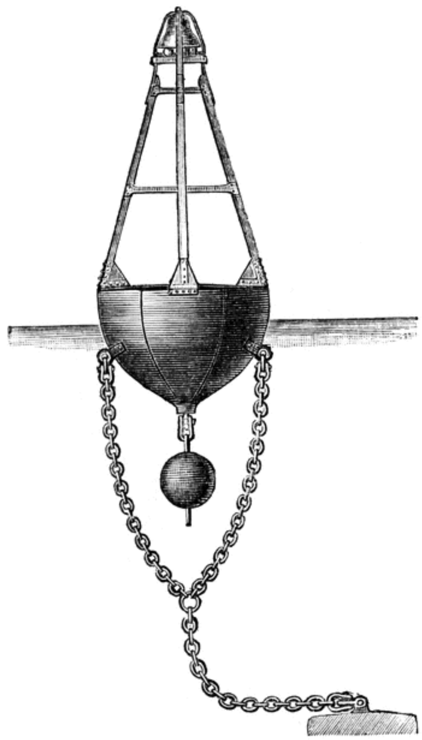

J.U.I.C.Y. Project Proposal

ELEC 4000

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Abstract

As a senior design project, a group of Auburn University students proposed a solution to drowning tragedies that occur frequently. One will find the motivation behind the team's project and how a solution was implemented. The students decided to first focus on a simple alarm system that could be implemented by the end of the semester, and if time permitted, focus on an alarm system that would become more useful by offering more live-saving attributes, rather than just signaling a distress call.

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1 Project Motivation

Drowning is often referred to as "The Silent Death" because there is often no cry for help or excessive splashing. With over 10 million residential swimming pools in the United States alone, it comes as no surprise that drowning is the leading cause of death for children under the age of 5 [1]. For every child that dies from drowning, an additional 5 children are treated each year for submersion accidents, many suffering permanent neurological damage [2]. Unfortunately, the horrors do not end there. Drowning is the most common source of death or injury for people suffering from seizures [2]. In addition, approximately 5,000 family pets are lost each year due to drowning [3].

2 Phase 1

The final project will be split into two phases. Phase 1 will be implementing a simple motion detection device. Phase 2 will be the device implemented in Phase 1, but better. Due to time constraints, our team wanted to choose a feasible task that could be completed by the end of the semester. Once our team completes Phase 1, and time isn't scarce, we can challenge ourselves by beginning Phase 2. Continuing with Phase 1 , there are measures that can be taken to prevent drowning tragedies. Constant supervision is, of course, the best option, but it never hurts to have backup measures in place. That's where J.U.I.C.Y. comes in. J.U.I.C.Y. is a little peace of mind that floats in your pool. With its durable outer shell and solar-powered battery, J.U.I.C.Y. can be dropped in your pool and forgotten. Unlike other similar products that only emit an alarm from the device itself or from a home base located somewhere nearby, J.U.I.C.Y. sends a notification directly to your phone. This simple but ingenious feature makes J.U.I.C.Y. ultra-portable, able to go from your pool to a friend's at a moment's notice. All you need is a WiFi connection.

3 Motion Processor Unit

An accelerometer will be needed to detect when a distress call should be signaled. Figure 1 shows the Sparkfun IMU Breakout MPU-9250 that will be used throughout this project, which features a 3-axis accelerometer. When an object of specific weight falls into the water, it causes water ripples of certain magnitude to spread throughout the water. A change in acceleration of the waves then causes an applied force on the MPU. This force causes a disturbance in capacitance between micro-structures within the MPU that is identified through internal circuitry [4]. Another feature of the Sparkfun MPU an inetgrated 3-axis gyroscope. The gyroscope can be helpful by identifying a specific change in angular velocity. By configuring the MPU onto a Raspberry-Pi microcontroller, an effective motion detection device can be achieved.

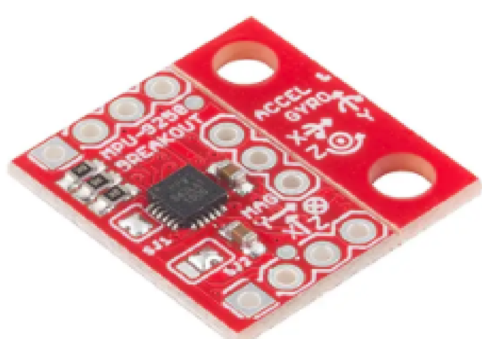

Figure 1: Sparkfun IMU Breakout MPU-9250 Board

4 Microcontroller

Like all engineering projects, our group needed a computer to handle our needs. The Raspberry Pi 3 is a programmable microcontroller that is compatible with the MPU we've selected. Figure 2 shows an image of the microcontroller. The features offered by the Raspberry Pi are exactly what our team needs to begin a prototype. Below one will find the features that attracted us the most [5].

- Cortex-A53 (ARMv8) 64-bit SoC
- Clock Speed: 1.4GHz
- 2.4GHz and 5GHz IEEE 802.11.b/g/n/ac wireless LAN, Bluetooth 4.2, BLE
- Gigabit Ethernet over USB 2.0 (maximum throughput 300 Mbps)
- Full-size HDMI
- 4 USB 2.0 ports
- Micro SD port for loading your operating system and storing data

Figure 2: Raspberry Pi

When it comes to the operating system, our team plans on using Ubuntu; an open-source Linux distribution. Our team comprises of two electrical engineers and five computer engineers, so navigating through the Linux terminal shouldn't be an issue. The team will also have the option to code in either C or Python. Because Python isn't a requirement in the computer engineering curriculum, this can be an opportunity for some of the team members to learn a new programming language.

5 Powering the Device

Our team plans to power our raspberry pi using solar power. The components we will use to do so can be found below.

- Lithium Polymer Charger
- Lithium Ion polymer Battery
- Powerboost 500
- Solar Panel

The Li/Poly charger would connect to the 2W, 6V solar panel. The charger has the charge current of 500 mA, but can be adjusted to anywhere in between 100 mA and 1000 mA by soldering a resistor. Charging is performed in three stages: first a preconditioning charge, then a constant-current fast charge and finally a constant-voltage trickle charge to keep the battery topped-up. The Charger is connected to a Li/Poly battery. This battery has a capacity of 2500mAh for a total of about 10 Wh, and the output ranges from 4.2V when completely charged to 3.7V. One of the outlets of the charger will be connected to the Powerboost 500 component. This little DC/DC boost converter module can be powered by any 3.7V LiIon/LiPoly battery, and convert the battery output to 5.2V DC, to run the Raspberry Pi. This hardware configuration can be seen in Figure 3 below.

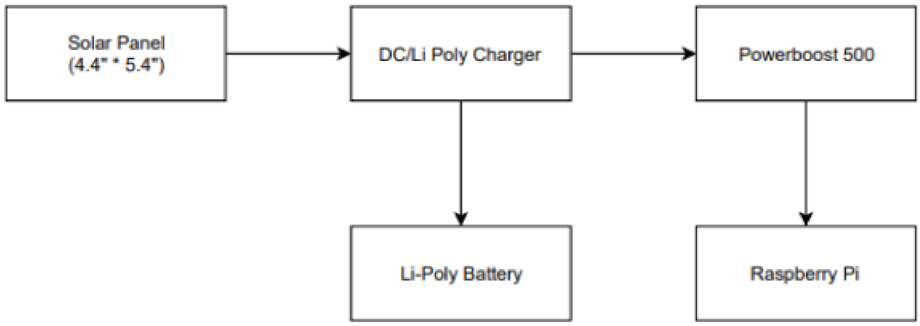

Figure 3: Power Flow Chart

6 3D Printing Materials

The casing of the pool alarm must be water-tight in order to prevent damage to the sensitive electronic components inside, buoyant, and durable enough to withstand day after day of sun and water exposure. So far the best option appears to be 3D-printing the case, but with which material? With all of the advances in 3D-printing technology, there are multiple types of plastic filament that appear to be viable options. Others, such as poly lactic acid (PLA) and polyvinyl alcohol (PVA), were quickly ruled out due to their intolerance to water.

Acrylonitrile Butadiene Styrene (ABS), stereolithography (SLA; also known as resin printing), and PETG, a glycol-modified version of Polyethylene Terephthalate are all still viable options. Unfortunately, no material appears to stand out above the rest at this point in time. Each plastic has several pros and cons, as laid out in Table 1 below.

Table 1: Comparison Printer Material

	ABS	SLA	PETG
Pros	Very sturdy Long lifespan Easy to process	Very economic High wear resistance	Recyclable Rugged Exceptional layer adhesion
Cons	Damages in direct sunlight Not biodegradable	More expensive Not suitable for outdoor use	Can be sticky Less resistance to scratches

ABS is by far the most popular option. It is used in most modern manufactured products, including LEGOs, keyboard keys, and the plastic face-guard on wall sockets [6]. It is reported to be durable, relatively inexpensive, and easy to process. However, many sources caution that ABS is susceptible to damage from direct sun exposure. Tests have yet to be run to determine the extent of the damage, so for now, ABS is still in the running.

SLA appears to be the most water-tight option as its very small layer heights almost eliminate the layer lines common among 3D printers [7]. Although SLA is friendlier to the environment and more resistant to wear and tear, it is more expensive. Despite its many great qualities, SLA may be off the table for the simple fact that it stretches an already tight budget.

PETG is another excellent choice, especially for water proof applications. PETG is commonly used to manufacture water bottles, and is chemically resistant so exposure to pool chemicals should not be an issue. It is reported to have a long lifespan, and is also recyclable. Although PETG is easily scratched, that appears to be one of its only drawbacks, making it a fantastic choice for J.U.I.C.Y. 's shell.

7 Product Testing

There are multiple factors to consider throughout the testing phase. Because it is unknown which factors will contribute to J.U.I.C.Y. 's performance, they must all be carefully monitored until they are ruled out. During the initial testing phase, the testing environment will be as controlled as possible in order to simplify matters. Once J.U.I.C.Y. is performing perfectly at this simplified level, one new obstacle at a time will be introduced in order to guarantee desired results for all possible conditions.

Initial testing will be conducted in an indoor pool in order to exclude interference from inclement weather. For the first several tests, J.U.I.C.Y. will be placed in the same location in the pool, and the simulated victim will be dropped into the pool at a nearby, unchanging location. After determining that J.U.I.C.Y. is operating well under these standard conditions, the location of the victim's immersion will be moved further away in small increments until J.U.I.C.Y. 's maximum range has been determined. In the next phase of testing, the shape, depth, and temperature of the pool will all be varied. Finally, outdoor elements such as wind and rain will be simulated to ensure that J.U.I.C.Y. still functions properly.

When conducting similar tests, the Consumer Product Safety Commission (CPSC) discovered that one to two year old children are at greatest risk of drowning in a home swimming pool. The weight of the average one year old child is eighteen pounds, which is the weight used by the CPSC in their product safety tests. However, the average child becomes mobile around the age of six months, which would decrease the absolute minimum testing weight to approximately sixteen pounds. In the future, J.U.I.C.Y. may be refined to detect disturbances caused by even smaller weights, such as that of a small dog.

8 Tentative Project Budget

One of the first rules of engineering is to make your product as cost efficient as possible. Everyone wants to save money, from the company designing the product, to the person buying the product, so sourcing reasonably-priced materials is high on the priority list. Our initial budget estimate fell somewhere between \$136.45 and \$181.45, as shown in Table 2 below. As with most initial estimates, it is anticipated that number will change as we refine our design over the life of the project.

Table 2: Proposed Budget

Quantity Needed	Item Description	Price (USD)
1	Solar Panel	\$29.00
1	DC/Lithium-poly Charger	\$17.50
1	Lithium-poly Battery	\$14.95
1	Powerboost 500	\$10.00
1	IMU	\$15.00
1	WiFi-Enabled Raspberry Pi	\$35.00
Unknown	3D-Printing Material	\$15.00 – \$60.00 per roll
	Total Estimated Cost	**\$136.45 - \$181.45**

This initial estimate is based off of a design with only one IMU; however we may need to add up to three more in order to achieve the desired sensitivity level. The 3D-printed shell is another price hurdle. It has yet to bet determined whether it would be more cost-efficient to print the shell ourselves or outsource that portion of the design. Factors to take into consideration include the types of 3D printers at our disposal and whether or not the printing material compatible with those machines would be an appropriate choice for our design.

Most surface pool alarms, such as J.U.I.C.Y. , are usually priced in the $150 to $200 range. J.U.I.C.Y. will have to be marketed within that price range to be considered a competitive device, which means that production costs will need to be reduced in order to maximize profit. Efforts will be made throughout the duration of the project to find the most cost-efficient materials that meet certain quality standards that have been set forth by the team.

9 Phase 2

The first phase of development ultimately aims to produce a simple, working prototype. The second phase instead aims to add more features to the prototype, or at least to noticeably improve the initial design. Assuming development in the first phase is successful, there are multiple directions for development that would significantly improve our system. The two main directions are the creation and integration of a first response system and improved detection capabilities using sensor fusion.

The design for a first response system can be made arbitrarily complex, and the speed of development later in the semester will determine the exact kind of system. An example of a simple system would be that of an automatically deployed raft. Using information from the sensors, the unit (or another unit that is activated) could place itself underneath the target and inflate itself. This would provide immediate and reliable safety, all while being among the simplest designs. More sophisticated designs could utilize networks of units to perform a rescue task in unison, as well as utilize other rescue mechanisms. For example, a first response system could be designed to coordinate a kind of mechanical "lift" that can attach itself to the target and lift it to safety (say the edge of the pool). While these kinds of designs are much more complicated and cross-disciplinary in nature, the simpler design will be attempted first. If time permits, various elements of the more advanced design (like the lifting mechanism) could be integrated with the design.

The other main direction of design objectives involves the integration of multiple sensors to greatly enhance the detection capabilities of the system. Some sensors ubiquitous to industry like lidar and sonar would provide localization assistance and target identification and tracking. Sonar systems have existed for a relatively long time, namely in the use of underwater navigation and intelligence systems in submarines. Lidar has been used extensively in recent times, namely in autonomous vehicles and ADAS (Advanced Driver-Assistance Systems) packages. The fact that these two sensors have had numerous, effective uses in tasks similar to those of our design show the potential for them to improve upon our design. Other simpler sensors exist and could be used to the same effect, such as optical and thermal cameras. The team has a relatively large amount of experience in signal and image processing, so the main candidates for sensor fusion are sonar and optical cameras.

While lidar, sonar, and cameras would improve the detection and tracking capabilities of the system, other types of sensors could make the system more useful in general. The addition of chemical and ecologically-motivated sensors could make the system marketable as more than a safety product. From inside the pool (or perhaps other types of bodies of water), the system could provide information about the weather, water health, and various information about the surroundings. With the rise of the IoT, products like this are invaluable not only to the consumer, but scientific and research agencies greatly benefit from the existence and development of such products. Because these kinds of sensors are decidedly independent of the tracking and detection technology, they could easily be integrated into the system, as their integration would not interfere with its primary functions.

10 Conclusion

Our team's primary goal is to have a functioning motion alarm device to demonstrate at the senior design fair, otherwise known as Phase 1. If time permits, our device will encompass attributes from Phase 2. Most importantly, our team would like the gain the experience of completing a real engineering task.

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Disposition

We, all members of the pool safety team, have all agreed to donate our widget to Auburn University for the purpose of inspiring a new age of engineering.

Approved: Marco Zuniga
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Joe Driscoll

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