Automations for ABLE Alliance: Proposal

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I. ABSTRACT

Individuals with mobility impairments have witnessed substantial advancements in the field of motorized wheelchairs, affording them newfound independence. No longer reliant on assistance for mobility, they can now navigate autonomously. However, this independence, while liberating, ushers in new challenges. With users now moving independently and without supervision, scenarios may arise where the wheelchair becomes immobilized. Given that such incidents can also involve the user's phone being inaccessible, there arises a pressing need for a sophisticated system capable of promptly detecting and alerting emergency contacts in such precarious situations.

II. AIMS & OBJECTIVES

The project is structured around two primary objectives: sensing emergencies and initiating contact with designated emergency contacts.

In the first phase, we aim to develop highly efficient, low-power sensors capable of detecting wheelchair immobilization. These sensors are designed to seamlessly integrate into the daily routine of wheelchair users, requiring minimal charging and straight-forward installation. Our priority is to ensure that even individuals using the wheelchairs can easily install these sensors without hindering their wheelchair's maneuverability.

The second phase entails establishing a notification to the user's emergency contact. This connectivity will grant access to the user's emergency contact and enable automatic emergency email to them. The system will include an automatic speech to convey the nature of the emergency to the contact personnel, to suit the needs of candidate with cerebral palsy. Simultaneously, we will implement a user-friendly feature that allows the wheelchair user to cancel the contact if it's determined that there is no actual emergency, providing a fail-safe mechanism to prevent false alarms.

All in all, this is the research question that we will address in this project:

> How can we effectively integrate efficient and reliable sensor-based, low-power smart technology into wheelchair systems to enhance the safety and overall quality of life for individuals with mobility impairments?

III. BACKGROUND

In this section, it is important to address the organization which will be the primary recipient of the implemented technology: the ABLE Alliance at Georgia Tech. To plead the case, we will first provide some context about the organization. The ABLE Alliance (at Georgia Tech), is dedicated to fostering a more inclusive and supportive environment for individuals of all abilities and disabilities within the Georgia Tech community. In terms of relating the outline of this project to the ABLE Alliance, the suggested project is set focused on enhancing the HRQoL (Health-Related Quality of Life) for its president, Trey Quinn, who faces the challenges posed by cerebral palsy. Trey's unwavering determination and ambition to succeed makes him an inspiring figure within the organization, but there are some aspects of his daily life that require assistance due to his condition. This project aims/attempts to best of ability to create a transformative environment through the implementation of advanced sensor technology that will not only improve Trey's day-to-day experiences but also serve as a somewhat beacon of inspiration for the entire ABLE Alliance community. So in simple terms, we intend to integrate smart automation systems into Trey's immediate environment, leveraging cutting-edge sensor technologies with respect to the manual task that we try to automate to have a more responsive access to safety in case of emergency that would otherwise consume precious time/effort (this is respective to the cerebral palsy condition Trey has). The advanced sensors and its propositional use details can be more thoroughly explained in the "Project Plan & Timeline" section.

Based on published literature, there are many ongoing efforts to go from stage "wheelchair" to stage "smart wheelchair" [6]. Most commercially sold wheelchairs do not have pre-built safety countermeasures put in place in case of many situations: uneven terrain, potholes, curb banks, and etc [4] [5] [2]. Currently, the market standard for such emergency cases is some sort of wearable system such as a pendant, to detect a fall. [10] proposed a method by using a ultrasonic sensor to judge any close curb markers and immediately stop the wheelchair itself. This light-weight implementation can be a easy installation, however, such approach can be sometimes unreliable due to false positives.

[9] also conducted research on the reliability of triggers that set off the subsequent workflow and its response time. They

use weight-sensitive pads as the input mechanism. As soon as the fall monitor signals have crossed a certain threshold, the caregiver is notified.

[1] was very vibrant in finding a specific use-case, where a Android patient was custom tailored an Android application which was co-linked with her Android smartwatch to continuously gather heart rate metrics. The metrics were then processed for any sudden abrupts / anomalies using a random forest machine learning model which then outputted the results in another Android caregiver's phone. Having such a open-minded ecosystem, would definitely make things much easier to work with. In our specific use-case, the patient is a Apple user. One key takeaway from this study is a comprehensive ecosystem with a proper segway for data flow.

[3] In this research, a study on human fall types and detection have been noted. They use vison-based system equipped with the latest machine learning, localization, and mapping techniques to gauge a unintentional fall. They seem to be on the cusp of utilizing the brightest talents, and vast accessibility to resources to accomplish their goal. This is a total over-achievement, however we do not have such privileges and man power. We also need a budget-friendly product.

We draw inspiration from these studies as valuable references and benchmarks that inform and guide our project's development.

IV. OUTCOMES & DELIVERABLES

Our project encompasses two primary deliverables. The first entails the development of a user-friendly sensor system designed for seamless installation onto wheelchairs, ensuring that individuals who rely on these wheelchairs can easily deploy these sensors themselves.

The second deliverable is a notification system (accessible via mobile) intricately linked with the sensor network. This application will harness sensor data to trigger email notifications when necessary. Through this project, we aim to not only learn more about the difficulties that people in wheelchairs face, which might not be as obvious, but also to acquire valuable skills in prototyping and design verification testing to truly create a sufficient piece of technology which will actually address those problems, similar to how [8] iterated through their design approach. Ultimately, our mission is to empower individuals with mobility impairments while advancing our knowledge and capabilities in the realm of assistive technology.

V. CHALLENGES / ALIGNMENT TO CLASS

Mobile and ubiquitous computing aims to seamlessly integrate technology into daily life, while having the users be unaware of their interaction. Our project epitomizes this concept, aiming to assist users without requiring their active involvement once set up.

The primary challenge lies in building a cohesive ecosystem where our sensors seamlessly interact with the wheelchair and user's devices, forming a harmonious whole. Achieving this initial integration is pivotal and complex.

Additionally, we face the task of designing sensors that enhance the user experience rather than causing inconvenience while riding in the wheelchairs. Essentially, the system should not be a nuisance to the audience using it. Striking this balance is crucial for user acceptance.

Finally, ensuring our sensors accurately detect emergencies while minimizing false positives presents another important challenge. Our goal is to create a system that not only enhances safety but also respects the users' independence and peace of mind. Meeting these challenges is at the core of our project's vision.

Despite having a smaller workforce (in comparison to other teams), we are determined cross out our objectives as per the timeline.

The scope of the project has already been discussed with the mentor and also with the TA facilitator.

VI. PROJECT PLAN & TIMELINE

We've structured our project into five distinct phases to ensure a comprehensive and well-organized development process. Incorporated into that cycle, we intend to have JIRA biweekly sprints to track accomplished progress, current status for any blockers, and next sprint goals.

1) Interface Research: In the initial phase, we'll explore various hardware options like Arduino Uno, ESP 32, and ESP 8266 assessing their compatibility with the project's requirements and iOS integration.
2) User-Centric Design: Phase two is dedicated to three key objectives (and the largest phase section): user interface setup, system implementation, and sensor signal processing.
    a) In terms of sensors, we will need to experiment thoroughly with MPU6050 6-axis Gyroscope/Accelerometer, Ultrasonic Sensor, Capactive Sensing, LCD1602 Module, and/or Potentiometer 10k Module.
    b) During this phase, we'll also deeply understand user needs and iterate through prototypes to refine our product before we start to uniform it.
3) Integration: Moving to phase three, we'll integrate the two core components of our project – the sensors and the application. This integration aims to establish a seamless and automatic connection between the two.
4) Logic & Design Verification: Phase four is dedicated to rigorous testing to ensure the product's functionality. Any issues or improvements identified during testing will be addressed promptly.
5) Documentation and Reporting: In the final phase, we'll compile our findings, progress, and outcomes into a comprehensive final report. This report will encapsulate the entire project journey, from inception to completion.
    a) We hold this as a important phase in our project itnerary becuase of [7]. Thomas Ploetz explains in his fifth postulate, "*Proper reporting, or it did not happen*". We exercise this profound evaluation to define our framework.

VII. ACKNOWLEDGMENTS

We acknowledge Robert ”Trey” Quinn, for his invaluable assistance and unwavering support thus far and as this project progresses. We also appreciate Dr. Thad Starner [Technical Lead/Manager on Google’s Glass] for allowing us to take on this enriching endeavor of a project.

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APPENDIX

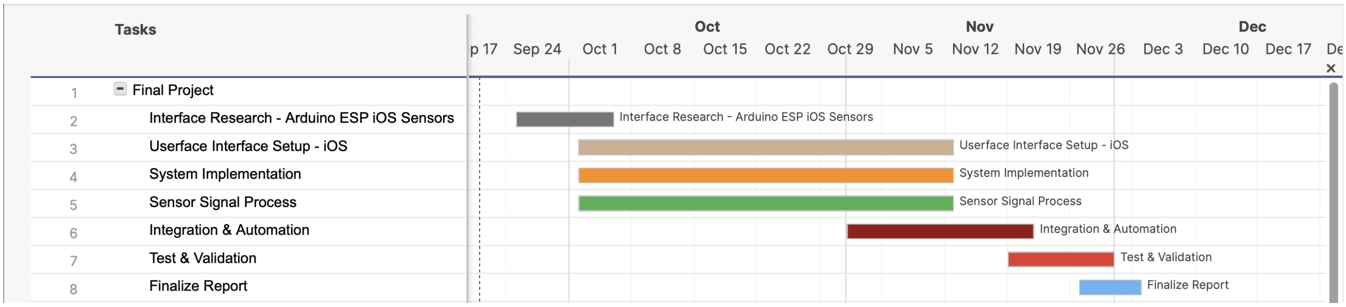

Fig. 1. Project itinerary as described in Section 6: ”Project Plan & Timeline”.