Design Proposal: Rescue Dye Drowning Prevention Bracelet

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Project Proposal Overview

Introduction:

Every day, around ten people die from drowning. Of those ten, two of them are children under age fifteen (CDC). Unfortunately, drowning is often a silent act that goes unnoticed, giving the victim little to no chance of receiving help. A great way to combat this is a bracelet, that can be worn by swimmers of all ages, to alert bystanders and lifeguards if they are ever in danger of drowning. The bracelet would measure pulse of the user and oxygen levels through a pulse oximeter.

If the user's vitals fall below the normal blood oxygen levels of 95-100%, or their heart rate goes below the normal range for their age and activity levels, the bracelet will release a fluorescent green rescue dye to alert anybody nearby that someone is drowning. The dye is used by the U.S. army for sea rescue, and a field test study done by Powerboat Reports determined it to be the most effective method of rescuing someone (Landfall). This distinct marker is effective for swimming pools and rough ocean waters, giving the drowning victim a better chance of survival with something as simple as a bracelet.

Design Proposal

1. Problem Definition:

Today, 3,500 drowning deaths occur across America every year. Tragically, young children make up a significant portion of these deaths. 75% of deaths of children younger than 15 occur in private pools (Edgar & Snyder) and according to a SAFE KIDS research study, 90 % of all child drownings occur in supervised environments (CNN). Also, younger kids are more likely to drown silently, rather than the exhibit the thrashing and splashing that are commonly expected in a drowning victim. Once a child has gone under the water, quickly being able to recover the child, and get them breathing again, becomes essential. This is often difficult to do, especially in a crowded or cloudy pool or lake.

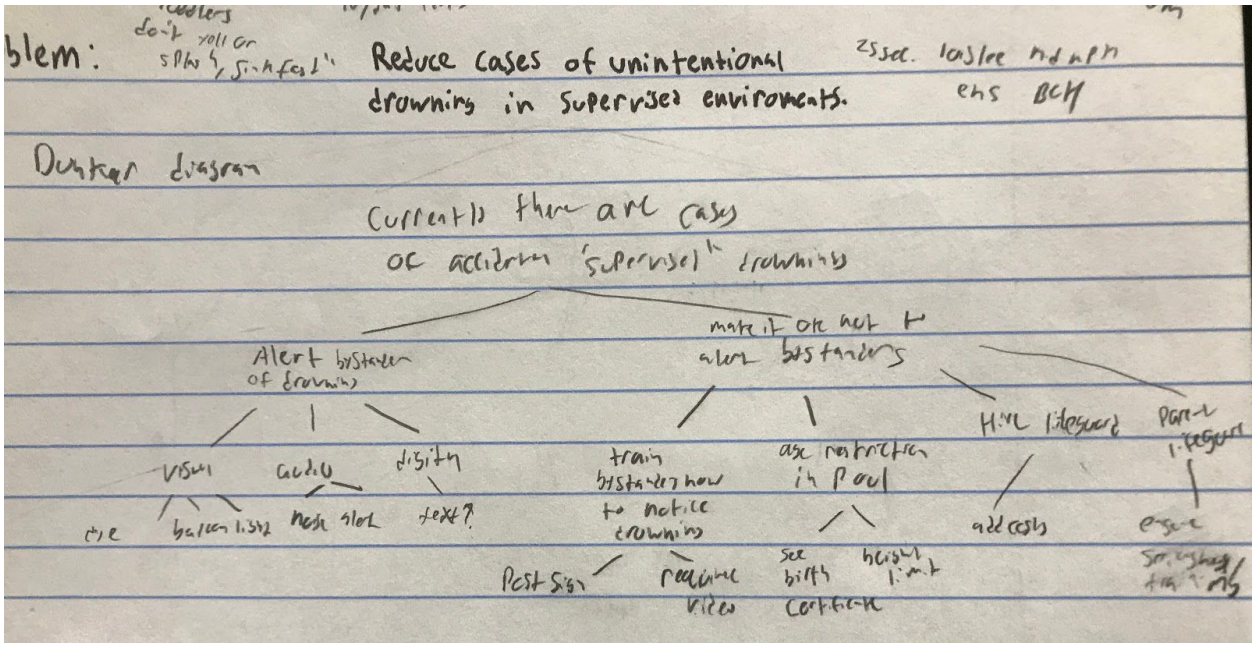
The problem statement for this design project is the following:

Design a wearable device that can detect when a victim is drowning, and alert those around them to the seriousness of their condition and aid in their rescue.

Hospitals and emergency medical services use vitals to determine the condition of their patients. They take pulse rate, blood pressure, breathing rate, pulse oximetry, and body temperature, to determine a general status of a patient and predict if someone is at risk of collapsing. To solve our problem, the most reliable and accurate measure of the condition of a child, or swimmer, is through pulse oximetry. This is because it can be done in a relatively passive and comfortable manner by passing light through into the major blood vessels of the wrist. Using this data that can be collected and processed on board the device, the users condition could be observed, and in the event of a drowning event, where blood oxygen levels will drop, the device could alert others in the pool. We have decided that a bright dye will work best because it will be more reliable than using underwater communications.

Some general criteria of this design are that it must be non-intrusive, incredibly user friendly, be reliable, but most importantly never provide false negatives. If there is even a chance that the user is drowning, it is important that the device activate at the risk of prematurely activating rather than not activating. the device should have a one day operating battery life, with a reserve battery power capacity for another 6 or 7 hours. The device must not need maintenance, and should have a product life of at least two years to be competitive on the market. Most importantly, the device should be a part of a larger service designed to teach the user, or their caregiver, how to prevent drownings and ensure that users understand that the device is a rescue aid, and does not in any way replace the need for careful and vigilant supervision of children in the water.

Duncker Diagram:



(1) Kepner-Tregoe Problem Analysis

	Is	**Is Not**	**Distinction**	**Possible Cause**
What (Identity)	Supervised drowning that goes unnoticed	Unsupervised Drowning	Bystanders available to help	Bystanders are not aware of the need for help
When (Timing)	Drowning event lasting more than two minutes	Drowning event lasting less than two minutes	How quickly the victim is found and rescued	How easy it is to find the drowning victim and abilities of those around them
Where (Location)	Supervised swimming locations- oceans, lakes, pools, etc	Unsupervised swimming locations	Bystanders within distance to help in time	Bystanders not able to reach victim in time
Extent (Magnitude)	Drowning event with the potential for death or serious harm	Drowning event resulting in survival and no serious harm, victim self rescues.	Time takes for a bystander to administer care and call medical help	Length of time spent without oxygen/ perfusion

2. Background

This bracelet has applications to prevent drowning in many different scenarios. It can be worn by anybody swimming in any body of water, children who walk around a pool that do not know how to swim, and anybody who wants an extra safety measure when around water. Medical expertise will be needed to design this product as it requires information about the user's vital signs, as well as mechanical expertise to design the bracelet. The United States military uses this rescue dye for people to be seen by helicopters overhead should they be lost at sea, and other organizations have used it as a safety measure on boats. It can be "seen for a mile or more and lasts for 30 to 40 minutes" (Landfall), making the drowning victim an easy to find target. It also makes it easier for lifeguards to find and recover the swimmer's body, should they be unconscious or unresponsive. The dye used in the seawater marker, fluorescein, has been used for years as a sea marker dye, and there has been no evidence of harm to marine life. A more purified form of the dye has been used in medicine, and has been reported to have low toxicity (Swinton and Gellert).

Figure 1: Demonstration of dye in a search and rescue exercise conducted by a Marine.

There have been many other products made to help prevent drowning, with different methods and science behind them. The SEAL SwimSafe necklace sends frequent signals to a hub monitored by lifeguards and parents to assure them that the wearer is safe, and if they stay underwater for longer than the "threshold of pain", the hub sounds an alarm (Blanford). Another example is the Kingii inflatable bracelets that bring the user to the surface when a lever is pulled

(Kooser). However, if the user is unconscious, having just their wrist above water will not be of much help, if they can pull the trigger at all.

Figure 2: Kingii inflatable bracelet

Better anti-drowning bracelets have been made, such as the BlueFox bracelet that produces an alarm in the form of a balloon if the bracelet exceeds a certain depth for a certain amount of time, depending on the user (BlueFox). This is similar to the rescue dye idea, but requires more advanced technology, which makes it more expensive and less accessible to the greater population. In addition, the balloon could float away from being directly above the person, making it difficult for the lifeguard to find the body.

Figure 3: BlueFox anti-drowning bracelet

An ideal design consists of simple technology, with a low risk of malfunctioning, and as affordable as possible. Combining the already successful rescue dye with the technology of a rescue bracelet sets this product apart from the competition. When searching for patents of similar products in the United States Patent and Trade Office, keywords such as “drowning prevention” and “bracelet”, came up with products connected to an alarm system using radio

waves (Sellers et al.), or an alarm system connected to somebody outside of the water triggered by water submersion (Snyder). The World Intellectual Property Organization came up with no results when “drowning”, “drowning prevention”, and “bracelet” were searched. Google patents, when prompted with the same keywords, produced results about bracelets connected to computer systems outside of the pool that will include a timer alarm and wireless communication, responsive to the water pressure, motion, and heart rate of the user (CN104517410A). There have also been rescue dyes used for people drowning to trigger when they are in danger, but not something automatic (CN104743084A). There have been no patents that involve “rescue dye”, “sea marker”, “sea dye” and “bracelet”/ “drowning” that are related to this product.

There are many other anti-drowning products, and the bracelet described in this proposal will have a similar function as the previous ideas, but the fluorescent powder will alert everybody while also providing a more clear visual sign in rough water. More advanced technology can include cameras that detect the colored powder in the pool and trigger an alarm to sound, as well as adding water depth detectors to the bracelet. For the purposes of this project, measuring the oxygen saturation and heart rate will be more than enough. Lastly, sensors to detect if the bracelet is in the water can help prevent against faulty readings, and the bracelet will detect consistent unsafe readings before the dye is released.

3. Value Sensitive Design

The project is designed to address the problem of swimming safety primerialy for children. This is a significant problem as swimming is one of the most statistically dangerous activities that children do. Every day in the United States alone, an average of 14 children die or are hospitalized from drowning incidents (CDC). Of all safety issues for children, pool safety is one of the most worthwhile problems to address.

Technically, the problem will ultimately be getting a small and precise sensor package with driver electronics able to fit comfortably on the wearers wrist and developing a system to deploy the dye. Being an emergency device, both the sensor package and dye deployment need to work quickly and be highly reliable. Seconds matter in how likely a person is to be saved in a

drowning incident. As a general rule, for every minute that the victim is submerged, the likelihood of their survival decreases by 10%.

Success for the project is not simply developing the device, but having a real impact on the rates of child drowning and near drowning incidents. In order for the device to have such an impact, not only must the technical challenges be overcome but also other factors need to be considered to help facilitate widespread adoption. To be adopted, the device will need to be comfortable on the wrist and affordable to consumers. Any device that is prohibitively expensive or that inhibits children's play will not be widely adopted regardless of what technical benefits the device may have.

Alternative solutions exist, but may be less effective or unacceptably constrain children's play when they are swimming. For instance, attaching a personal floatation device such as a life jacket to the child so that they simply cannot submerge themselves is a low cost and highly reliable solution. However, this greatly impacts the ability for a child to play and gain confidence in a swimming pool as they are never able to fully submerge themselves. Many existing products rely on radio frequency (RF) communication protocols such as Bluetooth or Wifi. While reliable transmitting through air, if the bracelet is submerged then the RF communication is interrupted. The shielding effect of water is so strong that even just a few centimeters of water can completely cut communication. This is an issue because many drowning incidents occur when the child's wrist is submerged. The dye releasing solution, on the other hand, can be made reliable and will still be visible even if the bracelet is submerged under a few meters of pool water.

One unfortunate side effect of the design solution is the dye that remains in the pool after the device is activated. However, this should only occur when a child is in distress and keeping the pool water clear is of low priority. Also, the dye selected can be non-toxic and ideally not environmentally harmful. Dyes already exist which are designed to diffuse quickly and make a highly visible area of water which are non-toxic and well suited for this purpose.

4. Methodology

Meeting:

The team will be meeting each Tuesday from 5:00-6:00 to discuss the progress made and assign tasks for the following week. If necessary, the team will also meet again throughout the week as determined by the meeting on Tuesday. Additionally, the team will communicate via text when not in person to answer any questions that may come up within the week.

Working in the FYELIC:

Ideally, the team will be working in FYELC in the weeks of February 18 and February 25 in order to create a prototype. However, most of the construction does not need to be done in FYELC; so most of the work will be completed either in class or in East Village.

Testing device:

The device will be tested by setting the wristband containing the blood oxygen sensor to trigger the release of the green powder when the blood oxygen levels are read as normal. The testing will be done in an enclosed environment to avoid any mess. Additionally, testing will begin around the week of February 25 and will continue until the product is completed. To ensure the best possible product, the testing will be done multiple times on each working version of the prototype.

Reworking:

Time allotted for reworking the problem and perfecting the prototype will be the weeks of February 25 to the week of March 24. This takes into account the week off for spring break while maximizing the time spent testing and improving the prototype before the design prototype presentation critiques.

Writing report:

The report will be completed in a timely manner as the project progresses; essentially, the team will work on the report as each portion of the project is completed in a rough draft fashion. Keeping in mind that the report is due at the end of April, the design itself will be finalized by early April, thus allowing for time to edit and finalize the report.

5. Expected Results

The expected results we hope to obtain from the final product are centered around preventing supervised drowning. In an ideal situation, the device should be able to accurately and reliably measure the users blood oxygen levels. This is crucial in the performance of the product, as false readings can endanger the life of the drowning victim and waste dye and resources if it sets off accidentally when the user is alright. It should be waterproof to roughly 5 meters of depth, as the purpose of the bracelet is defeated if it can not function properly underwater. This is not meant for deep sea diving, but swimming in reasonable depths, that a child could safely reach, should allow the bracelet to take readings and release dye should the user be in danger.

If blood oxygen levels reach dangerously low levels, the device should release a fluorescent dye into the water. This visible signal is how the bracelet will save the life of the user should there be bystanders watching, and it is arguably the most important part of the design. In order to avoid false positives, and premature release of dye, a 5 second buzzer and vibration will allow the user to cancel the alarm if they are not in danger. This combats against children playing with the bracelet and trying to set it off for fun, but even if they are playing around, if their blood oxygen levels get to dangerously low levels the bracelet should release the dye. The device should be cost efficient and have the ability to be mass produced. The simplicity of the dye alarm helps facilitate this cost efficiency, and hopefully make it affordable for most families. The device should be reasonably comfortable, and easy to swim with.

The device should be scalable in size, allowing for children and adult versions of the device. This will make the product both more commercially viable but also ensure that all can benefit from it’s life saving capabilities.

The dye should be non-toxic and provide no harm to a user or rescuer in the water. It must be able to be washed off of the skin within 10 minutes in a warm shower with standard soap. So that it does not necessarily cause harm in the case of a misfire. The dye must also be able to be reasonably filtered out of a pool environment if it is deployed.

6. Costs

Table 1: Estimated costs for prototyping

Design Component	**Part**	**Cost ($)**
Battery	Li polymer or Li ion	10
Control board	Arduino	15
Sensor package	MAX 30100	8
Housing	3D print from model	NA
Strap	Nylon	3
Dye	Green dye	7
Dye release system	9g servo	7
Total		50

7. Summary

Essentially, the product being designed aims to prevent lethal drowning cases and side-effects from prolonged drowning with early notification methods. This is due to the fact that drowning is one of the leading causes of accidental deaths and can cause severe, chronic physical and mental damage in some cases of survivable drowning. Collectively, the team will work to complete the electronic prototype by the end of February and have a final product by the end of March. Although the device will work on all ages, the device will be most useful for younger children and handicapped peoples in a supervised environment.

The device will be a band fitted around the wrist containing a pulse oximeter sensor, green dye that diffuses quickly in water, and the electronics needed for connecting the two. Thanks to all of the wiring being included in the wrist band, the device will not need to be connected to an external source; however, once the dye is released it will not be reusable. Continuing on, the dye will be released when the pulse oximeter sensor detects a drop in pulse oximeter readings from 100% to below 90%. This is indicative of unhealthily low pulse oximeter

readings which would warrant the need for a medical response. Therefore, in order to indicate that the person wearing the wrist band is symptomatic of drowning, the green dye will be released by a mechanism within the wristband that is linked to the pulse oximeter sensor. In order to ensure safety and usability in the water, the wristband will be made from waterproof materials and coated in a waterproofing spray or wrap. Given the option, the band will eventually contain depth sensing abilities, underwater communication abilities, and features that allow it to be reused. Despite the fact that the dye will remain in the water for up to a day, the dye itself is non-toxic and will dissipate; the lives saved and liability decreased will outweigh the color in the pool. Ideally, this product will be produced for a low price and utilized to decrease the overall drowning related deaths.

Signed:

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Appendix A: Images

Figure 1: "Marine Corps Photos." *The Official United States Marine Corps Public Website*, Marines, 6 Nov. 2015, https://www.marines.mil/Photos/igphoto/2001315493/

Figure 2: Kooser, Amanda. "Inflatable Anti-Drowning Device Sits on Your Wrist like a Mini Life Raft." *CNET*, CNET, 7 July 2015, https://www.cnet.com/news/kingii-inflatable-anti-drowning-device-is-a-wrist-worn-mini-life-raft/

Figure 3: BlueFox. "BlueFox Launches the World's First Anti-Drowning Bracelet." *Cision*, PR Newswire, 15 Mar. 2016, https://www.prnewswire.com/news-releases/bluefox-launches-the-worlds-first-anti-drowNing-bracelet-300236488.html

Appendix B: Patents

CN104517410A: https://patents.google.com/patent/CN104517410A/en?q=drowning&q=prevention&q=bracelet&oq=drowning+prevention+bracelet

CN104743084A: https://patents.google.com/patent/CN104743084A/en?q=rescue&q=dye&q=bracelet&oq=rescue+dye+bracelet

Snyder patent:

(12) **United States Patent**
Snyder

(10) **Patent No.: US 9,715,808 B2**
(45) **Date of Patent: Jul. 25, 2017**

(54) **WATER SAFETY MONITORING DEVICES, ALARM DEVICES AND RELATED METHODS**

(71) Applicant: **Seal Innovation, Inc.**, Raleigh, NC (US)

(72) Inventor: **Graham E. Snyder**, Raleigh, NC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(22) PCT Filed: **Mar. 13, 2014**

(86) PCT No.: **PCT/US2014/025719**
§ 371 (c)(1),
(2) Date: **Sep. 15, 2015**

(87) PCT Pub. No.: **WO2014/151432**
PCT Pub. Date: **Sep. 25, 2014**

(65) **Prior Publication Data**

US 2016/0042629 A1 Feb. 11, 2016

Related U.S. Application Data

(60) Provisional application No. 61/789,492, filed on Mar. 15, 2013, provisional application No. 61/844,584, filed on Jul. 10, 2013, provisional application No. 61/941,760, filed on Feb. 19, 2014.

(51) **Int. Cl.**
G08B 21/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G08B 21/08*** (2013.01); ***G08B 21/088*** (2013.01)

(58) **Field of Classification Search**
CPC G08B 21/00; G08B 21/08; G08B 21/088; G08B 21/0446; G08B 21/0453; G08B 23/00; H01Q 1/1257; G01S 5/0231
USPC 340/539.1, 539.11, 573.1, 573.6; 30/539.1, 539.11, 573.1, 573.6
See application file for complete search history.

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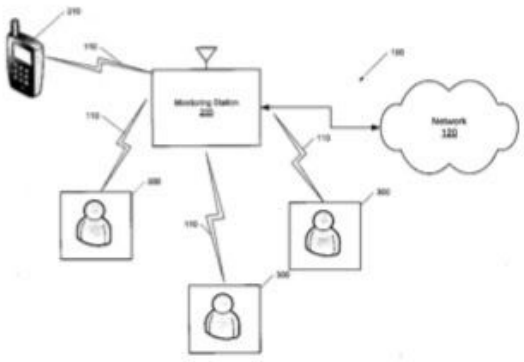
Primary Examiner — Hung T Nguyen
(74) *Attorney, Agent, or Firm* — Myers Bigel, P.A.

(57) **ABSTRACT**

A monitoring device for monitoring a risk of drowning for users of one or more alarm devices is provided. The alarm devices include one or more detectors configured to detect status data. A controller circuit is configured to receive status data from the alarm device, to detect a triggering event, and, in response to the triggering event, to select one of a plurality of alarm protocols based on the status data. A user interface unit is configured to convey the selected alarm protocol to the user.

35 Claims, 9 Drawing Sheets



Sellers et al. patent:

US006064309A

United States Patent [19]

Sellers et al.

[11] **Patent Number: 6,064,309**

[45] **Date of Patent: May 16, 2000**

[54] **SWIMMING POOL DROWNING PREVENTION SYSTEM**

[76] Inventors: **Scott D. Sellers**, 707 E. Papago Dr., Tempe, Ariz. 85281; **Edward C. Frieberg**, 3140 S. Beverly Cir., Mesa, Ariz. 85210

[21] Appl. No.: **09/162,211**

[22] Filed: **Sep. 28, 1998**

[51] **Int. Cl.**[7] **G08B 23/00**

[52] **U.S. Cl.** **340/573.6**; 340/573.1; 340/541; 340/539; 340/604; 340/566; 340/628; 623/24; 128/781

[58] **Field of Search** 340/573.6, 573.1, 340/541, 539, 604, 566, 628; 623/24; 128/781

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Primary Examiner—Daniel J. Wu
Assistant Examiner—Tai T. Nguyen
Attorney, Agent, or Firm—Harry M. Weiss; Jeffrey Weiss; Paul W. Davis

[57] **ABSTRACT**

A swimming pool drowning prevention safety system. The swimming pool drowning prevention safety system comprises: an article wearable by a person, a radio frequency transmitting device coupled to the article for transmitting a radio frequency signal, a microprocessor controlled radio frequency receiving station for receiving the radio frequency signal from the radio frequency transmitting device when the radio frequency transmitting device is within a user adjustable radio reception range of the radio frequency receiving station, and an alert signaling device coupled to the radio frequency receiving station for signaling when the person wearing the article has come within the user adjustable radio reception range of the radio frequency receiving station. The swimming pool drowning prevention safety system is further comprised of an adjustable gain control for varying the RF sensitivity of the radio frequency receiving station, and an RF sensitivity trigger circuit coupled to an audio messaging system for broadcasting at least one selected alert message. The swimming pool drowning prevention safety system further comprises telephone circuitry connection equipment for automatically connecting to a telephone system and transmitting the selected alert message. The swimming pool drowning prevention safety system further comprises a microprocessor that controls and integrates operation of the radio frequency receiving station.

18 Claims, 2 Drawing Sheets