and conclude if the sensor will work and continue this process until we find a sensor that would work for the project. Then for finding communication we want to do the same thing but need to find a transmitter that will work underwater and can be connected to a pair of headphones that would allow us to tell the swimmer when they need to turn.

3.4 Possible Risks And Risk Management

One concern that we have is with the waterproofing so that the electronics do not shock anyone swimming since the sensor might have to go into the water. We also are worried about finding a sensor that works since we have not been getting good test results. Then we have a little concern that we won't be able to find earbuds that are completely waterproof.

3.5 Project Proposed Milestones and Evaluation Criteria

Key Milestones:

- Finding consistent sensors for detecting the location of swimmer in the pool
- Choosing a transmitter and receiver for signal to the swimmer to tell when to turn around
- Interfacing all of the components to work together
- Creating a final product that will be easy to set up and consistently works

Tests:

- To confirm we have them working, test components out of water
- Get components working in the water reliably
- Reach out to a blind swimmer to test functionality
- Confirm that product works with all different strokes

3.6 Project Tracking Procedure

We have been tracking our progress this far with our weekly reports and presentations given to the instructor and our client. These reports have in-depth explanations that each of our team members

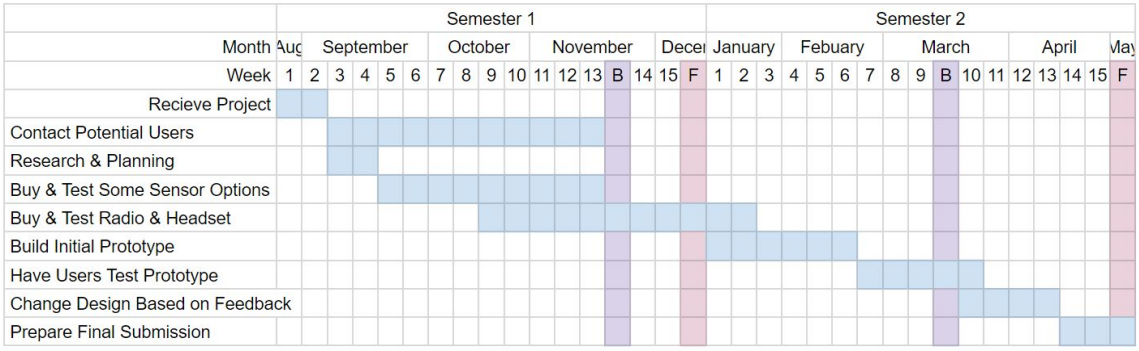
have accomplished along the way. To make sure we are on track, we are using a timeline found in section 4.1.

3.7 Expected Results and Validation

The desired outcome for our project is to create a device that allows a swimmer with visual impairment to be able to detect the end of the pool before running into the wall using sensors and wireless communication devices. We will confirm the successful implementation of our device by first testing our device with a team member either wearing a blindfold or keeping their eyes closed while swimming. After we believe the device works reliably, we will have visually impaired swimmers try the device themselves.

4. Project Timeline, Estimated Resources, and Challenges

4.1 Project Timeline



4.2 Feasibility Assessment

At the end of the project, we plan to have a working device that can help a vision impaired person to know when they reach the end of the pool. We think that this is a feasible goal. There are some potential challenges we may face in reaching this goal. We may not find a sensor that works as well as we hope. We may have stuff break due inadequate water resistance.

4.3 Personnel Effort Requirements

Task	Description	Estimated Hours
Contacting Potential Visually Impaired Users	Reaching out to visually impaired community members, ideally who are also swimmers, to learn more about the challenges they face and specifications for our project that we may not have known/thought of.	30 Hours

Research and General Planning	Brainstorming design ideas and evaluating the potential implementation of those ideas.	40 Hours
Sensor Testing	Testing swimmer detection sensors in a pool to determine what sensors will be ideal for our application.	60 Hours
Communications Testing	Testing devices to communicate with the swimmer when they are near the end of the pool.	20 Hours
Prototype Assembly and Internal-Testing	Integrating our chosen sensor and our communication devices into one system. Testing our system with team-members simulating vision impairment.	40 Hours
Design Revision and User-Testing	Getting feedback from our targeted users and making revisions based off of their feedback.	30 Hours

4.4 Other Resource Requirements

The sensors used to identify the swimmer's location that we have tested so far are the XL-MaxSonar sonar sensor and the Sharp GP2D12 IR sensor. We plan on testing various scenarios with each sensor to decide which gives us the most accurate data. Committing to the sonar sensor will require 2 units for each end of the pool while committing to the IR sensor may require 4 units, 2 for each end of the pool. We are using the Arduino system to interpret sensor data and send a signal to a communication device. The communications device we are using is a waterproof FM radio bud headset (Walkercam S1 MP3 player with FM radio) that will receive FM radio signal from a transmitter (Adafruit Stereo FM Transmitter) connected to the Arduino device.

4.5 Financial Requirements

We will need approximately $500 to complete this project for purchasing the various sensors and other devices.

5. Testing and Implementation

1. Define the needed types of tests (unit testing for modules, integrity testing for interfaces, user-study for functional and non-functional requirements)

We had to start by testing different sensors including sonar and IR sensors. We tested how they reacted to the water and if they could detect a swimmer in the water. We needed to test if with different swimming strokes and if the swimmer was to one side or the other from the sensor.

2. Define the individual items to be tested

We needed to test IR and sonar sensors and FM headphones and FM transmitters that both need to be waterproof.

3. Define, design, and develop the actual test cases

To begin we wanted to test how the sensors reacted to water so we took them to the pool and had someone swimming to see what results we would get. Then once we knew alittle more about the sensors we went to the pool and recorded the data as some one swam back and forth past then from that data we could use it along with having the swimmer swim to the side of the sensor.

4. Determine the anticipated test results for each test case

We thought that the sonar sensor would work better with the water.

5. Perform the actual tests

6. Evaluate the actual test results

IR sensor detected swimmer but the distance it detects the swimmer depends on the angle of the sensor.

7. Make the necessary changes to the product being tested

8. Perform any necessary retesting

9. Document the entire testing process and its results

Include Functional and Non-Functional Testing, Modeling and Simulations, challenges you've determined.

The first time we went to the pool to do testing we weren't sure what the IR sensor was going to give us for data so did not have a test setup, but then we went back with test that were better planned.

5.1 Interface Specifications

We plan on using an IR/sonar sensor to detect the swimmer that will send a signal to an arduino that will send a signal through an FM transmitter to FM headphones on the swimmer that will tell them when they need to turn.

5.2 Hardware and software

In the testing phase we used the sonar and IR sensors with the arduino connected to a computer , which we needed to see the output from the sensors. We will also need all that to test the FM headphones under water to see if the FM headphones can receive the signal underwater.

5.3 Functional Testing

Examples include unit, integration, system, acceptance testing

5.4 Non-Functional Testing

Testing for performance, security, usability, compatibility

5.5 Process

– Explain how each method indicated in Section 2 was tested

– Flow diagram of the process if applicable (should be for most projects)

5.6 Results

– List and explain any and all results obtained so far during the testing phase

- – Include failures and successes
- – Explain what you learned and how you are planning to change it as you progress with your project
- – If you are including figures, please include captions and cite it in the text

• This part will likely need to be refined in your 492 semester where the majority of the implementation and testing work will take place

-**Modeling and Simulation**: This could be logic analyzation, waveform outputs, block testing. 3D model renders, modeling graphs.

-List the **implementation Issues and Challenges**.

6. Closing Material

6.1 Conclusion

Summarize the work you have done so far. Briefly re-iterate your goals. Then, re-iterate the best plan of action (or solution) to achieving your goals and indicate why this surpasses all other possible solutions tested.

6.2 References

This will likely be different than in project plan, since these will be technical references versus related work / market survey references. Do professional citation style(ex. IEEE).

6.3 Appendices

Any additional information that would be helpful to the evaluation of your design document.

If you have any large graphs, tables, or similar that does not directly pertain to the problem but helps support it, include that here. This would also be a good area to include hardware/software manuals used. May include CAD files, circuit schematics, layout etc. PCB testing issues etc. Software bugs etc.

Sources

https://www.youtube.com/watch?v=qKPErSn6SGs