ChatterGlove - A healthcare appliance for speech/hearing impaired individuals

Theodor-Radu Grumeza

Faculty of Mathematics and Computer science - West University of Timisoara

Abstract

This work is intended to show a comprehensive healthcare hardware and software device that assists speech/hearing-impaired persons in communicating with the general public. This device embodies a 3D printed exoskeleton glove, which by means of electronic modules aims to translate hand signals and gestures into spoken text in order to facilitate communication between speech/hearing-impaired and ordinary people.

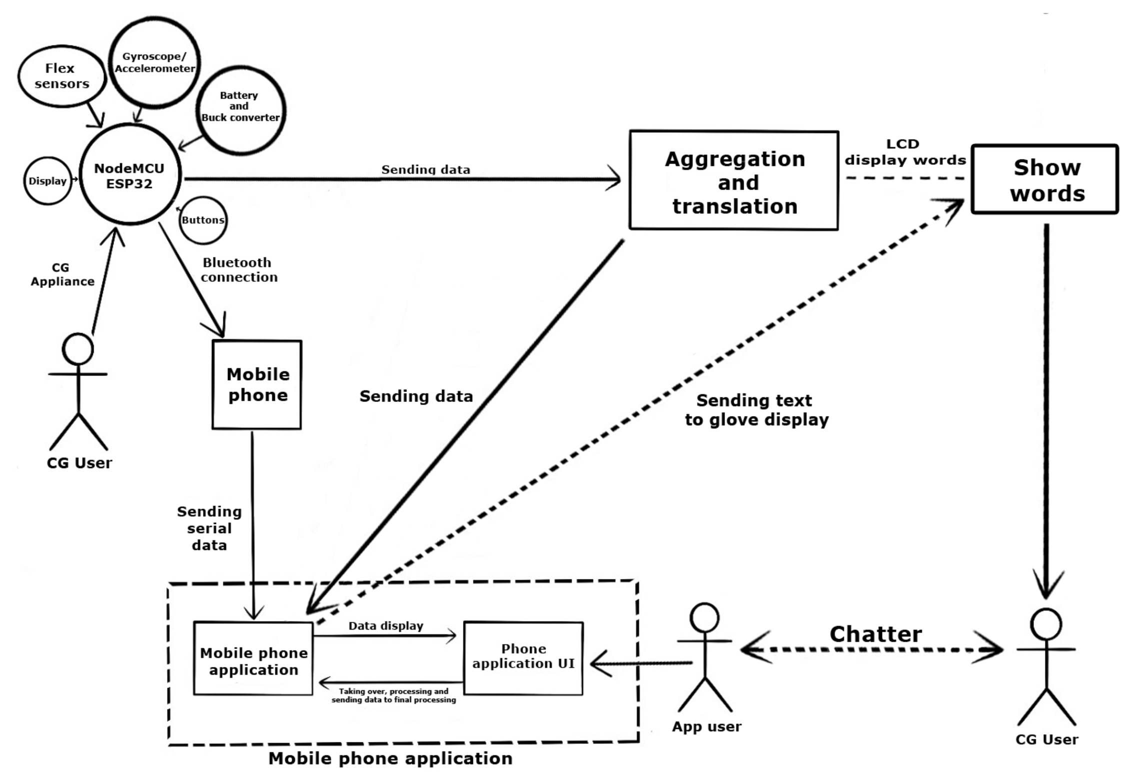

Figure 1. Structure of the system

Equipped with five flexible sensors, a NodeMCU ESP32 microcontroller, a gyroscope/accelerometer, a display for responses, scrolling buttons, and a power switch. The built-in ESP32 Bluetooth module connects it to an Android app which recognizes gestures, converting them into displayed words and speech.

Motivation

The project aims to provide a healthcare tool for speech/hearing-impaired individuals to communicate seamlessly, facilitating integration both socially and professionally. Most deaf people use sign language, a visually-rich and structured form of communication. However, a major communication barrier arises as most hearing people are unfamiliar with systems like American Sign Language (ASL). Consequently, deaf individuals often rely on interpreters or text messaging to communicate with those who hear, but interpreters can compromise privacy, are costly, and writing can be inconvenient, especially in dynamic situations.

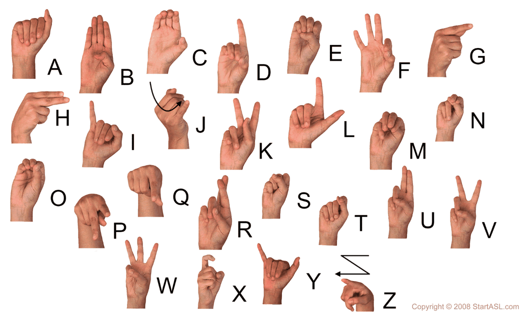

Figure 2. American Sign Language Letters

Sign language isn't universal. American Sign Language (ASL) and German Sign Language (GSL) have different alphabets and gestures compared to other countries' sign languages. In sign languages, communication isn't just about hand gestures. It also involves using the head, eyes, and facial expressions. Even within hand gestures, there are nuances like which hand is used more frequently. This project recognizes the need for an effective communication bridge between the deaf and hearing communities to overcome these barriers and challenges.

Proposed approach

Regarding the software implementation of the ChatterGlove system we used a NodeMCU ESP32 microcontroller as the system's core development board in order to convert the hand motions of the speech/hearing-impaired into English speech stigmatization. The implementation is based on five flexible sensors that sense the movement of each finger, a gyroscope/accelerometer for tilt sensing, a display where the deaf person can see the response from the interlocutor, two simple buttons that allow the user to scroll through the conversation, and a switch button for activating the system. Regarding connection between the mobile application and the display, the NodeMCU ESP32 board's Bluetooth module is utilized.

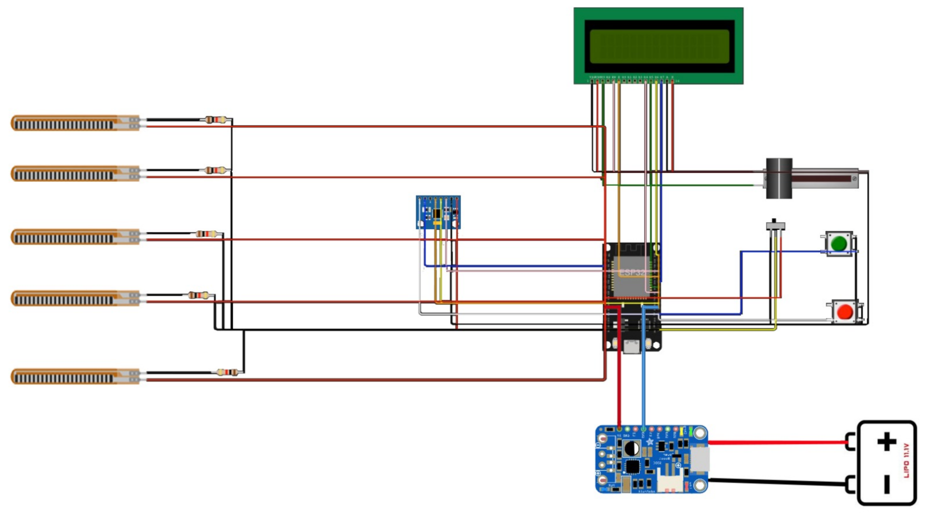

Figure 3. Circuit diagram

The glove was designed using Fusion 360 and CATIA V5, and printed with the "Original PRUSA I3 MK3S" printer using PLA filament. We started by taking hand measurements, adding a few millimeters for ease of wearing and margin of error. The design detailed hand outlines, individual finger diameters, and segment lengths. Each finger is divided into three parts: the base, middle, and tip, resembling wearable rings. Ensuring flexibility while connecting these segments was crucial, so fingers could move naturally, yet the segments remained securely linked through a mechanical resistance connection.

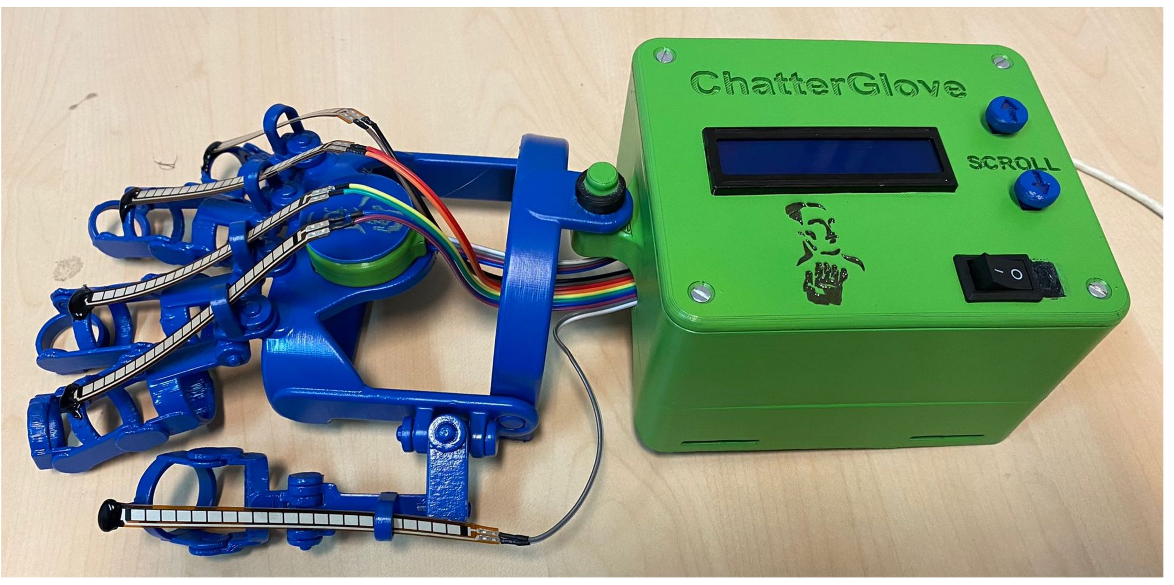

Figure 4. Final version of the device

The Android part of the application was implemented in Java, using Android Studio as the IDE. The program uses 4 activities: Login, Register, Bluetooth connection and Chat. MongoDB is the database platform used to store data from the ChatterGlove device and gather and utilise it throughout the training phase. To share the processing capacity of the application, we and the app created a microservices-based design. We utilized Docker to orchestrate these apps, with the microservices running independently. The services are likewise inaccessible to the general public, but there is an instance of NGINX that has access to them and can be accessed from the outside. We also hosted our app on Openstack using a VM instance with 8 vCPUs and 16GB RAM.

Conclusions and Future work

The ChatterGlove project addresses the challenge of designing an intelligent communication tool for individuals with hearing or speech impairments. The central objective was to devise a solution promoting effortless social and professional interactions for these individuals. The strategy merged mobile application technology with hardware boards and sensors to realize this goal.

Essentially, the ChatterGlove is a comprehensive fusion of healthcare hardware and software, shaped as a 3D-printed exoskeleton glove. It uses digital components to convert hand signals and gestures into audible speech. This caters particularly to those who cannot comprehend American Sign Language (ASL).

Two foundational principles support the ChatterGlove's efficacy. Firstly, it simplifies social and professional interactions for users, ensuring their prolonged comfort and use. Secondly, it serves as a universal communication bridge addressing the highlighted issue.

Recognizing that deaf or mute individuals employ more than just hand gestures for communication, we plan to incorporate an Xbox Kinect camera. This addition will employ a vision-based methodology to interpret facial expressions, enriching the communicative scope.

Further, to enhance clarity in communication, we intend to add a glove for the left hand. Some phrases in sign language necessitate the use of both hands for clear conveyance.

To ensure the ChatterGlove's widespread adoption, we're exploring the creation of iOS and desktop applications. This would make the tool accessible across diverse platforms.

An ambitious enhancement we're considering is enabling the ChatterGlove system to project phone call speech onto its integrated LCD. This feature could then interpret gestures into speech for the phone call's recipient.

To assess the current version of ChatterGlove, consultations with medical professionals are in the pipeline. Additionally, we aim to collaborate with the "Romanian Deaf Association" in Timisoara for real-world testing and feedback. This holistic approach ensures ChatterGlove's refinement, making it a truly inclusive communication tool.

Acknowledgment

This project could not have been completed without the support of the Media EDU Association, who provided the required hardware in the form of boards and sensors, and Dr. Marijus Musta for helping with the sketches for our project.

References

Armstrong, David; Karchmer, Michael (2002), "William C. Stokoe and the Study of Signed Languages", in Armstrong, David; Karchmer, Michael; Van Cleve, John (eds.), The Study of Signed Languages, Gallaudet University, pp. xi–xix, ISBN 978-1-56368-123-3, retrieved November 25, 2012

"Hearing Loss." Hearing Loss, www.who.int, 2 Mar. 2022

Bross F (2020). The clausal syntax of German Sign Language (pdf). Berlin: Language Science Press. doi:10.5281/zenodo.3560718