the g**EE**k squad

Spring Plan

Presented on
November 30, 2006

Michael Cozzolino
Colleen O’Hagan
Elizabeth Reed
Andrew Williams

Table of Contents

1 Overview

Initially we had decided to use an RFID method to solve our problem of locating a blind swimmer approaching a wall and signaling them to turn. The benefit of this method was that technologies already existed to sense and signal the swimmer. However, while we were initially led to believe that this technology would work in our desired environment, we have found out that this is not the case. As is such, we have reevaluated our problem and taken a more quantitative look at the types of sensors we could use and the factors that are critical to the success of our system.

Sensor Type Pugh Matrix

Factor	**Weight**	**Sensor Type:**	*RFID*	*IR*	*Ultrasonic*	*Thrubeam*
Cost	5		-1	1	-1	-1
Underwater use	5		-1	1	1	1
Accuracy	3		0	0	0	0
Range	5		0	0	1	1
Size	3		1	1	1	1
Ease of Use	3		1	1	0	1
Tunable	1		1	1	1	-1
		Total:	**-3**	**17**	**9**	**10**

- We do not want any specific component of the product to consume most of our budget so cost is an important factor when considering sensors.
- The device must operate in and around water, so this is crucially important.
- The safety of the user is relying on the operation specifications so we want to have an accuracy of +/- 15 cm. We also would like to ensure this at a rate of .99.
- The range must be comparable to the length of a human arm.
- The size of the device on the swimmer cannot be large because it would interfere with the swimmer's performance.
- Because the swimmers will not have visual capabilities, the design must be easy to operate without looking at it.
- To apply to a broad spectrum of swimmers, the detection should be adjustable based on which distance from the wall a particular swimmer prefers to turn at.

These criteria have led us to work with Infrared Sensor systems. The following is our plan to implement the design.

2 Sensing the Swimmer Subsystem

To solve the problem of sensing the swimmer in the pool we have decided to use infrared sensors. Starting in the spring semester up until February 28, we will develop, build, and troubleshoot this sytem. By February 28, we will be able to accurately and consistently detect the presence of a swimmer at a specific point in the pool. At this point we will also have a better idea of how tunable the device is and the best method to tune the sensor to the swimmer's specifications.

2.1 Parts ordered

We contacted Professor Bauer and spoke with him about what type of infrared sensors would be appropriate for our solution. He feels that passive infrared sensors (PIR, also called pyroelectric sensors) would be our best option and recommended a company from Switzerland, Kube

Electronics. Kube has agreed to send us samples of their products. We will receive two of each the C172 Standard pyroelectric sensor and the 6192 flat pack pyroelectric sensor. We will also order a few other PIR sensors and an IR transmitter and receiver from Electronics123 to test. The part numbers from Electronics123 are: MK120 for the transmitter/receiver package and BB083 for the RE200B type PIR sensor.

2.2 Develop and Build Test Circuit for Sensors

We will need to design and build a circuit to test the IR sensors. This circuit will need to interface with the IR sensor and output a signal when the sensor detects the presence of a person. To get a signal that is not very noisy, we will need to use a comparator (op-amp) and a low pass filter. The PIR sensor has three pins: V_{dd}, Ground, and an Output signal. When it does not sense IR radiation, the output is as if there is an open circuit. When it does sense radiation, the output is pulled up to V_{dd}. For the circuit, the output must first be connected through a resistor to ground so that when it is not sensing the output will be pulled to ground. The output will then go directly to one of the inputs of the comparator and through a low pass filter to the other input of the comparator. We will need to choose two resistors, a capacitor, and an op-amp to make the circuit. Once these are chosen, we will build the test circuit on a breadboard.

Start Date: January 16

End Date: January 24

2.3 Test IR Sensors Out of Water

Once we have built the test circuit, we will be able to test the different IR sensors out of the water to determine which is best. We will base our decision on the criteria we have predetermined and evaluations we will make with the Pugh matrix. These factors are similar to those we used in choosing a sensor type. To test the sensors out of the water, we will view the output of the comparator on an oscilloscope for several different scenarios (person walking toward the sensor, person walking away from the sensor, etc.). We will also test the dependence of the response on applied voltage and pitch of the sensor to determine the tunability of the system. Once we have fully characterized the IR sensors for a person out of the water, we will move on to characterize the sensors for a person in the water.

IR Sensor Pugh Matrix

Factor	Weight	Sensor	*C172*	*6192*	*MK120*	*BB083*
Operation in water	5					
Small	3					
Range	5					
Accuracy	5					
Precision	5					
Tunable	1					
Cost	1					
Ease of Implementation	3					
		Total:				

Start Date: January 25

End Date: February 2

2.4 In-Water Test and Calibration

We will need to waterproof our circuit at this point in a very simple way (perhaps enclosed in a plastic bag with a small opening for just the window of the IR sensor). We will need to bring the circuit and sensors to Rolfs Aquatic sensor and extensively test the sensor to discover how and when a person is sensed as they are approaching the wall. We will need to systematically determine the sensed distance versus pitch and sensed distance versus voltage characteristics of the sensor to find out the appropriate configuration of the sensor on the side of the pool. We must verify that the response is accurate and precise to within our specifications. Once we know that we can sense a person at a specific distance we must also consider shielding the sensor so that only one lane is targeted. Calibrating the sensor to fit the pool will take much trial and error to obtain an acceptable configuration.

Start Date: February 5

End Date: February 28

3 Vibration Motors

Since auditory signalling of the swimmer is strictly prohibited in not only competitive swimming but also practice, we have decided to alert the swimmer with a vibrating device. We have researched several vibrating motors and by January 23, we will have ordered, tested, and decided on the particular vibrating motor and vendor that we will utilize in our system.

3.1 Parts ordered

We have researched several different types of vibrating motors online and have found two main types that we are interested in using. The first type is a tiny motor with an offset weighted shaft. The way this motor works is simple. A voltage of 1.5 – 3.0 V_{dc} at 62 mA is required to run the motor. When applied, the offset weighted shaft will spin, causing a vibration. This motor is 0.24" diameter x 0.5" long. It is used in cell phones and pagers and the small size would be advantageous for our system. We have sent an email to All Electronics Corp. requesting samples which we would be able to test, but have not heard back from them yet. If we have not received any response by December 5, we will order a few since they are only $1.25 each.

The second type of motor is a DC coin vibrating motor. The operation of this motor is similar to the first; however, it is in the shape of a coin. This motor operates at a voltage of 2.5 – 4.0 V_{dc} at 85 mA max. This is a little higher than our first option but is still a very small amount. The advantage of this motor would be its shape. Because it is flat, it would cause less resistance and discomfort to the swimmer. This motor is 12 mm in diameter and 3.4 mm thick. The only disadvantage of this motor is the vendor, Chongqing Linglong Electronic Co., is located in China.

3.2 Develop and Test Circuit Out of Water

After we have developed an appropriate circuit, we will be able to test our different vibrating motors. We will begin by testing them out of water. We will send a signal (voltage) to the vibrating motors and make sure that they operate correctly. We will also be able to determine the voltage and current needed to power the different motors and decide, based on these tests and the sizes of the motors, which will be the best to incorporate into our system. Once this is completed, we can integrate this with the communication subsystem and work on an encasing to attach to the swimmer. We will choose the motor typed based on success factors.

Vibrating Motor Pugh Matrix

Factor	Weight	Type	*Offset Weighted Shaft*	*DC Coin Motor*
Small	5			
Vibration Strength	3			
Power needed	3			
Gradient	1			
		Total:		

- This will be a part of the device the swimmer wears so size is an issue.

- We want to be sure that the swimmer will feel the device's alert as they are performing stokes and creating turbulent water.
- The motor may need a power supply, this must be reasonable for the swimmer to wear in water.
- It may be desirable to adjust the strength of the motor's vibration for different alerts to the swimmer.

Start Date: January 16

End Date: January 23

4 Signaling the Swimmer Subsystem

4.1 Pick Communication Scheme

To communicate to the swimmer that they have reached the desired point we will need to transmit a signal and activate the vibrating motor. The transmitter/receiver scheme does not need to be incredibly sophisticated. We only need it to send one kind of information, a signal that will activate the buzzer. We are considering the following options: RF and Ultrasonic transmitters and receivers. Professor Schafer already has a few types of RF transmitter and receivers we can work with. We will need to order ultrasonic parts. We must determine which type of transmitter and receiver scheme we'd like to use based on three main factors.

Communication Scheme Pugh Matrix

Factor	**Weight**	**Type**	*RF1*	*RF2*	*Ultrasonic*
Small Receiver	5				
Behavior near water	5				
Cost	3				
		Total:			

Deadline: January 17

- The receiver should be small because it will be a part of the headpiece worn by the swimmer and we are keeping this small to reduce drag effects.
- The behavior of the system near water is critical to its values as it not be useful if it cannot transmit to a swimmer in the pool. It also must be something that is protected in the wet environment.
- The cost of the scheme is slightly less important, but we do not want it to dominate the price of our system.

4.2 Identify Voltage Change-Plan

The signal from the IR sensors will be manipulated in such a way that a microcontroller will receive input as a change in voltage when the swimmer is sensed. The microcontroller must determine if the change it sees is the rising or falling edge of the signal. It should also be able to determine if the swimmer is coming or going.

Start Date: January 17

End Date: February 9

4.3 Identify Voltage Change-Test

To test if the microcontroller is programmed correctly we will use a function generator to input a signal with a voltage change similar to that it would receive from our circuit. We will study the behavior of the microcontroller and make adjustments if necessary.

Start Date: February 12

End Date: February 16

4.4 Transmitter Communicate with Receiver

The transmitter to receiver communication is what allows the swimmer to be alerted. To test that our scheme is operating we will activate the transmitter with an external stimulus. The receiver will ultimately be connected to a transistor which it will switch to provide voltage to the vibrating motor. In this test we will have the receiver connected to a transistor and observe if the output from the transistor changes.

Start Date: January 18

End Date: February 9

4.5 Receiver to Buzzer Activation

The receiver switching a transistor will lead to buzzer activation. After we can activate the receiver we can develop and test a circuit to provide a voltage to the vibrating motor to power it.

Start Date: February 9

End Date: February 16

4.6 Integrate Detection and Transmission

The final step to complete the signaling subsystem is to link the pieces from the microcontroller detection to the motor vibration.

Start Date: February 19

End Date: February 28

5 Post Subsystems

Once we have successfully completed the design of our subsystems, we will have approximately two months for the remainder of the project. This will include several different steps.

5.1 Refined Encasing on Swimmer

After we have developed our circuit and tested our vibrating motor, we will need to build an encasing for the receiver, motor, and circuitry. This encasing will be located on the swimmer so there are several considerations we will need to take into account.

Encasing Pugh Matrix

Factor	Weight	Type				
Shock durability	3					
Impervious to water	5					
Weight	1					
Drag	3					
		Total:				

- This encasing must have optimal durability to shock. The location of the encasing will be on the swimmers cap. When the swimmer dives into the water, the encasing must be able to withstand the shock that such a dive will incur.
- It must also be waterproof. It will contain electronic circuitry which can be dangerous for the swimmer if water comes into contact with it. It can also cause defects in the system if exposed to water.
- Finally, it must be small in weight and size. It will be uncomfortable for the swimmer if it is too heavy and will cause drag, slowing down the swimmer, if it is too large.

Start Date: March 1

End Date: March 16

5.2 Integrate Subsystems

We will have two main subsystems and the vibrating motor circuit to put together. The two main subsystems are the sensing and the communications systems. We will need to have the sensor detect the swimmer, which will then send a signal (voltage spike) to the communications system to detect and in turn, send a signal to the vibrating motor circuit located on the swimmer. This circuit will take the signal and power on the vibrating motor to alert the swimmer of their proximity to the wall.

Start Date: March 1

End Date: April 2

5.3 User Interface and Final Product Build

This is an important aspect of our final project. Since the majority of users will be sight-impaired, it is essential to have a user-friendly interface for our product. After we have integrated the sensor and communications subsystems by building a board, we will need to create a simple interface for the user. The main option for the user will be tuning of the sensor. Different sized swimmers will need to adjust the sensor so that it will alert them at different proximities to the wall.

Start Date: April 3

End Date: April 10

5.4 Final Testing

After the project has been completely built with all the subsystems working together, it will need to have extensive testing. We will begin testing simply by having a swimmer use the system in the water. The final test will be done by having the swimmer wear blacked-out goggles so that he is completely relying on our system.

Start Date: April 11

End Date: April 25

5.5 Filming and Documentation

The final step in our project will be to film our system being used and write all the documentation necessary. Since this is not a project that can be demonstrated in a classroom, we will need to film our system being used in the pool so that we may show the video during our presentation.

Start Date: April 26

End Date: May 2

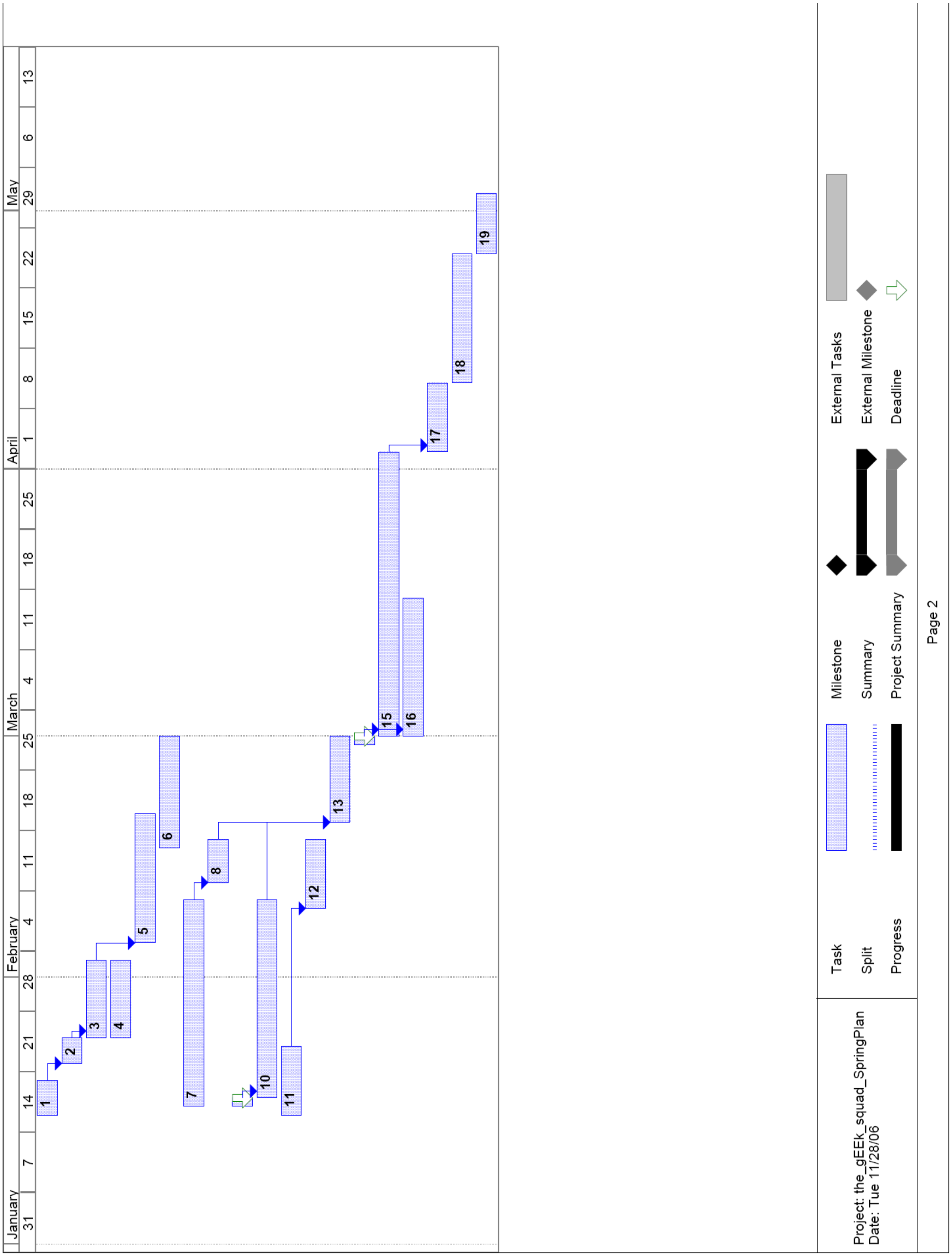
Appendix A: Gantt Chart

ID		Task Name	Duration	Start	Finish	Owner	Dep
1		Develop test circuit for IR sensors	4 days?	Tue 1/16/07	Fri 1/19/07	Beth	
2		Build test circuit	3 days?	Mon 1/22/07	Wed 1/24/07	Beth, Mike	1
3		Test IR sensor out of water	7 days?	Thu 1/25/07	Fri 2/2/07	Beth, Mike	2
4		Determine best method for tuning	7 days?	Thu 1/25/07	Fri 2/2/07	Beth, Mike	
5		Test IR sensor in water	11 days?	Mon 2/5/07	Mon 2/19/07	Beth, Mike	3
6		Calibrate sensor for pool	9 days?	Fri 2/16/07	Wed 2/28/07	Beth, Mike	
7		Plan and implement detection of voltage change	18 days?	Wed 1/17/07	Fri 2/9/07	Drew	
8		Test detection of voltage change	5 days?	Mon 2/12/07	Fri 2/16/07	Drew	7
9		Pick transmission receiver scheme	1 day?	Wed 1/17/07	Wed 1/17/07	Colleen	
10		Transmitter communicate with receiver	17 days?	Thu 1/18/07	Fri 2/9/07	Colleen	9
11		Test and choose vibrating motor	6 days?	Tue 1/16/07	Tue 1/23/07	Mike	
12		Receiver actuate vibration	6 days?	Fri 2/9/07	Fri 2/16/07	Colleen	11
13		Integrate detection and transmission	8 days?	Mon 2/19/07	Wed 2/28/07	Drew, Colleen	8,10
14		Subsystems Complete	1 day	Wed 2/28/07	Wed 2/28/07	Team	
15		Integrate Subsystems	23 days?	Thu 3/1/07	Mon 4/2/07	Team	14
16		Design encasing	12 days?	Thu 3/1/07	Fri 3/16/07	Beth, Colleen	14
17		Build system	6 days?	Tue 4/3/07	Tue 4/10/07	Drew, Mike	15
18		Final Testing	11 days?	Wed 4/11/07	Wed 4/25/07	Team	
19		Filming and Documentation	5 days?	Thu 4/26/07	Wed 5/2/07	Team	

Project: the_gEEk_squad_SpringPlan
Date: Tue 11/28/06

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Page 1


January
February
March
April
May
31
7
14
21
28
4
11
18
25
4
11
18
25
1
8
15
22
29
6
13
Project: the_gEEk_squad_SpringPlan
Date: Tue 11/28/06
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 2

Appendix B: Sensor Circuit