Problem Statement/Research Question and Background

The development of call buttons for individuals with physical disabilities in hospitals, caregiving facilities, and at home is an important area of research and one that has not been adequately addressed. There are existing alternatives being used in hospital settings but many do not effectively help patients communicate or are not reasonable in terms of cost, but some other issues are as follows:

- The size and mobility of the device
- The lack of mounts for the device
- The use of materials which cannot easily be sanitized
- The limited range of operation

Our team was tasked with implementing the most low cost call button that was reliable, easy to setup, and could be mounted several ways for any individual to easily use. Throughout the year our prototype adapted to be almost exclusively for home use, as it is dependent on a home Wi-Fi network. We began by examining other popular call button implementations to get an idea of what features we wanted our device to have.

One such option is the Smart Caregiver Two Call Buttons and Wireless Caregiver Pager developed by Smart Caregiver. This device weighs about 7.2 ounces and has dimensions of 5.5”x5.5”x1.2”. It has a maximum range of about 300 feet. This option assumes that most patients would have enough finger dexterity to be able push on the call button to alert a caregiver which is not very accurate assumption. Our solution wishes to make use of readily available materials so that this technology could be easily and cheaply utilized by any individual, facility, or organization interested in using it and even could be applied in developing countries.

The need for alternative forms of communication is especially important in hospitals and rehabilitation centers, both for communication about medical needs to staff as well as interaction with family and friends. People may need to use augmentative and alternative communication devices in a hospital setting for a variety of reasons. Some people may have a temporary condition (e.g., following throat surgery) that will result in a temporary need for AAC. Other individuals may have a long term or even permanent communication disability (e.g. cerebral palsy) resulting in the need to use an AAC system outside of the hospital setting as well. Information about the importance of communication in hospital settings for people with complex communication needs is available at the PSU RERC AAC website (McNaughton, 2016).

Many of these speech disabilities are accompanied with motor skill impairments as well. People with limited movement can use wireless switches to operate a communication device (a simple call signal) designed to accommodate these mobility difficulties. Jessica Gormley, a doctoral candidate in the Department of Communication Sciences and Speech Disorders at Penn State, helped us better understand what patients often experience, particularly ones who lose the ability to speak due to illness or injury. Whether their impairment is temporary or permanent, many feel isolated and frustrated because they cannot express their needs or discomfort due to the inability to access or use communication devices. It was the task of our team to create a device that could most quickly put patients in touch with those they need to mitigate such a feeling.

Methods/Approach/Solutions Considered

Using a combination of internal and external searches, the team compiled a list of devices that could be modified to fabricate a wireless switch. Early on, our team narrowed down our microcontroller options to the Adafruit HUZZAH and the Amazon AWS IoT Button as they were the only microcontrollers with built-in Wi-Fi support that fit our price and footprint requirements.

The enclosure for our device was printed using 3D printers. This was not much of a debate for our team, since we knew that the printers could provide us with very strong plastic materials that are resilient and do not bend. The enclosure design was something that took our design team many weeks, and relied heavily on the hardware remaining small. Our team printed a handful of designs as we frequently changed the sizing specs of the hardware, but in the end, we managed to get a case that properly and safely housed the internal hardware.

Description of Final Approach and Design

We finally narrowed down our microcontroller choice to the Adafruit HUZZAH which is a breakout board for the Espressif ESP8266. We decided upon this based on its extensibility and ease of programming. We chose Adafruit over other ESP8266 breakout boards due to the company's extensive technical support and its tutorials. Once we chose the breakout board, we were faced with several firmware alternatives:

- NodeMCU - Lua (https://github.com/nodemcu/nodemcu-firmware)
- Arduino - C++ (https://github.com/esp8266/Arduino)
- Esp-open-rtos - C++ (https://github.com/SuperHouse/esp-open-rtos)

We settled on using Arduino because it combined the memory management of C++ with the ease of the Arduino library which allowed us to focus on fitting as many features as possible into our device within the time constraints of a semester. We then attached two pushbuttons, one which allows the user to power on the device and the other which allows the user to send one of three messages.

We then attached a 500mAh Lithium Polymer battery and added a microUSB charging circuit so that the user could easily recharge the device. Finally, we used a 3D printer to print an enclosure of ABS plastic. The ABS plastic gave us the rigid design we desired, but took a few attempts from the 3D printer to get the tolerance and width of the device correct. With more time, our team could have potentially implemented a more low profile device.

Outcome

It was during the final weeks of this semester that our device finally came together and was able to start sending messages. The Adafruit microcontroller worked flawlessly in its limited space enclosure, and was able to perform for the engineering showcase. The device is easily able to be put into setup mode to edit the messages to be sent, and can effortlessly connect to home Wifi networks in the area. The use of GroupMe API allowed us also to easily create groups to send messages to, our device fully functioned for the original goals we set out to accomplish.

Overall Design

The design of the device was something that we as a group were very proud of, but there definitely exists room for improvement. Our team was just able to fit the Adafruit microcontroller, the battery, and a few push buttons inside the casing, and it still came out to be just under the size of a deck of cards. This is due to many factors that we hope that future semesters can improve upon.

First off, the use of 3D printers makes it difficult to print very small components. When considering making a wristwatch casing for our device, we wanted to make all components as small as possible. However, going under a certain tolerance of material using the 3D printer can sometimes lead to a big mess, other times the device just comes out too flimsy. The use of more advanced materials would have allowed us to create a more low profile design.

Next is the hardware aspect, which also has a slight area for improvement. Our selection of the Adafruit microcontroller was a nice choice because of the very small size of the chip itself. However, the device lacks certain ports that could have made wiring easier and led to a smaller design. We urge future semesters to examine battery connections to the device before determining what device they plan to program with.

Cost

The cost of the prototype’s components is just over $25. The breakdown of the cost for each component follows:

- Adafruit HUZZAH - $9.95
- 3.7V 500mAh LiPo battery - $7.95
- microUSB LiPoly charger - $6.95

- Push buttons - $0.50
- Enclosure - Free
- Wires - Free
- Solder - Free

Significance

We believe that our device is an important stepping stone in the world of AAC. The device is one of the first (if not the first) devices to send distress signal text messages via GroupMe. We wanted to create a new way of helping those living at home with disabilities to reach those they need to reach and we believe we as a team accomplished just that. Future capstone design projects can examine our code, hardware, and enclosure to create an even better AAC device. It is our goal that future semesters use our project as a learning experience stepping forward into the world of AAC.

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