Development of an at home use Brain Computer Interface with Augmented Reality

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Introduction/current technology

Over the last couple of decades, Brain-Computer interface (BCI) technology has emerged as an alternate communication and device control option for people with neuro-muscular impairments that preclude voice or motor control. Current BCIs use electroencephalographic (EEG) activity recorded at the scalp to control cursor movement, select letters or icons, or operate neuroprostheses. BCI systems have been developed for various clinical groups, including Amyotrophic Lateral Sclerosis (ALS), a fatal neurodegenerative disease of the motor system, causing loss of muscle control.[1][2] Presently, BCI use poses a number of challenges for those living with physical disabilities. They require upright positioning of the user to see the display monitor, often propped-up for extended time durations. Due to the excessive amount of weakness and fatigue that people with ALS (PALS) experience, this can be extremely uncomfortable for them and hinder use.[3][4] Additionally, changes of position in response to fatigue can lead to a loss of screen calibration because of changes in the relative location of the user with respect to the display. Finally, most research grade EEG systems use wet electrodes, wired components and multiple hardware boxes that result in a system that is bulky, fragile, non-portable, and complex for caregivers to organize and set up.

Methods/Results

Our goal is to develop a practical, accessible, and at-home use BCI system for PALS. To decrease the need for frequent recalibration and uncomfortable positioning with fixed computer displays, an Augmented Reality head-mounted display was incorporated as a solution to provide BCI stimuli and output. (See Figure 1.b) This solution eliminates the need to keep the user upright in a potentially fatiguing and uncomfortable position and reduces the need for frequent recalibrations. The headset is placed on the forehead of the user allowing them to stay in any orientation without changing the relative distance between the screen and the user's eyes. To decrease the number of wired connections a wireless battery-operated Bluetooth connected 8-channel dry electrode EEG system was incorporated and tested. The new wireless EEG headset allows the user to be in any position comfortable to them. The P300 selection matrix was customized from the original keyboard layout to display icons corresponding to various home control actions which the user might need in their current environment. This custom matrix interface can improve the user experience by eliminating the need to spell out entire words and sentences to communicate. Instead, the user can select the icons which have built-in functionalities. Finally, the P300 interface is integrated with a built-in smart assistant (Google Assistant) that provides environmental control. The matrix icons and their corresponding actions can be customized by the primary aide. This added control of their surrounding environment using smart devices allows the user to have more autonomy in their day-to-day actions.

Overview

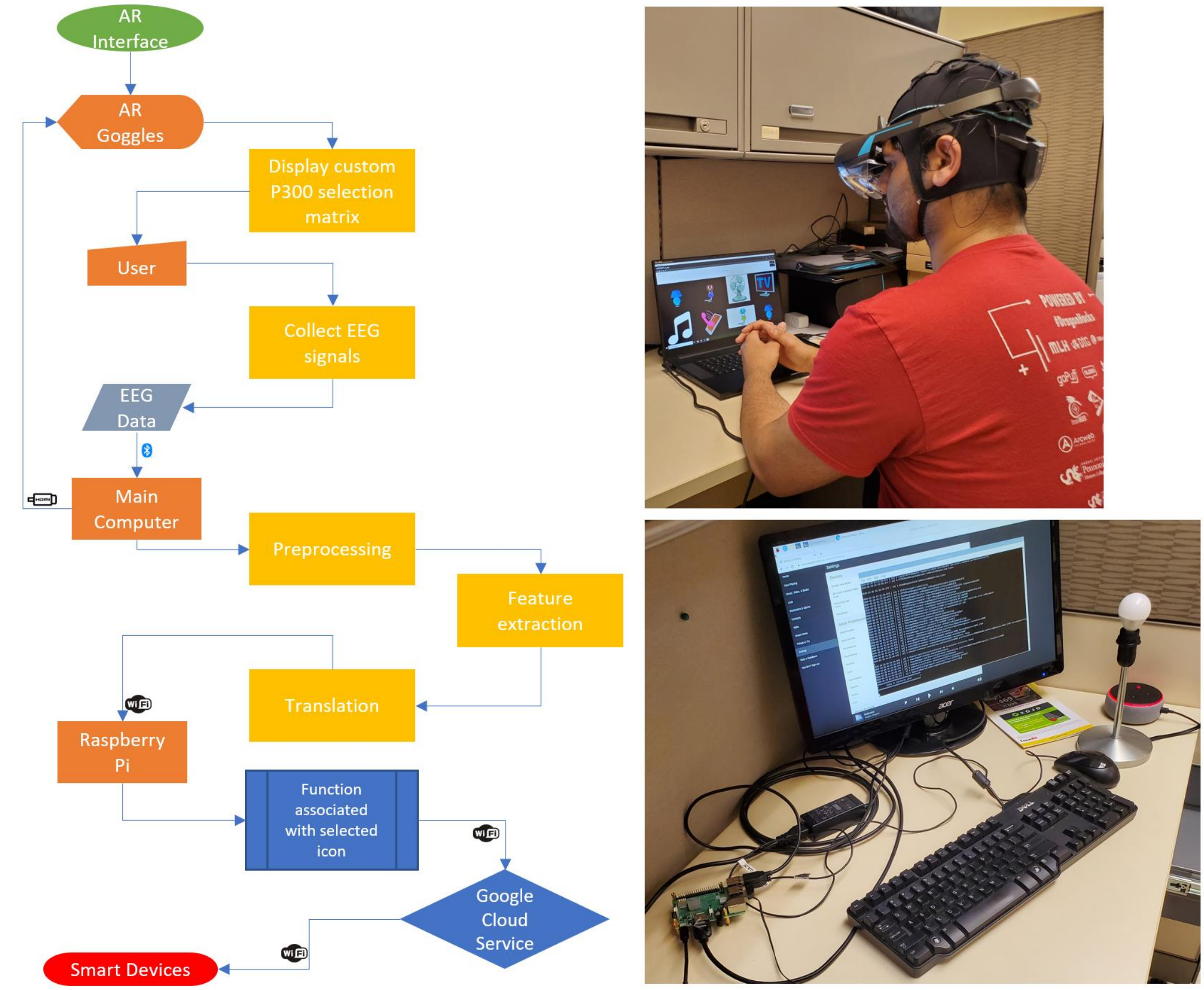

*Figure 1: **(a)** System design diagram (left) **(b)** AR-EEG headset combination running custom P300 selection matrix (top-right) **(c)** Google Assistant running command (bottom-right)*

The proposed system uses an interface consisting of a customized selection matrix displayed on an AR headset. The bluetooth enabled 8 channel EEG electrode headset captures the signals at scalp and sends them to the main computer for processing, which involves preprocessing the EEG data and running feature extraction and translation algorithms to make an icon selection. Once the user selects the icon, the function associated with that icon is sent to Google Assistant cloud service. Google Assistant executes the command as required.

Conclusion

With the integration of Google Assistant in a mobile P300 BCI interface system, the assistive technology takes another step in improving the quality of life of people living with ALS by increasing independence from caregivers. In this work, we describe the engineering process we employed to develop this new BCI intended for at-home use by individuals with neuromuscular diseases.

References:

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