TispyTracker

Ece 445 Project Proposal - Spring 2023

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1. Introduction

1.1. Problem

Irresponsible drinking is a widespread problem, especially among university students. Unfortunately, many people often lose control of their alcohol consumption simply due to a lack of awareness of how much they have consumed. The statistics are clear: according to the Centers for Disease Control and Prevention (CDC), excessive alcohol consumption leads to the deaths of more than 140,000 individuals each year (NPR 2022). By promoting responsible drinking habits and encouraging individuals to take control of their own actions, we can work towards reducing the harm caused by this preventable issue. Our mission is to proactively tackle this challenge head-on, particularly during social gatherings and parties, by developing a cutting-edge system that monitors alcohol intake.

1.2. Solution

To address this, we have developed TipsyTracker, a system that encourages responsible drinking and keeps individuals informed about their blood alcohol content (BAC) levels. Upon arrival, guests will sign-in to the registration station (the host's computer) and will be given an RFID-enabled wristband/card that is attributed to their name and phone number. After a certain time period, the guest will be notified (via text) to scan their BAC levels at the TipsyTracker device. The device is controlled by an ESP32 microcontroller and consists of an RFID sensor, breathalyzer sensor, and an LED. The guest will scan their RFID tag, and once the LED turns green, breathe into the breathalyzer module that calculates their BAC levels. This information is then sent to an off-PCB Raspberry Pi. The Pi maintains the necessary software and databases, handles communication between the device and registration station, and sends notifications. If a guest's BAC level exceeds a predetermined limit, the host and guest will be notified, which encourages safe drinking. By promoting awareness and responsibility, TipsyTracker is an effective solution to the issue of excessive alcohol consumption.

1.3. Visual Aid



1.4. High-Level Requirements

- Accurate Alcohol Monitoring: The device must provide precise and reliable alcohol monitoring, ensuring that Blood Alcohol Content (BAC) readings are consistent and accurate within a +/- 5% tolerance.
- 2. Instant Results: The device must enable quick and convenient testing, delivering instant results that are available on the web-portal in less than 10 seconds.
- 3. User capacity: The device must be able to accommodate and store BAC test results for at least 500 partygoers.

2. Design

2.1. Block Diagram



2.2. Subsystem Overview and Requirements

2.2.1. Subsystem 1: RFID Identification

Overview:

This subsystem will be responsible for identifying each partygoer by reading their RFID-enabled wristband/card when they initiate a breath test, and will utilize the MFRC522 RFID sensor. This subsystem will be connected to the ESP32 microcontroller that wirelessly sends this data to the Raspberry Pi, which correlates an RFID to a user's name and phone number.

Requirements:

- Needs to read tags with high degree of accuracy
- Must transmit to microcontroller at minimum 9600 baud rate
- Must be sufficiently polled by the microcontroller to prevent any missed scans and ensure accurate monitoring of tag readings.

2.2.2. Subsystem 2: Breathalyzer Measurement Subsystem Overview:

This subsystem revolves around the MQ-3 breathalyzer sensor and will be responsible for measuring the BAC levels of the partygoers. This module will be connected to the ESP32 microcontroller and will communicate with the RFID identification subsystem to ensure that the test results are associated with the correct partygoer. A light will turn green when the device is ready for a partygoer to test their BAC.

Requirements:

- Needs to read BAC levels with a deviation of less than 5%
- Must transmit to microcontroller at minimum 9600 baud rate
- The microcontroller must effectively poll the breathalyzer module to ensure seamless synchronization with the RFID scans and accurate attribution of readings to the appropriate partygoer.
- Ensures the LED lights up when the device is ready for BAC levels to be tested

2.2.3. Subsystem 3: Data Measurement Subsystem

Overview:

This subsystem will be responsible for handling the communication between the device and the registration station, as well as sending notifications to partygoers and the host. It will be powered by a Raspberry Pi, which will handle data storage, analysis, and management of the entire system. It will also send notifications to partygoers at set intervals to remind them to test their BAC levels, and notify the host.

Requirements:

• Needs to send notifications at correct time frames, so that the successive updates are correctly monitored

- Notifications need to be sent to the correct person associated with each BAC measurement/RFID
- Data must remain tamper-proof/non-exportable
- Needs to maintain reliable communication with the microcontroller

2.2.4. Subsystem 4: Power Control

Overview:

The Power Subsystem will be a crucial component in ensuring the seamless functioning of the entire system. The Micro USB 5V & USB-UART will serve as the primary source of power, providing the necessary voltage to establish a stable connection with the ESP32. The 5V voltage from the USB-UART will be then transformed through a voltage transformer to a consistent 3.3V, which will sustain the operational needs of the ESP32, LED, and RFID sensor. However, the MQ-3 peripheral will need to be directly powered by the 5V output. This subsystem will play a vital role in ensuring the system runs smoothly and efficiently.

Requirements:

- Needs to power the MQ-3 sensor with a steady 5V and at least 150 mA.
- Needs to convert 5V to 3.3V power and produce at least 150 mA to power the ESP32, LED, and RFID sensors
- Must maintain stability and withstand any voltage fluctuations, operating within a tolerance of +/- 0.2V.

2.3. Tolerance Analysis

Datasheet Conversion from MC3 Voltage to PPM



Let **X'** and **Y** be the analog readings from the MQ-3 sensor and a standardized breathalyzer tool, respectively. X will be an analog value 1023. We will map X' to a number between 0V and 5V linearly. Using the data sheet above, we will convert from Volts to ppm, the inverse of which will give us **X** in mg/dL (BAC units). We will then perform the following analysis between **X** and **Y**.

The Pearson correlation coefficient, denoted by r, is calculated as:

r = **cov**(**X**, **Y**) / (**std**(**X**) * **std**(**Y**)) [Eq1]

where **cov**(**X**, **Y**) is the covariance between **X** and **Y** and **std**(**X**) and **std**(**Y**) are the standard deviations of **X** and **Y**, respectively. The covariance is calculated as:

$$cov(\mathbf{X}, \mathbf{Y}) = \mathbf{E}[(\mathbf{X} - \mathbf{E}[\mathbf{X}])(\mathbf{Y} - \mathbf{E}[\mathbf{Y}])$$

where **E**[**X**] and **E**[**Y**] are the expectations of **X** and **Y**, respectively. The standard deviation is calculated as:

where **var(X)** is the variance of **X**.

The Pearson correlation coefficient is a measure of the linear relationship between X and Y. If the correlation coefficient is close to 1, it indicates a strong positive relationship between the two measurements, which is necessary for the TipsyTracker to work reliably. On the other hand, a correlation coefficient close to -1 indicates a strong negative relationship, while a correlation coefficient close to zero indicates a weak relationship between the two measurements. The correlation coefficient should be calculated and analyzed to assess the accuracy of the MQ-3 sensor and ensure that the TipsyTracker works reliably.

3. Ethics and Safety

The ethics and safety of our system, TipsyTracker, are of utmost importance. There are potential ethical and privacy concerns surrounding the collection and use of data. To

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ensure that privacy is maintained, we will temporarily collect and store the minimum necessary data and promptly remove it after every party. Furthermore, notifications will only be sent to guests and the host in accordance with the set intervals and BAC thresholds, and will not be shared with third parties or easily exported by the host. To ensure transparency, we will have clear and open policies regarding data collection and storage, providing users access to all their data. This aligns with the IEEE Code of Ethics, which states: "to accept responsibility in making engineering decisions consistent with the safety, health and welfare of the public, and to promptly disclose factors that might endanger the public or the environment" (IEEE, 1).

It is our duty to ensure that our users are fully informed and kept up-to-date in the event of any outages. In situations where individuals may have relied on our system to monitor and regulate their alcohol intake, it is of utmost importance that we promptly communicate any system failures. This not only helps to protect our users' health and well-being, but it also aligns with our moral obligations to provide accurate and timely information. In the event of a system shutdown, it is our responsibility to immediately notify users and advise them to closely monitor their behavior until the system is fully restored.

To combat misuse of TipsyTracker, we will make a clear emphasis on the system's proper utilization. The ACM Code of Ethics and Professional Conduct highlights the importance of responsible behavior, stating: "Maintain high standards of professional competence, conduct, and ethical practice" (ACM, 1). The instructions for using TipsyTracker will emphasize its intended purpose of promoting responsible drinking and avoiding any malicious use, such as deliberately not informing guests of their BAC levels, which could put them in danger by misleading them into thinking they are drinking responsibly.

With regards to safety, the potential for electrical equipment being near liquids is a concern. To mitigate this risk, we will enclose our system in a water-resistant encasing, and also protect the power source. Furthermore, when developing our system, we will

make sure to adhere to safety standards and regulations. By prioritizing ethics and safety, we aim to promote responsible drinking and reduce harm caused by excessive alcohol consumption, while upholding the standards set by the IEEE and ACM Codes of Ethics.

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