Introduction

Our personal experiences involving bars, restaurants, and the environments they create.
Objective

Create a device for bar and restaurant owners that would allow their businesses to be more accessible to those with sensory processing disorders.
Our entire product must be simple, small, and effective.

In order for business owners to elect for the use of our device, certain parameters must be met. The device must be simple to set up/use, unobtrusive, and useful in the information it presents.

In order for bar and restaurant patrons to want to use our data, it must be accessible and easily understood, such that those who want to view the information have minimal difficulty doing so.
Our Solution
Final Product - Physical Unit
## Sensory Awareness, Champaign-Urbana

Project for SP22 ECE 445 by Megan Heinhold, Evan Lindquist, and Carl Wolff

### About the data

<table>
<thead>
<tr>
<th>Device One</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last updated: April 27, 2022 at 02:18PM</td>
</tr>
<tr>
<td>Dangerous sound levels detected in last 10 minutes? yes</td>
</tr>
<tr>
<td>Flashing lights detected in last 10 minutes? no</td>
</tr>
<tr>
<td>Sound level: <strong>moderate background noise</strong></td>
</tr>
<tr>
<td>Light level: <strong>very bright</strong></td>
</tr>
<tr>
<td>Temperature: 73.84 F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Murphy’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous sound levels detected in last 10 minutes? yes</td>
</tr>
<tr>
<td>Flashing lights detected in last 10 minutes? no</td>
</tr>
<tr>
<td>Ambient sound level: loud</td>
</tr>
<tr>
<td>Ambient light level: dark</td>
</tr>
<tr>
<td>Temperature: 85 F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kam’s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous sound levels detected in last 10 minutes? yes</td>
</tr>
<tr>
<td>Flashing lights detected in last 10 minutes? yes</td>
</tr>
<tr>
<td>Ambient sound level: loud</td>
</tr>
<tr>
<td>Ambient light level: dark</td>
</tr>
<tr>
<td>Temperature: 78 F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BreadCo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous sound levels detected in last 10 minutes? no</td>
</tr>
<tr>
<td>Flashing lights detected in last 10 minutes? no</td>
</tr>
<tr>
<td>Ambient sound level: quiet</td>
</tr>
<tr>
<td>Ambient light level: dark</td>
</tr>
</tbody>
</table>

Flashing lights are defined as light levels changing drastically at a rate of **10-12 Hz**.

Dangerous sound levels refer to noise that peaks above **110 dB**.

*Each of these circumstances pose a threat to your health and safety, especially if you have epilepsy, a sensory processing disorder, or another condition that might make you more bothered by sensory overload.*

Overall sound falls into **“little background noise,” “moderate background noise,” “significant background noise or light music,” “significant background noise or loud music,” and “very loud” categories.**

Overall light falls into **“very dark,” “dark,” “ambient lighting”, “bright,” and “very bright”**.
Design and Build
Power Supply

- Provides 0.5 A at 5 V +/- 0.5% from a wall power adaptor
- Provides 0.1 A at 3.3 V +/- 0.5% from a fixed LDO

Why LM1086-3.3?
- Needed an LDO since converting from only 5 V to 3.3 V
- Fixed 3.3 V output since we don’t need to adjust our output
Control Unit

- Minimum of six GPIO pins that can sink/source 20 mA +/- 0.5% at 5 V +/- 0.5%
- A/D converter with at least ten bits of resolution and three available channels
- Must be able to communicate with 3.3 V UART signals

Why ATmega88A?
- Exceeded minimum specs (RAM, program memory)
- Through-hole packaging available
WiFi Module

- Must be able to send and receive data over UART
- Must be able to connect to WiFi network and send an HTTP request

Why ESP8266-01?
- Cheapest integrated package
- Exceeded minimum specs (RAM, program memory)
- Small footprint
Sensor Block

- Sensor outputs must always be less than 20 mA and between 5 V and 0 V

Why this photoresistor?
- In general, allowed for an analog reading (in contrast to photodiode or phototransistor)
- Photoresistor and accompanying resistor sized to maximize ADC usage while minimizing power consumption
Software

Sampled data (device) → HTTP POST request (WiFi module) → Google Sheet storage (IFTTT) → Front end web application
PCB Fabrication

Major changes from PCB 1 to PCB 2:
- Added additional connectors to the microcontroller and wifi chip for debugging
- Added a connector that could function as a power supply
- Changed mini-USB to micro-USB plug
- Corrected incorrect footprints (capacitor, LDO)
Driving Factor:

Stability in temperature readings
Introduction of the Logic Level Converter

Logic Level Converter

HV = High Voltage
LV = Low Voltage

5V

3.3V

Input/Output

= WiFi Chip Voltage
= Microcontroller Voltage
Driving Factors:

Avoid bricks, stable data transmission

* we ran the same code on these two devices with identical connections (i.e. we did not use any of the additional Development Board features)
Major Changes

Embedded WiFi Chip Software

- Switched from the WiFi chip continuously polling to an “interrupt-like” method

**Continuous Polling**

1. Begin serial communication
2. Connect to WiFi network
3. Six serial items available?
   - False: Send negative response over serial lines
   - True: Decode six items from serial feed
   - True: Send HTTP post request
4. JSON file updated?
   - False: Send positive response over serial lines
   - True: Six serial items available?

**“Interrupt-like” Method**

1. Wait for RST signal from microcontroller
2. Begin serial communication
3. Connect to WiFi network
4. Decode six items from serial feed
5. Enter Deep Sleep
6. Send HTTP post request
7. Delay for microcontroller to send six serial items
8. Six serial items available?
Major Changes

Higher Level Software
Conclusions

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Results</th>
<th>Requirements</th>
<th>Results</th>
</tr>
</thead>
</table>
| 1. The power supply provides 5 V +/- 0.5% from a wall power adaptor.  
2. The power supply provides a 3.3 V +/- 0.5% from a low dropout regulator driven by the 5V mentioned above.  
3. The power supply is able to operate within 0-1 A from the 5 V source and able to operate within 0-0.1 A from the 3.3 V source. | passed | 1. The C++ program must take raw input data from 3 sensors over the span of 10 minutes and output averaged levels in terms of temperature, light, and sound.  
2. Data from the microcontroller must be able to be transmitted via the WiFi module to the JSON file.  
3. The web application must display updated data within 1 minute +/- 30 seconds. | passed |
| 1. There must be a total of six GPIO pins that can appropriately handle signals between 0 V and 5 V +/- 0.5% while sinking/sourcing at least 20 mA +/- 0.5% of current per pin.  
2. The RX pin must be able to interpret 3.3 V +/- 0.5% signals (from WiFi chip) as logical HIGHs.  
3. There must be an A/D converter with at least ten bits of resolution and three available channels which can be read sequentially. | passed | 1. The output of the photoresistor must be within 0 V and 5 V +/- 0.5% with a current of no more than 20 mA +/- 0.5% in various light levels.  
2. The microphone output must be within 0 V and 5 V +/- 0.5% with a current of no more than 20 mA +/- 0.5% depending on sound levels.  
3. The temperature sensor output must be within 0 V and 5 V +/- 0.5% with a current of no more than 20 mA +/- 0.5% depending on temperature. | passed |
| 1. The chip must be able to take commands via UART from an external microcontroller.  
2. The RX pin must be able to handle a 5 V +/- 0.5% signal (from the microcontroller) without breaking the chip.  
3. The chip must be able to connect to a network and send 4 kB (max size) of data supplied by the microcontroller once every ten minutes +/- thirty seconds. | passed |
What We Accomplished

- Safety alerts identified
- Ambient sound and light levels classified
- Enclosure completed (25% of goal size)
- Data interpretation and display on frontend (down from 10 minutes to 1 minute)
Future Recommendations

Going Further

- Use more powerful components
- Add music genre identification
- Reduce words on webpage
- Integrate location information into web application
- Allow for interaction and feedback to web application
Thank you!

Any questions?
Appendices
void setup() {

    Serial.begin(115200);
    pinMode(micD, INPUT);
    pinMode(micA, INPUT);
    pinMode(tempSensor, INPUT);
    pinMode(lightSensor, INPUT);
    pinMode(rstPin, OUTPUT);
    digitalWrite(rstPin, HIGH);
}

void loop() {

    int buf = 0;
    int util = 0;
    int maxVol = 0;

    digitalWrite(rstPin, LOW);
    delay(20);
    digitalWrite(rstPin, HIGH);
    delay(180);

    // Temperature Signal
    for(int i = 0; i < 16; i++) {
        buf = buf + analogRead(tempSensor);
    }
    buf = buf >> 4; // average

    sendChar((char)(buf)); // chop off two Lsb's to allow a send over one byte
    sendChar((char)(buf >> 8)); // chop off two Lsb's to allow a send over one byte

    // Microphone Signals
    for(int i = 0; i < 3000; i++) {
        buf = analogRead(micA);
        if(buf > maxVol) maxVol = buf;
    }
    sendChar((char)(maxVol >> 2));
    buf = 0;
    for(int i = 0; i < 1024; i++) {
        if(digitalRead(micD))
            buf = buf + 1;
    }
    if(buf > 4)
        sendChar('1');
    else
        sendChar('0');

    // Photoresistor Signals
    buf = 0;
    maxVol = analogRead(lightSensor);
    for(int i = 0; i < 16; i++) {
        int x = analogRead(lightSensor);
        buf = buf + x;
        if(abs(maxVol - x) > 50)
            util++;
        delay(30);
    }
    buf = buf >> 4;
    sendChar((char)(buf >> 2));
    if(util > 1)
        sendChar('1');
    else
        sendChar('0');
    sendChar('\n');
    delay(10 * 10000);
void initWiFi() {
    WiFi.begin(ssid);
    while(WiFi.status() != WL_CONNECTED) {
        yield();
    }
}

void httpRequest() {
    WiFiClient client;
    int retries = 5;
    while(!client.connect(server, 80) && (retries-- > 0)) {
        delay(2);
    }
    float trueTemp = (((float)temp * 5.0 / 1024.0) - 0.5) * 100.0 * 9.0 / 5.0 + 32.0;
    String jsonObject = String("\"value1\":\"" + trueTemp + ",\"value2\":\"" + noise + ",\"value3\":\"" + light + \");
    client.println(String("POST " + resource + " HTTP/1.1"));
    client.println("Host: " + server);
    client.println("Connection: close\nX-Content-Type: application/json");
    client.println("Content-Length: \\");
    client.println(jsonObject);
    String ans = client.readString(); // String ans = client.readString();
    int timeout = 5 * 10; // 5 seconds
    while(!Serial.available() && (timeout-- > 0)){
        delay(100);
    }
    client.stop();
}

void serialDecode() {
    char buf[7];
    while(Serial.available() < 7) {
        delay(2);
    }
    buf[0] = Serial.read();
    buf[1] = Serial.read();
    buf[2] = Serial.read();
    buf[3] = Serial.read();
    buf[4] = Serial.read();
    buf[5] = Serial.read();
    buf[6] = Serial.read();
    int temp = (((int)buf[1]) << 8) + ((int)buf[0]);
    int noise = (((int)buf[2]) << 2);
    int light = (((int)buf[4]) << 2);
    if(buf[3] != 0)
        noise = 1;
    if(buf[5] != 0)
        light = 1;
    while(Serial.available()) {
        Serial.read();
    }
}
Conclusions

What We Learned

- PCB best practices
- How to choose components online
- How to integrate sensor data into web design

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(Main section divider slide, background image option six.)
Heading

(Transition slide option two.)
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(Use a photo for the entire slide like the example shown here. Send the photo to the back so the Block I and footer text is not covered.)

(Slide the blue transparent box and the text left or right to fit over your background image. Use this text box for a call out or caption to the image.)

\[
\begin{align*}
\alpha < 1 \\
\frac{x - x_n}{x_n - x} \left( h' \right) & \leq \left( h(x) - h(x_n) \right) + \frac{\alpha}{2} \left( h(0) - h(1) \right) \\
\end{align*}
\]
Summary
Thank You
Questions
Contact Information

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