SWIMMING GOGGLES WITH PROXIMITY SENSORS

Daya Sharon

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Contents

Abstract

Many swimmers have poor concentration, or poor eyesight, and ultimately obtain injuries by crashing into the wall of the pool. Radiofrequency identification (RFIDs), the same technology used in identification cards for business places and schools, was used to provide the wall-sensing technology. The goal of this project was to engineer a wearable device that alerts a swimmer as he or she approaches a wall. A test was conducted to find the range of the RFID. The same test was then conducted in water to confirm that the device would function in a pool. The device created serves as a model for a crash-prevention device for swimmers. However, the range of the RFID used in this project was only one to four centimeters. The model could be modified for use with a longer-ranged RFID. Ranges of around four meters suffice to create a functional device capable of providing information when the swimmer is far enough from the wall to comprehend the visual cues from the device.

Literature Review

Introduction

Many new devices have been created to help athletes improve the quality of their training. For example, swimmers are now able to listen to music underwater and track their lap count and heart rate. Some devices even allow swimmers to see their times and stroke rates. However, not many devices are able to warn a swimmer of an obstacle in his or her way.

Capacitive Sensors

Within the broad category of capacitive sensors, there are two types of sensors: parallel-plate capacitors and fringe capacitors. Parallel-plate capacitors use two “plates” to sense the object. The sensor itself is one of the plates and the object is the other plate. However, parallel-plate capacitors can only be used to sense objects that are conductors. Fringe capacitors use live electrodes to detect an object. Unlike parallel-plate capacitors, fringe capacitors do not require the object to be a conductor. (Chen 1998)

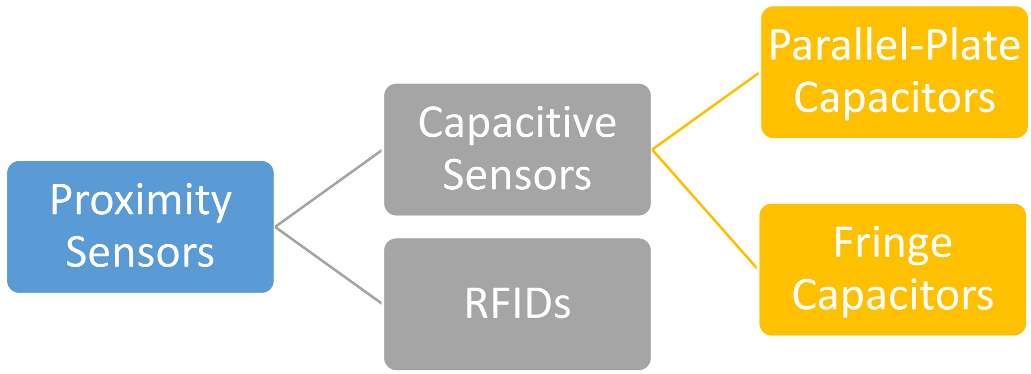

Figure 1. The hierarchy of proximity sensors.

Radiofrequency Identification

Radiofrequency identification is one way to distinguish between objects. The apparatus uses two parts: a reader and a tag. The tags are passive, meaning they do not transmit any signal. These tags do not require batteries, can be waterproof, and are very small (Nath 2006). Many systems today use radiofrequency identification to assist in simple processes. For example, “EZ-Pass” uses radiofrequency identification to allow for a quicker transition at tollbooths (Nath 2006). Although radiofrequency identification tags can be waterproof, radio frequencies do not often travel well through water (Schill 2016). Low frequencies have very short underwater ranges, and high frequencies have even shorter underwater ranges (Schill 2016).

Displays

The display of any device is critical for the device to be functional. Without the display, the user would not be able to retrieve the feedback that the device is trying to relay. In most cases, instant feedback is essential for athletes and students in learning and correcting a skill (Hagem 2015). Whether the display uses light, sound, or vibration, the user must be able to interpret these transmissions.

Heads-Up Display

One type of display often used in optical devices is the heads-up display. Heads-up displays work by projecting an image into the field of view of the user. This method creates the three-dimensional effect that makes heads-up displays similar to holographs in appearance. Heads-up displays are used by all types of virtual reality goggles to give the user a realistic experience without making the device too bulky. The visual display used in heads-up displays is effective for communicating information to the wearer without resorting to color-coding the information. (Caudell & Mizell, 1992)

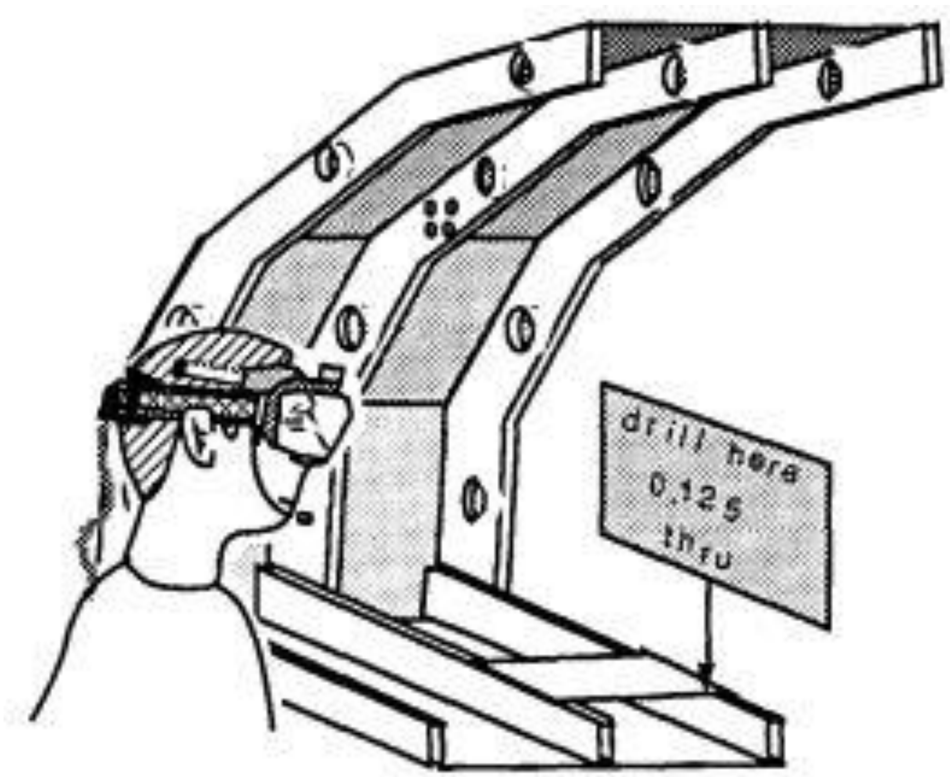

Figure 2. An example of what a heads-up display would look like in a manufacturing setting. (Caudell & Mizell, 1992)

Previous Display Methods

Many devices use a variety of display types. Light emitting diodes have been used with different colors or intensities to communicate with the user. In a stroke rate sensor, the display includes three different colors of light emitting diodes. A swimmer is able to preset a goal pace and the device is able to calculate and display whether the swimmer goes faster than, slower than, or keeps up with his or her preset pace. The swimmer is able to determine his or her speed because the display uses a red light emitting diode to indicate that the swimmer is moving too slow, a blue light emitting diode to indicate that the swimmer is right on track, and a green light emitting diode to indicate that the swimmer is moving faster than his/her preset pace. (Hagem 2013)

Similarly, a device created by a few British engineers uses optical guides as the display. The guides are paths that steer the light into the position required for the image that is to be displayed. The entire display utilizes seven, fourteen, or sixteen guides. The result of the display is an image that can contain numbers, or a combination of letters and numbers. The display is also focused at infinity, with the depth of field starting in front of the glasses and extending to infinity. This method provides a completely transparent display that the wearer can read and see through at the same time. Heads-up displays can be used in any optical device that has a clear viewing surface. (Hazell, Millar, Williamson, & Golder, 2006)

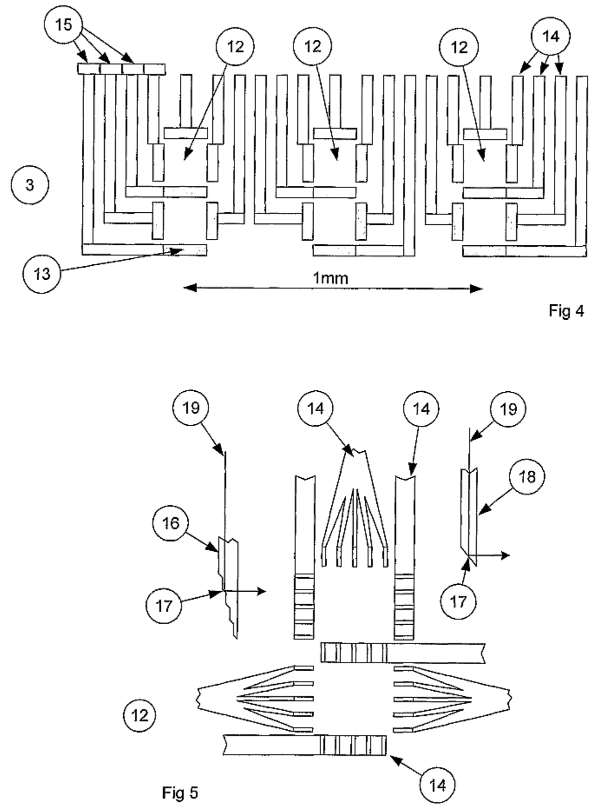

Figure 3. Light guides positioned in a segmented display (Hazell, Millar, Williamson, & Golder, 2006)

Goggle Devices

Swimming goggles are a common piece of equipment for swimmers. The goggles are comprised of two plastic cups connected by a nose bridge and a stretchy, flexible strap. The cups are designed in such a way that there is enough space between the swimmer's eyes and the plastic to prevent blurry vision. The cups also have a flat surface directly opposite the eye; this surface is angled to minimize light refraction. This slant also optimizes the swimmer's field of vision. A removable suction cushion is placed on the outside rim of each of the two plastic cups for comfort. The basic structure of swimming goggles allows the equipment to be used as a base for many other devices, such as the device described below. (Yokota 2007)

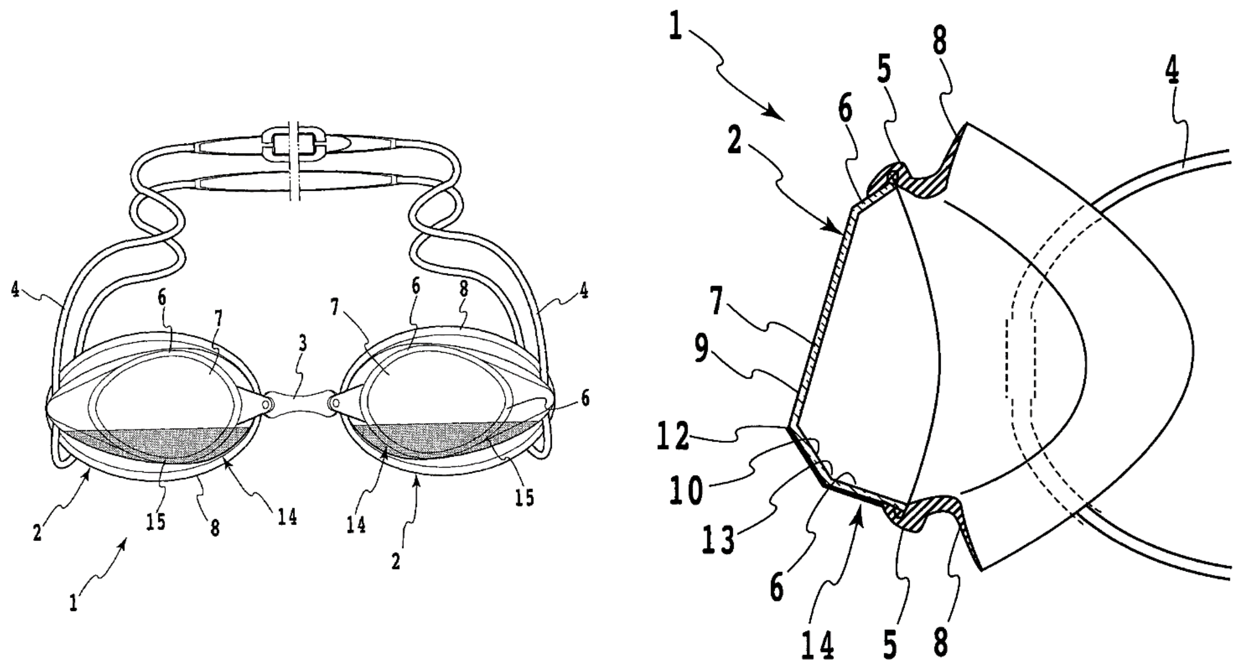

Figure 4. (Left) A front view of a pair of swimming goggles. (Right) A side view of a pair of swimming goggles. (Yokota 2007)

Another electronic timing system uses an accelerometer. The device can measure how long each swim stroke takes, recognize flip turns, and detect stops. A liquid crystal display is used in a pair of swimming goggles to show lap counts, total times, split times, and heart rates. The device shows flashing light emitting diodes when the heart rate increases or decreases. (Taba 1997)

Conclusion

Many of the devices that have already been created were designed to assist swimmers in tracking their training. Regarding displays, heads-up display is an ideal method for displaying information, but light-emitting diodes are much simpler to use. The timing systems and accelerometers used in previous devices cannot warn a swimmer of an upcoming wall, but proximity sensors could help prevent a crash. There is a need for a device that indicates when a swimmer is approaching a wall so that he or she can prepare for a turn immediately.

Engineering Plan

Problem Statement

Many swimmers lose track of their location in the pool while swimming and crash into the wall at the ends of the pool. These collisions can cause painful injuries.

Engineering Goal

The goal of this project is to engineer a waterproof wearable device that utilizes a proximity sensor and a display to warn swimmers of an upcoming wall.

General Overview of Potential Methods

Radiofrequency identification technology was used for the proximity sensor. The display was built using light-emitting diodes. These technologies were attached to a pair of swimming goggles. All assembly was done at home and at school. The technology was tested outside of the water (in air) first, in order to ensure that the systems were functional. Another set of tests was conducted to determine the ideal thickness of PLA material for a box to house the device. Next, the system was tested in a tub of water to check that the device was waterproof. Finally, the device was tested in the water at a pool. The data that included collected during these tests was how many times the sensor was able to accurately sense the wall to within 10 centimeters and whether or not the display was functional.

The potential risks involved in this project were minimal. The main concern was putting electronic equipment in water. Safety measures such as being cautious and putting the electronics in the water while they were turned off were utilized. Proper safety techniques learned in an Engineering class were also utilized. In addition, an insulating material was used to protect the tester.

Methodology

Materials

An RC-522 radiofrequency identification (RFID) module was purchased from Amazon. The package contained the RFID module, a card tag, a fob tag, and two sets of extra pins to solder to the module. All connecting wires, an Arduino USB cord, a light-emitting diode (LED), and an Arduino Genuino Uno were obtained from an Arduino and Engineering elective at school.

Procedure

The RFID module was attached to the Arduino with the connecting wires. The LED was also connected to the Arduino, and the entire system was plugged into a computer for power. Code for reading an RFID tag was downloaded from GitHub. The LED has specific code to illuminate the bulb, so the RFID program was modified to include these instructions.

The program was implemented in the Arduino developer's web app. When one of the tags got close enough to the RFID module, the LED turned blue. Once the RFID completed a successful read of the tag, the LED turned green and then shut off. If there was an error of any sort when reading the tag, the LED turned red and shut off.

The first test was done to find the range of the sensor. The RFID module was plugged in to the Arduino and the computer, with the LED also plugged in to the Arduino. The RFID was laid flat on a table while a ruler was taped to an open laptop at a 90^{o} angle. The laptop was only used as a support for the ruler to keep it perpendicular to the table. The fob tag was slowly lowered over the RFID, until the LED turned blue to indicate that the fob had been sensed. The height at which the fob was sensed was then recorded. This process was repeated for a total of 50 trials, and then another 50 trials with the card tag.

A similar test was conducted to investigate whether or not the RFID functioned underwater as well as it did in air. Instead of propping a ruler against an open laptop, the ruler was taped to a table. A clear plastic bin was placed on the ruler and filled with water. The RFID module was placed in a clear plastic bag to provide protection from the water. The bag with the module was then placed on the rim of the bin at the beginning of the ruler. The fob was then slowly moved towards the module, while still underwater. The distance at which the fob was sensed was recorded. This procedure was repeated for a total of 30 trials with the fob, and 30 trials with the card tag.

Three small rectangles were 3D printed using PLA filament. The first rectangle was one millimeter thick, the second was two millimeters thick, and the third rectangle was three millimeters thick. The range test was then conducted three times in air with each of the three rectangles laying on top of the RFID module.

A piece was designed in SolidWorks to connect the fob tag to a pair of swimming goggles and 3D printed on a Makerbot printer. The piece was then fitted to the goggles and the fob was inserted. A repeat of the range test was conducted to check that the connector did not interfere with the radiofrequency signal required for the RFID to sense the fob.

Because the Arduino, RFID, and LED had wires everywhere and were very spread out, a box was designed in SolidWorks and printed using a Makerbot 3D printer to condense the system into a smaller space. One final range test was completed to ensure that the box did not affect the sensor.

Results

For all tests, the data collected was the distance between the tag and the sensor when the tag was sensed. Each test included 50 trials. The following table summarizes the data.

	Height (cm)					
	in AIR	in WATER	through 1mm PLA	through 2 mm PLA	through 3 mm PLA	through BOX and WATER
Avg	1.64	1.23	1.37	1.23	1.19	1.33
STDEV	0.15	0.17	0.08	0.11	0.08	0.10
MIN	1.10	0.75	1.10	0.95	0.95	1.15
MAX	1.90	1.50	1.50	1.40	1.30	1.50
RANGE	0.80	0.75	0.40	0.45	0.35	0.35

Figure 5. A summary table of the data collected for each test. The full data set may be found in Appendix A.

An ANOVA statistical test was conducted using all of the data, providing a P-value of 1.1102e-16. A Tukey post-hoc test was also conducted.

Data Analysis

The data collected during the tests was the distance between the reader and the tag when the tag was sensed. This distance represents the range of the sensor. In air, the tag was sensed within a range of 1.10cm to 1.90cm. In water, the range was from 0.75cm to 1.50cm. These ranges indicate the potential precision of the device. The standard deviations for each test was less than 0.20cm, also indicating a high precision in the test results.

The ANOVA P-value of 1.1102e-16 suggests that at least one of the data sets was significantly different. The Tukey test helped to identify that there were four insignificantly different pairings: in water vs through 2mm of PLA filament, in water vs through 3mm of PLA filament, through 1mm of PLA filament vs the box test, and through 2mm of PLA filament vs through 3mm of PLA filament. These results show that the data of these four comparisons was too similar to be significantly different.

Conclusions

The prototype created in this project serves as a model for a device using a stronger RFID. The data collected using the short range RFID provides ample evidence that the device is capable of functioning underwater and through PLA 3D printing material. A fully assembled device could assist swimmers in avoiding a painful collision with the pool wall.

Acknowledgements

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Appendix A

Height (cm)						
Trials	in AIR	in WATER	through 1mm	through 2 mm	through 3 mm	through BOX and WATER
1	1.65	1.20	1.30	1.10	1.10	1.35
2	1.50	1.15	1.45	1.15	1.15	1.50
3	1.55	0.90	1.10	1.25	1.05	1.45
4	1.65	1.05	1.35	0.95	1.20	1.20
5	1.70	1.35	1.40	1.10	1.25	1.40
6	1.85	1.00	1.45	0.95	1.20	1.30
7	1.70	1.20	1.45	1.00	1.25	1.20
8	1.50	1.40	1.35	1.10	1.20	1.40
9	1.60	1.50	1.25	1.20	1.20	1.15
10	1.55	1.45	1.45	0.95	1.15	1.40
11	1.10	1.25	1.25	1.35	1.15	1.30
12	1.70	1.10	1.40	1.25	1.25	1.35
13	1.60	1.35	1.50	1.20	1.20	1.30
14	1.50	1.40	1.45	1.25	1.25	1.30
15	1.55	1.15	1.35	1.30	1.25	1.20
16	1.50	1.20	1.40	1.25	1.10	1.30
17	1.50	1.10	1.35	1.20	1.15	1.20
18	1.65	1.30	1.50	1.30	1.20	1.35
19	1.85	1.05	1.40	1.35	1.30	1.15
20	1.60	1.25	1.30	1.20	1.20	1.45
21	1.55	0.95	1.25	1.25	1.25	1.40
22	1.50	1.30	1.30	1.30	1.05	1.30
23	1.45	0.90	1.45	1.35	1.15	1.45
24	1.40	1.05	1.35	1.40	1.20	1.25
25	1.45	1.00	1.25	1.35	1.15	1.30
26	1.60	0.75	1.45	1.40	1.15	1.40
27	1.65	1.35	1.30	1.30	1.25	1.30
28	1.70	1.25	1.45	1.30	1.30	1.25
29	1.70	1.05	1.40	1.25	1.15	1.20
30	1.65	1.40	1.45	1.20	1.05	1.45
31	1.65	1.40	1.35	1.15	1.20	1.40
32	1.50	1.35	1.30	1.20	0.95	1.30
33	1.75	1.30	1.40	1.30	1.30	1.50
34	1.65	1.35	1.40	1.25	1.25	1.25
35	1.70	1.20	1.45	1.30	1.20	1.30
36	1.70	1.30	1.35	1.35	1.25	1.35
37	1.65	1.25	1.50	1.30	1.30	1.20
38	1.85	1.35	1.35	1.25	1.25	1.45
39	1.80	1.45	1.35	1.20	1.15	1.40
40	1.90	1.40	1.40	1.20	1.20	1.15
41	1.75	1.25	1.30	1.15	1.25	1.25
42	1.70	1.20	1.25	1.25	1.05	1.50
43	1.75	1.30	1.30	1.20	1.25	1.40
44	1.70	1.25	1.40	1.30	1.30	1.45
45	1.65	1.45	1.35	1.25	1.15	1.35
46	1.85	1.00	1.35	1.35	1.20	1.20
47	1.75	1.45	1.40	1.35	1.10	1.45
48	1.90	1.30	1.30	1.30	1.25	1.40
49	1.80	1.40	1.30	1.20	1.15	1.35
50	1.60	1.15	1.50	1.25	1.10	1.30
Avg	1.64	1.23	1.37	1.23	1.19	1.33
STDEV	0.15	0.17	0.08	0.11	0.08	0.10
MIN	1.10	0.75	1.10	0.95	0.95	1.15
MAX	1.90	1.50	1.50	1.40	1.30	1.50
RANGE	0.80	0.75	0.40	0.45	0.35	0.35

Figure 6. A complete chart of all data collected over the course of this project.

Appendix B

Arduino Code with LED Modifications

```
/**
 * ----------------------------------------------
 *             MFRC522      Arduino
 *             Reader/PCD   Uno/101
 * Signal      Pin          Pin
 * ----------------------------------------------
 * RST/Reset   RST          9
 * SPI SS      SDA(SS)      10
 * SPI MOSI    MOSI         11 / ICSP-4
 * SPI MISO    MISO         12 / ICSP-1
 * SPI SCK     SCK          13 / ICSP-3
 *
 */

#include <SPI.h>
#include <MFRC522.h>

#define RST_PIN         9           // Configurable, see typical pin layout above
#define SS_PIN          10          // Configurable, see typical pin layout above

MFRC522 mfrc522(SS_PIN, RST_PIN);   // Create MFRC522 instance.

MFRC522::MIFARE_Key key;

/**
 * Initialize.
 */
 int blue = 5;
 int red = 3;
 int green = 6;
void setup() {
  pinMode(blue, OUTPUT);
  pinMode(red, OUTPUT);
  pinMode(green, OUTPUT);
    Serial.begin(9600); // Initialize serial communications with the PC
    while (!Serial);    // Do nothing if no serial port is opened
    SPI.begin();        // Init SPI bus
    mfrc522.PCD_Init(); // Init MFRC522 card

    // Prepare the key (used both as key A and as key B)
    // using FFFFFFFFFFFFh which is the default at chip delivery from the factory
    for (byte i = 0; i < 6; i++) {
        key.keyByte[i] = 0xFF;
    }

    //Serial.println(F("Scan a MIFARE Classic PICC to demonstrate read and write."));
    //Serial.print(F("Using key (for A and B):"));
    dump_byte_array(key.keyByte, MFRC522::MF_KEY_SIZE);
    //Serial.println();

    //Serial.println(F("BEWARE: Data will be written to the PICC, in sector #1"));
}

/**
 * Main loop.
 */
void loop() {

      digitalWrite(red, LOW);
      digitalWrite(blue, LOW);
      digitalWrite(green, LOW);
    // Look for new cards
```

```
    if ( ! mfrc522.PICC_IsNewCardPresent())
        return;

    // Select one of the cards
    if ( ! mfrc522.PICC_ReadCardSerial())
        return;

    // Show some details of the PICC (that is: the tag/card)
    //Serial.print(F("Card UID:"));
    digitalWrite(blue, HIGH);
    dump_byte_array(mfrc522.uid.uidByte, mfrc522.uid.size);
    //Serial.println();
    //Serial.print(F("PICC type: "));
    MFRC522::PICC_Type piccType = mfrc522.PICC_GetType(mfrc522.uid.sak);
    //Serial.println(mfrc522.PICC_GetTypeName(piccType));

    // Check for compatibility
    if (    piccType != MFRC522::PICC_TYPE_MIFARE_MINI
        &&  piccType != MFRC522::PICC_TYPE_MIFARE_1K
        &&  piccType != MFRC522::PICC_TYPE_MIFARE_4K) {
        //Serial.println(F("This sample only works with MIFARE Classic cards."));
        return;
    }

    // sector #1, covering block #4 up to and including block #7
    byte sector         = 1;
    byte blockAddr      = 4;
    byte dataBlock[]    = {
        0x01, 0x02, 0x03, 0x04, //  1,  2,   3,  4,
        0x05, 0x06, 0x07, 0x08, //  5,  6,   7,  8,
        0x08, 0x09, 0xff, 0x0b, //  9, 10, 255, 12,
        0x0c, 0x0d, 0x0e, 0x0f  // 13, 14,  15, 16
    };
    byte trailerBlock   = 7;
    MFRC522::StatusCode status;
    byte buffer[18];
    byte size = sizeof(buffer);

    // Authenticate using key A
    //Serial.println(F("Authenticating using key A..."));
    status = (MFRC522::StatusCode) mfrc522.PCD_Authenticate(MFRC522::PICC_CMD_MF_AUTH_KEY_A, trailerBlock,
&key, &(mfrc522.uid));
    if (status != MFRC522::STATUS_OK) {
      digitalWrite(blue, LOW);
      digitalWrite(red, HIGH);
      delay(1000);
       // Serial.print(F("PCD_Authenticate() failed: "));
       // Serial.println(mfrc522.GetStatusCodeName(status));
        return;
    }

    // Show the whole sector as it currently is
    //Serial.println(F("Current data in sector:"));
    mfrc522.PICC_DumpMifareClassicSectorToSerial(&(mfrc522.uid), &key, sector);
    //Serial.println();

    // Read data from the block
    //Serial.print(F("Reading data from block ")); Serial.print(blockAddr);
    //Serial.println(F(" ..."));
    status = (MFRC522::StatusCode) mfrc522.MIFARE_Read(blockAddr, buffer, &size);
    if (status != MFRC522::STATUS_OK) {
      digitalWrite(blue, LOW);
      digitalWrite(red, HIGH);
      delay(1000);
        //Serial.print(F("MIFARE_Read() failed: "));
        //Serial.println(mfrc522.GetStatusCodeName(status));
    }
    //Serial.print(F("Data in block ")); Serial.print(blockAddr); Serial.println(F(":"));
    dump_byte_array(buffer, 16); //Serial.println();
```

```
    //Serial.println();

    // Authenticate using key B
    //Serial.println(F("Authenticating again using key B..."));
    status = (MFRC522::StatusCode) mfrc522.PCD_Authenticate(MFRC522::PICC_CMD_MF_AUTH_KEY_B, trailerBlock,
&key, &(mfrc522.uid));
    if (status != MFRC522::STATUS_OK) {
      digitalWrite(blue, LOW);
      digitalWrite(red, HIGH);
      delay(1000);
        //Serial.print(F("PCD_Authenticate() failed: "));
        //Serial.println(mfrc522.GetStatusCodeName(status));
        return;
    }

    // Write data to the block
    //Serial.print(F("Writing data into block ")); Serial.print(blockAddr);
    //Serial.println(F(" ..."));
    dump_byte_array(dataBlock, 16); Serial.println();
    status = (MFRC522::StatusCode) mfrc522.MIFARE_Write(blockAddr, dataBlock, 16);
    if (status != MFRC522::STATUS_OK) {
      digitalWrite(blue, LOW);
      digitalWrite(red, HIGH);
      delay(1000);
        //Serial.print(F("MIFARE_Write() failed: "));
        //Serial.println(mfrc522.GetStatusCodeName(status));
    }
    //Serial.println();

    // Read data from the block (again, should now be what has been written)
    //Serial.print(F("Reading data from block ")); Serial.print(blockAddr);
    //Serial.println(F(" ..."));
    status = (MFRC522::StatusCode) mfrc522.MIFARE_Read(blockAddr, buffer, &size);
    if (status != MFRC522::STATUS_OK) {
      digitalWrite(blue, LOW);
      digitalWrite(red, HIGH);
      delay(1000);
        //Serial.print(F("MIFARE_Read() failed: "));
        //Serial.println(mfrc522.GetStatusCodeName(status));
    }
//    Serial.print(F("Data in block ")); Serial.print(blockAddr); Serial.println(F(":"));
    dump_byte_array(buffer, 16); //Serial.println();

    // Check that data in block is what we have written
    // by counting the number of bytes that are equal
//    Serial.println(F("Checking result..."));
    byte count = 0;
    for (byte i = 0; i < 16; i++) {
        // Compare buffer (= what we've read) with dataBlock (= what we've written)
        if (buffer[i] == dataBlock[i])
            count++;
    }
//    Serial.print(F("Number of bytes that match = ")); Serial.println(count);
    if (count == 16) {
      digitalWrite(green, HIGH);
      delay(1000);
//        Serial.println(F("Success :-)"));
    } else {
      digitalWrite(red, HIGH);
      delay(1000);
//        Serial.println(F("Failure, no match :-("));
    }
//    Serial.println();

    // Dump the sector data
//    Serial.println(F("Current data in sector:"));
    mfrc522.PICC_DumpMifareClassicSectorToSerial(&(mfrc522.uid), &key, sector);
//    Serial.println();
```

```
    // Halt PICC
    mfrc522.PICC_HaltA();
    // Stop encryption on PCD
    mfrc522.PCD_StopCrypto1();
    digitalWrite(red, LOW);
    digitalWrite(green, LOW);
    digitalWrite(blue, LOW);
}

void dump_byte_array(byte *buffer, byte bufferSize) {
    for (byte i = 0; i < bufferSize; i++) {
//        Serial.print(buffer[i] < 0x10 ? " 0" : " ");
//        Serial.print(buffer[i], HEX);
    }
}
```

Appendix C

Limitations and Assumptions

The only pair of goggles that were available for testing during the course of the project were Speedo goggles. Therefore, it is assumed that any person who uses the device will also use the same make of goggles. Otherwise, the piece that connects the fob tag to the goggles will not fit. The code written to run the RFID was assumed to be correct, and the RFID was assumed to work as stated in the product description when the module was purchased.

Appendix D

Background Notes

A pair of swimming goggles that have a proximity sensor attached to warn the swimmer of the approaching wall.

DAYA SHARON

LAST UPDATED: FEBRUARY 13, 2017

Ezabella, Brave New World: Rio 2016 Games to showcase technological innovations

Original URL	https://www.rio2016.com/en/news/rio-2016-olympics-technological-innovations		
File name of PDF	160914_ezabella_rio_tech.pdf		
Date written	24.06.2016	**Date accessed**	14.09.2016
Type of paper	Secondary source		
Goal of the paper	To introduce the new technological advantages to be used in the Rio 2016 Olympic Games		
Major findings	None		
Notes on the paper	• Using digital lap counters that are on the bottom of the pool near the wall (visible after flip turn), Update with touchpad sensors, 2015 world championships in Kazan= 1st time used • GPS on rowing boats for spectators to competitors' position, Use for the athletes to see themselves and their opponents? Tracks speed changes, direction= helpful for figuring out what other teams are trying to do • High-tech sensor system for archery scoring: what type of sensors? Also heart rate monitors for the spectators, why? • Shooting using laser tech for scoring, also radio-frequency id tags (RFID) to keep track of all guns • Weightlifting using a special camera, does it use sensors? • Virtual reality to advertise the opening/closing ceremonies, how do they work? • Visa bracelet/ring paying devices, waterproof (how?), also use near field communications (NFC) what is it?		
Biases of the authors	Advertising Rio 2016 Games		
My opinions on the paper	It was interesting to see the new technology used in sports.		
Follow up questions & ideas	• Can the rowing GPS be displayed for the athletes to see as well as the spectators? Why or why not? • What type of sensors were used for the archery scoring thing? And why do the spectators need to see the athlete's heartrate? • Does the special camera for weightlifting use sensors, and if so, what type of sensors? • How do virtual reality glasses work?		

	• What makes the Visa ring waterproof? And what is NFC?
keywords	Rio, Olympics, Technology, digital lap counters, innovations

Caudell, Augmented Reality: An Application of Heads-Up Display Technology to Manual Manufacturing Processes

Original URL	http://ieeexplore.ieee.org.ezproxy.wpi.edu/stamp/stamp.jsp?tp=&arnumber=183317		
File name of PDF	160915_caudell_headsup.pdf		
Date written	7-10.01.1992	**Date accessed**	15.09.2016
Type of paper	Article		
Goal of the paper	To lower costs and increase efficiency of the human-involved aspects of aircraft manufacturing.		
Major findings	“Projecting” images onto surfaces using heads-up display technology (Google Glass type stuff)		
Notes on the paper	• Heads-up display used with head position sensing • Put simply, projects an image holograph-style but the display is on some type of goggles • If successful, will help lower cost and improve efficiency by “eliminating templates, form board diagrams, and other masking devices”		
Biases of the authors	They work for Boeing so they want this to work.		
My opinions on the paper	Abstract: nice and simply detailed project. I know what they are going to do.		
Follow up questions & ideas	• Proximity sensors for the head position sensing? Or motion sensors?		
keywords	Augmented reality, Two dimensional displays, Manuals, Manufacturing processes, Aircraft manufacture, Robotics and automation, Virtual reality, Robotic assembly, Aircraft propulsion, Production facilities, computer graphics, CAD/CAM, heads-up display technology,		

Hagem, Self-Contained Adaptable Optical Wireless Communications System for Stroke Rate During Swimming

Original URL	http://ieeexplore.ieee.org.ezproxy.wpi.edu/xpls/icp.jsp?arnumber=6515615#article		
File name of PDF	160925_hagem_wireless.pdf		
Date written	July 10, 2013	**Date accessed**	25.09.2016
Type of paper	Journal Article		
Goal of the paper	To introduce a system that measures a swimmer's stroke rate and stroke length in order to display the swimmer's velocity in his/her goggles.		
Major findings	Created the system described above.		
Notes on the paper	• Used LEDs to indicate faster/slower/good pace to swimmers- I wanted to do that • Measured stroke rate from top to top and compared stroke rate for speed analysis • Real-time info is important for swimmers for training • Wireless communications: a) radio frequency is not good because water disrupts the waves b) acoustic communication is not fun for the swimmers, it's scary to hear someone talk to you when they shouldn't be able to/loud noises c) light waves are still messed up by the water but not as badly		
Biases of the authors	They want it to work.		
My opinions on the paper	I thought they worked backwards. They explained their own design last, which left me with a lot of questions that weren't answered until later.		
Follow up questions & ideas	• They mentioned injury recovery/prevention. Is there any way my project could help with that? • Wireless communication techniques? • How did they do that thing with the RGB LEDs without coach input?		
keywords	Underwater optical wireless communication, accelerometer, real time swimmers feedback, stroke rate, visible light communication		

Hagem, Coach-Swimmer communications based on wrist mounted 2.4 GHz accelerometer sensor

Original URL	http://ac.els-cdn.com.ezproxy.wpi.edu/S1877705815014915/1-s2.0-S1877705815014915-main.pdf?_tid=513ba2e6-8365-11e6-81a6-00000aab0f6b&acdnat=1474838365_ce6c534fb451a143a715d49feefbab08		
File name of PDF	160925_hagem_coach.pdf		
Date written	January 1, 2015	**Date accessed**	25.09.2016
Type of paper	Journal Article		
Goal of the paper	To introduce this system of coach to swimmer communication about stroke rate		
Major findings	Creating the system described above		
Notes on the paper	• Instant feedback from coach to swimmer • Measures stroke rate, stroke length, and velocity (same as the above article) • Radio frequencies still fail because the water still disrupts the waves • Sound feedback is still bad because no one can hear anything while they swim		
Biases of the authors	They want this to be a success		
My opinions on the paper	I was a little disappointed that they never mentioned the swimmer's display system. Is there even one? I thought it just repeated most of the same things as the article above, which is, coincidentally, written by the same authors.		
Follow up questions & ideas	• They never describe the display system that the swimmer sees		
keywords	Body sensor networks; real-time communication; gesture identification; acceleration measurements; swimming.		

Taba, Electronic Timing Swimmer's Goggles

Original URL	https://patents.google.com/patent/US5685722A/en?q=swimming+goggles&q=proximity+sensors		
File name of PDF	161003_taba_electronicTiming.pdf		
Date written	11.11.1997	**Date accessed**	10.3.2016
Type of paper	Patent		
Goal of the paper	To introduce a pair of swimming goggles with electronic timing and a display		
Major findings	Created technology described		
Notes on the paper	• used a lot of other patents • one of these patents describes a "submersible" device for non-contact timers • the device has an accelerometer that detect strokes and times them. it's able to distinguish flip turns as well • the accelerometer can also detect stops (end of race) • the device then displays the total time for the race and the last split time • also displays heart rate with flashing lights for increasing/decreasing • magnetic switches and wipers to count laps • has removable batteries • liquid crystal displays • for pulse monitor, has an LED or other light display		
Biases of the authors	They want this product to succeed.		
My opinions on the paper	It was very in depth. The wording was a little vague, which was odd, but I understood enough of it.		
Follow up questions & ideas	• Patents to look up: 5162828, 4757714, 5136621, 4776045, 4796987, 5258785 • how does the accelerometer help? • sound vs light underwater		
keywords	goggles, liquid crystal displays, accelerometer		

Yokota, Swimming Goggles

Original URL	https://patents.google.com/patent/US7165837B2/en?q=swimming+goggles&q=proximity+sensors&q=A63B33%2f002		
File name of PDF	161003_yokota_goggles.pdf		
Date written	1.23.2007	**Date accessed**	10.5.2016
Type of paper	Patent		
Goal of the paper	To make swimming goggles that make it easier to avoid light refraction and improve the field of vision		
Major findings	Created technology described.		
Notes on the paper	• not enough space in front of eyes = blurry vision • all the angles on this product are very specialized to make sure that there is no light refraction or any other issues with vision • nose bridge made of polyurethane plastic • goggle strap made of stretchy, rubbery elastic material • goggles made of transparent plastic (cellulosic plastic, acrylic plastic, polycarbonate, etc.) • suction cushion on eyepieces is removable (my goggles vs dad's) • optimizing field of vision by making the slant of the eyepiece offset from the direct line of sight		
Biases of the authors	They want the product to be successful.		
My opinions on the paper	I thought it was very interesting and descriptive. It wasn't hard to understand, just a little repetitive.		
Follow up questions & ideas	• how did they get the information about line of sight? -> surveys or experiments? • they keep mentioning graphics and colors and text and other visual display items to put in the difficult-viewing section of the goggles but they never mention what it'd be used for		
keywords	swimming goggles, line of sight		

Hazell, Spectacles with embedded segmented display comprising light guide end

Original URL	https://patents.go.com/patent/US2008v0316605A1/en?q=swimming+goggles&q=proximity+sensors&q=A63B33%2f002
File name of PDF	161003_hazell_spectacles.pdf
Date written	12.25.2008 — **Date accessed** 10.9.2016
Type of paper	Patent
Goal of the paper	To introduce an inexpensive optical device that has a display built into the device
Major findings	Created technology described
Notes on the paper	• 3 types of display: see-through, see around (slight obstruction to field of vision), and fully-blocking • use ‘optical guides’ to guide light into a segmented display • does not obstruct the wearer’s field of vision • references a “transparent substrate”, which is just the lens of the optical device (the clear part that you see through) • the display is focused at infinity allowing the user to see through the display and still be able to read the display • uses an angle to reflect the light at the end of the optical guide • displays can be numbers or letters and numbers, using 7, 14, or 16 segments • easily waterproofable • can be applied to cameras, car windshields, etc. • for swimming, can display time, distance traveled (lap count), heart-rate (they’re just spouting out ideas now) • can be used on normal correcting glasses as well • the characters in the display can be anywhere from 0.1 to 1 mm in height, though they are usually 0.5 mm • LEDs can/are used as the light source • Optical guides end in a way that it shows one segment/pixel of the display
Biases of the authors	They want the product to be successful.
My opinions on the paper	The paper was easy enough to understand once I found the first descriptions they used. They described things at the very beginning and it was very easy to miss. But then the rest of the patent didn’t make sense so I had to go back and reread.
Follow up questio	• look up patent 5,886,822 • refractive optics? • How do you focus displays at infinity? Just how does that work and what does it mean?

ns & ideas	
keywords	LED, display, spectacles

Chen, Design and Implementation of capacitive proximity sensor using microelectromechanical systems technology

Original URL	http://libraries.state.ma.us/login?gwurl=http://go.galegroup.com/ps/i.do?p=AONE&sw=w&u=mlin_c_worpoly&v=2.1&id=GALE%7CA57877561&it=r&asid=3a0d6c0a5c7a823b82718656bb09f416		
File name of PDF	161005_chen_capacitiveProximity.pdf		
Date written	12.1998	**Date accessed**	10.05.2016
Type of paper	Journal article		
Goal of the paper	To introduce a proximity sensor that uses microelectromechanical systems technology		
Major findings	Created and tested technology described		
Notes on the paper	• Very small sensors, but size is flexible • Use "smart sensors" • Apparently 4/5 measurements in industry are displacement measurements • Two types of capacitive sensors: 1. Parallel-plate capacitor 2. Fringe capacitor • Parallel-plate: sensor is one plate and object is the other, object must a conductor for sensor to sense it, useless when object in rotating or is coated in something • Fringe: electrodes, metal screens, and other stuff I don't understand		
Biases of the authors	They want their idea to be used and to be successful.		
My opinions	The article gave me a good basic overview of the two types of capacitive sensors. The science behind it is a little too complicated for me, however, which made it very hard to understand the article.		

on the paper	
Follow up questions & ideas	• What are "smart sensors"?
keywords	fringe capacitance, microelectromechanical systems, proximity sensor

Nath, RFID Technology and Applications

Original URL	http://ieeexplore.ieee.org.ezproxy.wpi.edu/document/1593567/?reload=true		
File name of PDF	161009_nath_rfid.pdf		
Date written	January 2006	**Date accessed**	10.09.2016
Type of paper	Journal Article		
Goal of the paper	To explain the technology and applications of RFIDs		
Major findings	The applications of RFIDs		
Notes on the paper	• Battery-less tags read by a reader • "EZ-Pass" • Static readers: don't move: for car rentals? • Luggage labels also? • Mobile readers: put it in our phones to use as price scanners?		
Biases of the authors	None		
My opinions on the paper	It was quite literally just applications, which was kind of annoying because I wanted how the technology works.		
Follow up questions & ideas	• "An Introduction to RFID Technology" by Roy Want		
keywords	RFID, applications, technology		

Schill, Visible Spectrum Optical Communication and Distance Sensing for Underwater Applications

Original URL	n/a		
File name of PDF	161025_schill_underwater.pdf		
Date written	2004	**Date accessed**	10.25.2016
Type of paper	conference proceedings		
Goal of the paper	To introduce an optical communication system for underwater applications		
Major findings	Tested the system described above		
Notes on the paper	• Used LEDs to measure the efficiency of an optical communications system • Low bandwidth for data, but still sufficient enough for this purpose • Compromise speed for range • They want: a communication range of more than one meter, multidirectional coverage, small size, and low cost-------- it's their design matrix • Longer ranged devices are too big for their application: swarm robot communication • Different wavelengths of visible light are absorbed at different rates • Two parts: transmitter and receiver • Prototype costs: AUS$ 45 each or $34.59 USD each • Distance sensing is done by using time received and kinematics		
Biases of the authors	They want their system to work.		
My opinions on the paper	I thought the paper was easy enough to read, but the authors used a lot of jargon that I didn't know.		
Follow up questions & ideas	• How fast is the data relayed to the display? • Is this all instantaneous?		
keywords	distance sensing, optical communication, underwater technology		

Schill, Personal Communication

Original URL	n/a		
File name of PDF			
Date recieved		**Date accessed**	
Type of paper	email		
Goal of the paper	response to my email		
Major findings			
Notes on the paper	Hi, Thank you for your interest :) The output is pretty much instantaneous in terms of data transmission (6000 bytes/second, so more or less 1/6000 sec latency per transmitted byte). However, as I understand you are not interested in the data transmission part, but rather the distance sensing? In my paper, the distance/proximity sensing was a neat side-effect in a device primarily designed for communication. The method indirectly measures the signal strength by looking at the number of received bytes as a proxy for the bit error rate. This only works in a small range where the signal strength is at the edge of the range - if the signal is too strong, no bytes are lost, so the only distance information you'd get is "it's close", but not how far away. Also, to get the error statistics, one needs to integrate over a number of bytes, which increases the delay - but looking at 100 bytes would still give you 1/60 sec latency which is still pretty fast. The size of the device back then wasn't optimized, but I'm currently working on a similar optical modem for my company Hydromea(http://hydromea.com) which is 30x50mm, with 9 LEDs. It could be made a bit smaller with less LEDs. There is other work by some colleagues done in air, specifically for distance sensing using similar methods. In this case they directly measure the received signal strength of the optical pulses, instead of the detour through an IrDA decoder chip, as they didn't need to communicate through the device. Here are some references: https://infoscience.epfl.ch/record/131138/files/IEEE-ASME-TMech09_camera-ready.pdf https://infoscience.epfl.ch/record/139026/files/RobertsIROS2009_2.pdf Maybe also look up James Robert's thesis, it might contain more information. What you should be aware of however is that in all cases, the light emitter is well-known and the signal has direct line of sight, while in your case I assume the light is indirectly reflected off a wall, so the signal strength also depends on the color and brightness of the wall, reducing the accuracy. As pools are pretty consistent it might not be a big problem, depending on the accuracy you need. For precise distance measurements underwater you might also want to look at acoustic systems (ultrasound). Underwater acoustics is generally tricky, and you probably want a very small system, but for the relatively short distances in your project it could be doable. There are some ultrasonic transducers for cars (reverse parking sensors) that are splash-proof/waterproof, you might be able to use those, and an adapted circuit of an ultrasonic distance sensor for air, and get some results. Alternatively, you could try some of the new low-cost Lidar sensors (time of flight with light), e.g. TeraRanger, or check at Sparkfun electronics. The problem here is that IR light doesn't go through water terribly well, you'll want blue or green light, but it might be another avenue to explore.		

	Best of luck, Felix
Biases of the authors	
My opinions on the paper	
Follow up questions & ideas	
keywords	

Schill, Personal Communication

Original URL			
File name of PDF			
Date written	11.7.16	**Date accessed**	11.7.16
Type of paper	Personal Communication		
Goal of the paper			
Major findings			
Notes on the paper	Hi, Radio communication in water doesn't work terribly well, particularly at high frequencies. In saltwater, wifi or bluetooth would only have a range of a few centimeters. In freshwater it might work for very short distances (<1m). I'd recommend doing a very quick test first to see if it's feasible, before investing time. Lower frequencies work better, but it's more difficult to find radio modules sub-Ghz. Underwater can be challenging... :) But if in doubt, just try it out and see what works :) All the best, Felix		
Biases of the authors			
My opinions on the paper			
Follow up questions & ideas			
keywords			