Project Proposal

Customer Problem

Client

For Canadian Youth, aged 15 to 17, grappling with dysthymic disorder, which is a milder but long-lasting form of major depression. Research from Cook, Peter and Sheldon estimated that 1.6%-8% of adolescents have dysthymic disorder, which implies that among 1200000 youth from 15 to 17, 19200-96000 youth have depression[1,2].

We're here to help Canadian teens aged 15 to 17 who are going through depression

Main Challenge Defined

1. Software
    a. User interface / experience: A user-friendly interface is paramount as it enhances effective communication with users and facilitates the provision of appropriate solutions. Given our limited expertise in coding, achieving this objective presents a substantial challenge for our team.

- User interface design: creating an intuitive and user-friendly interface for users to interact with the device and receive solutions is important. Given our limited expertise in coding, achieving this objective presents a substantial challenge for our team.

2. Hardware
    a. Sensors and Biometrics: Within the scope of this project, the task of discerning the suitable sensors for data acquisition poses a noteworthy challenge. The project entails the utilization of commonplace sensors such as those employed in voice analysis and vibration monitoring. It is imperative to acknowledge that each of these sensors possesses inherent limitations and necessitates meticulous integration.

- Sensor selection: Choosing appropriate sensors (e.g.voice analysis, vibration monitoring sensor) is crucial. Different sensors have varying levels of accuracy and suitability for depression detection. Additionally, it's important to assess whether the sensor is well-suited for human use.

- Build the device: maximize the use of sensors while minimize the device's size can be challenging, especially when incorporating a microcontroller and power source.

Problem Statement

Nowadays, dysthymic disorder is not uncommon among teenagers. Teenage dysthymic disorder can be caused by a combination of genetic, environmental, and psychological factors. Common triggers may include academic stress, family issues, and personal trauma.

Additionally, teenagers often refrain from seeking assistance directly, and some of them may not even recognize what they are experiencing matches the symptoms of dysthymic disorder, such as low self-esteem, loss of interest in activities, and persistent feelings of sadness.

The research shows that “[4]59.8% of youth with major depression do not receive any mental health treatment [while] 78% [Asian youth with major depression] reporting they did not receive mental health services in the past year” This could be due to various factors, such as “[3]lack of knowledge about mental health” and “not recognised the need for professional help”.

Utilizing the dysthymic disorder detection device for personal use has the potential to enhance mental well-being and subsequently improve the overall quality of life. This device could be particularly beneficial for adolescents grappling with dysthymic disorder, as it may contribute to a reduction in feelings of sadness and anxiety, ultimately leading to an enhanced emotional state. Consequently, they may find it easier to participate in daily activities and pursue their personal goals. Additionally, for government entities, successful management of dysthymic disorder through this device could translate into reduced healthcare expenditures, potentially resulting in cost savings within the healthcare system.

Stakeholder

1. Teaching Assistant(TA)

   The graduate TA has over six years of experience as a full-stack software engineer, which means he can offer valuable professional insights, and assess our project. Concurrently, his primary expertise lies in the field of social robotics. Following the completion of project visualization and the establishment of fundamental software and hardware components, we can start building robots aimed at assisting teenagers in diagnosing dysthymic disorder and presenting potential remedies.
2. Teenager

Teenagers are the primary target beneficiaries of the dysthymic disorder detection device. This device aims to provide a means for early detection of dysthymic disorder, potentially leading to timely intervention and support. Understanding teenagers' needs, preferences, and the user-friendliness of the device is crucial to its success. Their feedback and engagement are essential for effective device development and adoption.

3. Hospitals / Mental Health Clinic
    a. Hospitals and Mental Health clinics are important stakeholders as they could either use the device or collaborate as partners in its implementation. The device has the potential to be utilized within clinical contexts to assist in diagnosing and treating dysthymic disorder. Meanwhile, these entities, being situated within genuine medical environments, can offer valuable service data, thereby contributing to enhancing the device's precision, dependability, and integration with established healthcare systems.

4. Suppliers of Client
    a. Suppliers play a critical role in the project's success as they provide the necessary materials, components, or technology for the device's production. They are stakeholders because the project's timeline, cost, and quality depend on the suppliers' performance. Effective communication and collaboration with suppliers are essential to secure the required resources and ensure the device's timely and cost-effective development.

5. General Public
    a. With the wide implementation of this device, the device could be used as a mechanism for the general public to better understand what dysthymic disorder is and how to help people with dysthymic disorder. As a result, it could increase the awareness one has about the disorder and subsequently people with the disorder could more likely get help from others.

6. Special Interest Groups (Researchers)
    a. Researchers could retrieve the database of the device obtained through sample conversations of patients with dysthymic disorder to aid their research on the speech of people with dysthymic disorder, and subsequently develop more effective methodologies to combat such disorders.

Initial Requirements

Functional Requirement

1. User data storage capacity: computer storage and memory should be at least 1TB.
2. Data recovery time(software): Make sure the average data recovery time is no more than 4 hours[6].
3. Data transmission speed(hardware): Ensure that the data transmission speed falls within the standard range, which spans from 1 to 100 megabits per second[7].

Requirement Reason Explanation

1. The computer storage employs a flat-file database to save words and their single-digit frequency. With 170,000 words averaging 4.7 characters each, this totals 799,000 bytes, equaling 799 KB. To calculate space per word, add word length (4.7 characters) and frequency space (1 character) for 5.7 characters per word. Thus, you need around 946KB of storage. You can consider options like a 128GB SSD, 500GB HDD, or a 1TB external hard drive.
2. The four-hour recovery period guarantees consistent data retrieval and prevents data loss. This timeframe is chosen because it allows the database to be fully replicated and meets the Recovery Time Objective in less than four hours.
3. The 1-100 MB/s is a standard range of data transportation. By setting it in a standard range, it ensures the reliability and efficiency of the data transfer.

Technical Requirement

1. Sound detection sensitivity: the sound detector should have a sensitivity range between 20 and 120 dB to capture relevant audio cues[8].
2. LED brightness: the brightness of an LED display in a room is about 300cd/m^2 - 600cd/m^2, the brightness requirement is proportional to the size of the room[9].
3. Vibration Time: The system should vibrate for at least 18 seconds, representing the reaction times for people to make more complicated decisions involving six to twelve choices[10].

Requirement Reason Explanation

1. The sound was set to 20 dB as sounds below 20dB are barely audible, while it was set to 120 dB to prevent ear damage. This technical requirement protects the ear safety of users.

2. The minimum of LED brightness was set to 300cd/m^2 as the visibility may be affected under this range, while the maximum is set to 600cd/m^2 to avoid the overexposure of light that results in ear damage.

3. The vibration time was set to 18 seconds because such time allows people to make a comprehensive decision on clicking the “accept” or “reject” button by giving them sufficient time.

Safety Requirements

1. Maintain your equipment in optimal condition by conducting thorough checks on all sensors prior to usage, ensuring the keyboard functions effectively, and making sure complies with electrical safety standards to prevent electrical hazards.
2. Provide user manuals and educational material to help users understand how to use the device effectively

Principles(scientific / mathematics)

(1) Ohm's Law

a. Ohm's Law is expressed as the equation V = IR [11], which defines the connection between voltage, current, and resistance. By utilizing the given current from the circuit and the resistance from the STM32F401RE, we can compute the necessary input voltage for the circuit. This voltage value is also valuable for validating whether the product exceeds the 30W power requirement specified in the "ECE 198 Project Requirements," by employing the formula $P = \frac{V^2}{R}$.

(2) Inter-integrated circuit: I^2C

a. The I^2C standard is a protocol that regulates the procedure of data communication between a circuit and a microcontroller. Section 3.2.7 states the methodology of data transfer from a transmitter to a receiver after meeting the START condition outlined in Section 3.1.4 stating that the "START and STOP conditions are always generated by the controller"[14] This protocol will be implemented when we transfer data like wordlist conditions and buzzing command from the STM32F401RE microcontroller to the hardware installed inside the product like a vibrator.

(3) Statistical distribution: minimum, maximum, mean, standard deviation. Make decisions based on the properties of the statistical distribution of information/data collected.

a. The product would compute the statistical distribution by first computing how many times on average patients need to say a specific word signifying dysthymic disorder in order for the users to identify that the patient has dysthymic disorder. To increase or decrease the average, the user could click the "accept" button of the system before it vibrates to signify they think the patient has a dysthymic disorder or click the "reject" button after the system vibrates to signify they do not think the patient has a disorder at that time.

To reduce the possibility of bias, the system would remove the minimum and maximum of the set of data, along with the outliers, during the calculation of the average. The initial average of every specific word on the dysthymic disorder wordlist would be set to 2, meaning that the user would need to say the specific word 2 times in order for the system to vibrate.

Define Set T as $T = \{t_1, t_2, t_3 ... t_n\}$ where t_n represents the number of times that the n^{th} patient says a specific word that possibly represents dysthymic disorder, and inside Set T, we assume that t_1 and t_n are minimum and maximum of the data set. We also define set S as $S \in T$ where S includes m records that are the outliers of T. Using the above definitions, we could propose the following formulas for this mathematics principle:

$$\text{Standard Mean of T} = \frac{t_1 + t_2 + t_3 ... + t_n}{n}[13] \qquad \text{(Formula 1)}$$

Outlier Formula: t_n is considered an outlier of set T if and only if

$$t_n > 1.5\ \text{IQR} + \text{Q3} \ \text{ OR } \ t_n < \text{Q1} - 1.5\text{IQR}[12] \qquad \text{(Formula 2)}$$

Where

$$IQR\ \text{(Interquartile Range)} = Q3 - Q1[13]$$

Applying Formula 1, Formula 2, and the condition outlined in (a), we could intuit that the number of times the patient needs to say a specific word in order for the system to buzz would be:

$$\text{Buzz} = \frac{2 + \sum_{1}^{i=n} t_i - t_1 - t_n - \sum_{1}^{i=y} S_y}{n + 1 - 2 - y} = \frac{2 + \sum_{1}^{i=n} t_i - t_1 - t_n - \sum_{1}^{i=y} S_y}{n - y - 1} \qquad \text{(Formula 3)}$$

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