[Capstone Category]

Project Name **Lectio Signum: Real-Time ASL Mobile Translator**

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Problem Statement: Approximately 600,000 individuals suffer from deafness in the United States alone. Many such people resort to sign language as their primary source of communication, with American Sign Language (ASL) being the most popular method in America. Even though the communication of those individuals within the deaf community is satisfied, many barriers still exist between this minority and the people who use spoken English as their language. To ease these obstacles and promote the inclusion and empowerment of deaf people, Lectio Signum aims to fill in the communication gap by translating ASL to English in real-time through analysis and classification of biological signals from the device user.

Challenges: To develop a device that aims to promote inclusion, the product must be portable and inexpensive; since biomedical devices can be considerably high-priced, bulky, and heavy, a concern is raised when choosing the system components. Accuracy of translation is also demanded because the user must be correctly interpreted, which means that selecting features and methods of classification is a decisive task. In the same spectrum, it is a challenge to ensure the consistency of the device's performance when considering the diversity of users, the variation of sensor positioning, and outright random noise – thus, the system must be robust. Finally, even though the device has electronic components and is in direct contact with the skin, it must bestow little to no harm to the user to ensure safety.

Solution Methods: The proposed system consists of two bands that are worn together by the user: an armband with four electromyography (EMG) sensors to maximize muscle activity readings, and a wristband with an inertial measurement unit (IMU) to potentialize measurements of motion. Initially, the user is required to do a calibration step to ensure consistency of readings taken at different times. The signals are then acquired and streamed from embedded Arduino boards to a mobile device via Bluetooth. In the device, a web application receives the data, crops the gesture performed from the signal, classifies the sign using a Random Forest (RF) machine-learning algorithm, which then displays the translation in the form of text or voice in the User Interface. The RF classifier is previously trained using data from volunteers.

Data Analysis: Two sets of data are analyzed. The first, consisting of 13 basic hand gestures, were experimental signals recorded from team members using the Delsys Trigno Research+ system, and were used to build the system's architecture. The second set consists of the ten gestures deemed useful for ASL speakers whilst remaining differentiable by the Lectio Signum system. This new set of data works as a proof of concept that the translator is functional and is suitable for real-life applications. The signals collected are subjected to pre-processing and feature extraction – leading to a matrix of descriptive parameters – and are fed into the classifier for the sign translation.

Conclusion: The project aims to develop a biomedical device that aids the communication between ASL users and spoken English speakers by having signs translated into words. The system consists of a pair of bands that collect muscle activity and motion data when the user performs a gesture. The signals are sent to a computer where processing and feature extraction occurs; once this is performed, an RF classifier is used to classify the sign. Finally, the corresponding translation is displayed in the user interface of a web application in the form of text or voice.

Future Work: Part of the plan to extend the applications of the Lectio Signum device is to implement a more comprehensive dictionary, composed of more complex signs useful for daily activities. A pending task is the implementation of Bluetooth into the device, enabling the user to utilize the device more comfortably. Lastly, the optimization of the web application to ensure multiple devices can access the translation system of Lectio Signum is planned. A possible pathway to accomplish this is to develop a phone application.