GESTURE-BASED VOICE AID FOR HOSPITALS AND SAFETY

Dr. MohanaPriya M[1], Aishwarya V[2], Amirtha Shree K[2], Nivetha R T[2], Varshan S[2]

[1]Associate Professor, Department of Computer Science and Engineering, Coimbatore Institute of Technology
[2]UG Students, Department of Computer Science and Engineering, Coimbatore Institute of Technology

Abstract

This project presents a low-cost Hand Gesture Vocalizer designed to assist individuals with speech impairment to communicate more conveniently. The system comes with a wearable glove and flex sensors to recognize certain hand gestures, purposefully avoiding complex components like accelerometers for the sake of simplicity and low cost. An Arduino Uno deciphers the sensor information and transmits the interpreted gestures via Bluetooth to a smart phone app, which displays text as well as speech feedback. The app is designed to real-life purposes such as hospitals, where patients are unable to speak, and women's safety, where subtle gesture-based cues can be vital. Through the offer of timely, credible, and accessible information, the solution herebelow aims to empower users with a useful tool of everyday use.

Keywords

Arduino Uno, Flex Sensors, Gesture Recognition, Bluetooth Module, Real-Time Communication.

1. Introduction

The potential of communication is one of the most important aspects of human contact, but for speech-impaired individuals, communicating fundamental needs or feelings can be a common challenge. While sign language is a useful communication tool, it is ineffective if the other person does not understand the signs. This disconnect can lead to frustration or a feeling of isolation for those individuals who cannot speak, an evident need for a more universally accessible substitute.

The Hand Gesture Vocalizer is a functional and economical means to fill this void. The Hand Gesture Vocalizer is an alternative means of communication for environments like hospitals or women's safety, where input of basic gestures is converted to speech and/or text.

The Hand Gesture Vocalizer consists of a glove with flex sensors that detects finger positions, an Arduino Uno microcontroller that identifies and interprets the finger positions, and a mobile application that receives the interpreted gestures from an Arduino via Bluetooth, shows the output in text, and vocalizes it out loud.

By eliminating everything and anything that is unnecessary, and grant users the ability to express themselves without any knowledge of sign language[2][3][10], they can communicate clearly and quickly whether that is a patient calling for help in a hospital, or an individual.

2. Literature Survey

Gesture recognition[1] technology has come a long way over the past few years, with majority of the research focusing on either vision-based systems or glove-based systems. Vision-based approaches typically use a camera and have varying image processing algorithms, however they tend to work well in controlled environments but are unreliable in real world applications due to issues with camera angles, lighting conditions, and background clutter.

Glove-based approaches seem to have a higher level of accuracy, portability and real-time useability. These systems are essentially embedded with sensors within a wearable glove that has the capability to recognize hand and finger movement. Flex sensors are the most popular choice for consistently measuring finger bending motion; they are also much simpler, and reliable when compared to a vision-based approach.

Prior research has examined glove-based systems in the context of virtual reality environments, robotics and smart healthcare, but many of these systems have limitations such as having a significant cost related with the entire hardware requirements, complicated credentials to implement, and many products have not been practically deployed in a real-life scenario. Some glove-based systems are simply signing to a camera with the assumption the recipient understands the signs (or gestures) that are being performed.

This project is going to address these issues by designing a low-cost and real-time gesture vocalizer.

3. Methodology

The Hand Gesture Vocalizer system[4] integrates new hardware and software components to achieve accurate and efficient gesture recognition**.**

Hardware Components:

The glove contains flex sensors *(Figure 2)*, which record the amount of finger flexion by monitoring resistance changes. This information is the basis for gesture identification. The Arduino Uno microcontroller[5][9] *(Figure 1)* is the central functionality of the system whereby sensor inputs are interpreted via known algorithms. Wireless transmission of information to the mobile app is done using the HC-05 Bluetooth module for smooth transmission

Figure 1: Arduino UNO

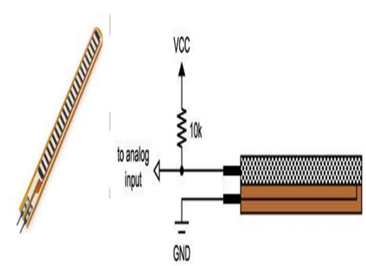

Figure 2: Flex sensor

Software Components:

Arduino Integrated Development Environment[7][8] *(Figure 3)* is the main code used in programming and uploading the code into the microcontroller. The app supports the collection, processing, and mapping of sensor data into pre-programmed gestures. The mobile app of the system produces identified gestures as text and reads them out as spoken speech through text-to-speech functionality. The two-output system makes the communication partner's access to and comprehension of the identified gestures and the speech-impaired user's production of and listening for the identified gestures both easy.

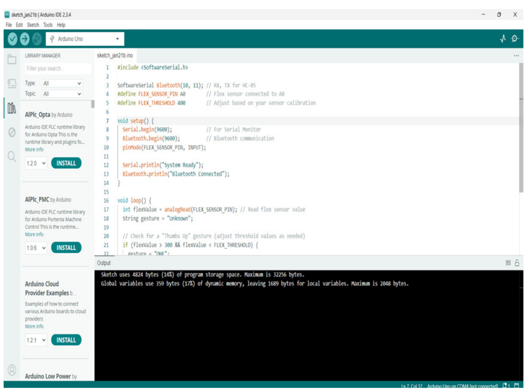

Figure 3: Arduino IDE

Process Flow:

The steps of the process in the system (*Figure 4*) start off with the glove identifying hand gestures by using flex sensors installed on each of the fingers. The sensors read the bending degree of each individual finger, and transmit the information to an Arduino Uno which then processes the findings and compares them to a set of motions that were pre-defined as gesture patterns associated with relevant messages surrounding hospital communication and women safety scenarios.

Once the gesture has been identified, the associated message will be transmitted via Bluetooth to a mobile application[6]. The mobile message/application will show the text output and play the audio output at the same time (supporting both message forms) so that the user's message can be seen and heard.

The key relationships in this process are communication in real-time! Presenting a message clearly and quickly is vital for someone who may require urgent help - such as a patient in a medical facility, or safety assistance when a signal is sent. The system is simple, quick, and specialized to travel into a world where people with speech impairments often operate, and become challenged with everyday communication.

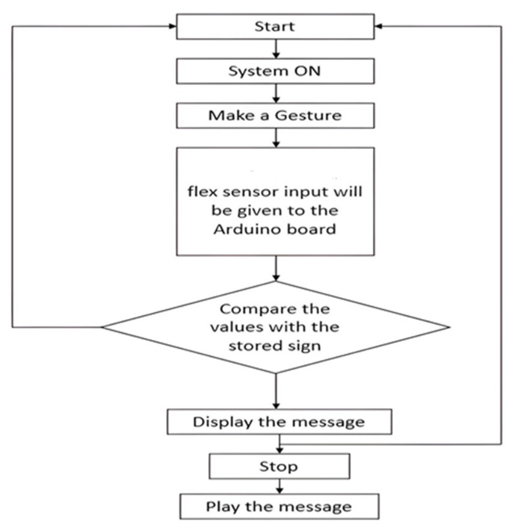

Figure 4: Process flow

4. System Design

The system design (*Figure 6*) can be divided into three main steps, namely input, processing, and output.

As mentioned, the first phase is input and the system captures gestures by using flex sensors that are attached to a glove. The flex sensors capture the bending of fingers, which mapping is done to the gestures that have been precoded for these contexts, namely hospital communication and women's safety.

Next, as the gesture is captured, gestures are transmitted from the flex sensors to the Arduino Uno microcontroller for processing. The microcontroller will compare the gesture with a list, and, if the gesture matches a pattern preset to the microcontroller, it will determine the gesture to be a meaningful message (i.e. I need help or call a nurse).

The output phase takes place when the microcontroller decides on the gesture, based on its determined message (i.e. I need help, or I need a nurse) and transmits it via Bluetooth to an app (Figure 8). The produced app will display the message as text and also play a voice output which makes messaging simple and immediate.

The modular aspect of the systems design makes it usable, cost effective, and user friendly. There was a healthy collaboration of the hardware and software aspect of the system, which allowed the device to translate gestures into a form of aiming and understandable messaging. The data flow across the system is conveyed in the two block diagrams (Figure 7) and the low-level data flow diagram (Figure 5), illustrating the flow of data from gesture recognition through to the output message.

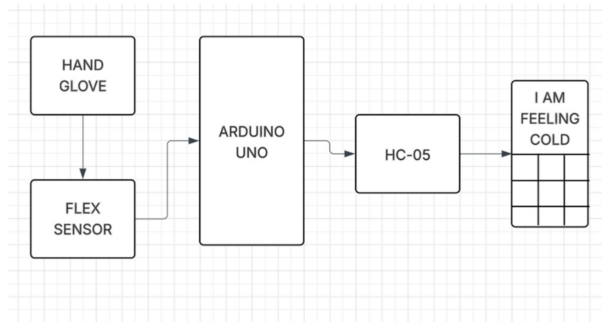

Figure 5: Block diagram

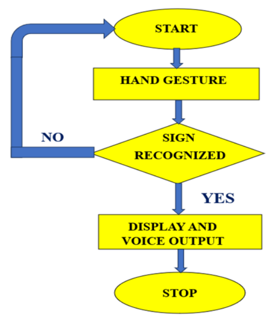

Figure 6: System design

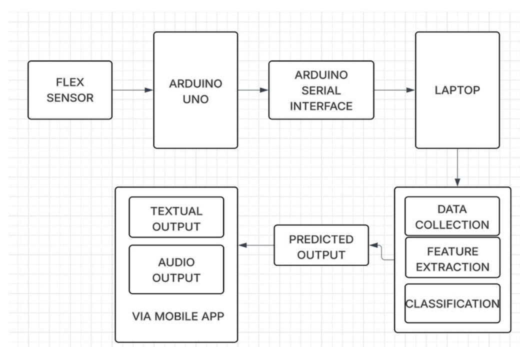

Figure 7: Architecture

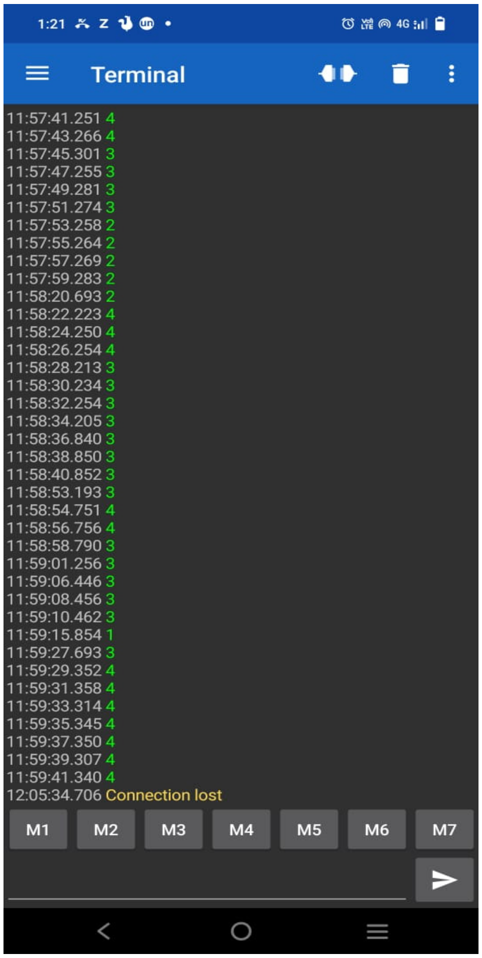

Figure 8: App output

5. Results and Discussion

We tested the system rigorously on carefully designed sets of hand gestures (*Figures 9 & 10*), which were associated with the messages that often would be needed in hospitals and women safety situations. There was a remarkably high accuracy – greater than 90% – in identifying static hand gestures from finger bending patterns read by flex sensors on the hands.

One of the difficult challenges we faced during development was establishing the calibration of the sensor thresholds. Accurate detection required careful adjustments and recalibration of the flex sensors to make valuable distinctions on hand gestures that may have only slight variations in the movement of fingers. When we were running our tests, we did not use accelerometers, but we still able to achieve consistent and reproducible results over many tests and trials, but especially in controlled settings.

Figure 9: Pre-programmed gestures (Hospital scenario)

Figure 10: Pre-programmed gestures (Women safety scenario)

Another challenge we faced was reducing "noises" in the sensor readings caused by differences in the pressure on fingers and whether the sensors were in the same location from trial to trial. Through careful adjustments in the reading intervals on the Arduino and modifications to the coding logic to reduce any changing readings, we successfully removed fluctuations in readings.

Overall, the system (*Figure 11*) had many advantages: it was efficient in execution, functional and responsive to gestures, and user friendly. It is much cheaper, portable and offers a real-time communication capability, therefore would provide a great option (in applied spaces) than comparable systems with similar technology. These are especially important in medical settings, wherein a patient may not have the ability to speak to summon attention, or in situations wherein a woman requires help, but wants a 'silent' and/or immediate method to get help.

Unlike systems limited to sign language interpretation, this project focuses on direct gesture-to-message translation tailored to specific, high-need scenarios — making it not only more universally accessible but also highly relevant and impactful for daily use.

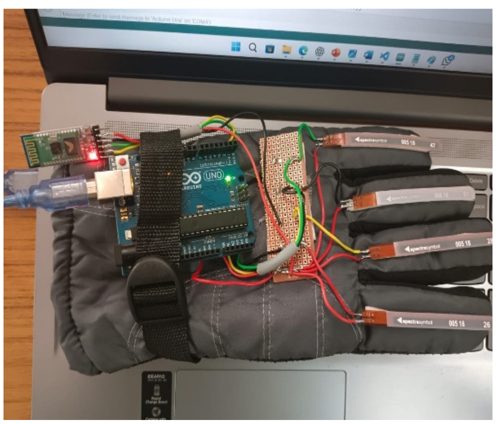

Figure 11: Working model

6. Conclusion

The Hand Gesture Vocalizer represents a leap forward in assistive communication technologies, particularly for individuals with speech impairments. By transforming hand gestures to either text or audio, the system affords users the ability to express crucial needs and warnings simultaneously, which is beneficial in hospital environments or personal safety situations.

The design of the device is based on flex sensors, processed by an Arduino microprocessor with GUI and performed by a companion mobile application. The proposed design offers a low-cost, portable, and simple design. There is no need to know sign language and consequently opens communications to potentially a much larger audience, including caretakers, medical staff, and bystanders.

Furthermore, in future iterations of the system, machine learning algorithms could be implemented to facilitate a wider set of gesture recognition deepening personalization and improving gesture[1] accuracy through diverse users, allowing the device to be more adaptable and operational in more complicated real-world settings. All in all, this project has provided an affordable and useful communication technology that answers an urgent need for inclusive communication in urgent situations.

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