

A HAND GESTURE RECOGNITION BASED COMMUNICATION SYSTEM FOR SILENT SPEAKERS

Wearable Device for Hand Gesture Recognition

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Abstract- A communication system has been proposed which converts sign language used by dumb people into speech. It is done based on the hand gesture recognition technique. The system will be able to recognize predefined hand gestures and provide voice and text output to the user. This design is composed of hardware and software application which includes an accelerometer sensor, an Arduino Uno microcontroller, a Bluetooth module, an LCD display, and an Android application. The accelerometer sensor will be used to detect the hand gestures, and the Arduino Uno will process the data from the sensor and send it to the Android application via the Bluetooth module. The LCD display will be used to display the status of the system. The software part includes an Android application that will receive the data from the Arduino Uno via the Bluetooth module and recognize the hand gestures. The Android application is to recognize the hand gestures and provide voice and text output to the user. The output will be displayed on the Android application and also sent back to the Arduino Uno to be displayed on the LCD display. The design of glove and the concept of decoding gestures by considering the axis orientation with respect to gravity and their corresponding voltage levels are discussed. In Software part an android application named Speaking gestures have been developed. It receives the data (alphabet/word) via Bluetooth, converts them into text and speaks it out. The proposed project gesture recognition is able to recognize definitive signatures for the corresponding motions, exhibiting promising potential in practical applications for deaf-dumb people.

Keywords: Sign language, Dynamic gesture, Wearable device, ADXL335, Artificial voice output.

I. INTRODUCTION

In the present world it is very complicated for the deaf & dumb people to talk with the ordinary people as impaired people lacks the amenities which a normal person should own. It actually becomes the same problem of two persons which knows two different languages, no one of them knows any common language so its becomes a problem to talk with each other and so they requires a translator physically which may not be always convenient to arrange and this same kind of problem occurs in between the normal person and the deaf person or the normal person and the dumb person. Although technology has been evolving rapidly in this information age, deaf/mute people still use sign language as their only way of communication. Using sign language as a communication tool can be beneficial among those who are familiar with this language, but the problem remains when communicating with the wider community. Sign Language Translator is the appropriate solution that enables deaf/mute people to communication fluently through technology in different languages. As sign language is a formal language employing a system of hand gesture for communication (by the deaf). Many projects used glove-based systems for automatic understanding of gestural languages used by the deaf community.

The systems developed in these projects differed in characteristics such as number of classifiable signs, which could range from a few dozen to several thousand, types of signs, which could be either static or dynamic, and percentage of signs correctly classified. The simplest systems were limited to understanding of finger spelling or manual alphabets (a series of hand and finger static configurations that indicate letters). In recent years, hand gesture recognition is mainly used in human Computer interactions. They play a vital role in gaming and control application like Tele- robotics, 3-D mouse, and virtual reality controlling. Beyond this, it can also be used in application aiding the physically challenged community like dumb people. Hand gesture recognition is the primary requirement for conversion of sign language to speech. This work aims at solving the problem of limited communication abilities of the disabled people who know sign language by transforming it into a form of verbal and vocal communication. Gesture recognition can be done by

two major techniques namely vision-based approach and Haptic-based approach. Due to high data processing, low speed response, limited lighting, and occlusion constraints in vision-based approaches, the haptic approach is considered for dumb people who are usually deprived of normal communication with others. Sign Language is the primary means of communication in the deaf and dumb community. As like any other language it has also got grammar and vocabulary but uses visual modality for exchanging information. The problem arises when dumb or deaf people try to express themselves to other people with the help of these sign language grammars because normal people are usually unaware of these grammars. As a result it has been seen that communication of a dumb person are only limited within his/her family or the deaf community.

The work described in this project is with an aim of developing a system to aid deaf-dumb people which translate the sign language recognition into text static or continuous palm side of right hand images. In this project, the proposed algorithm identifies the number of fingers open in a gesture representing an alphabet or a word of Binary Sign Language efficiently and quickly.

II. RELATED WORK

1. Two-dimension parallel spatio-temporal pyramid pooling for hand gesture recognition

F. Jafari and A. Basu discussed in detail in IEEE Access October 2023 about a model for hand gesture recognition based on CNN and evaluate the results using images with plain and complex backgrounds. Recognizing different hand signs by Two Dimensional Parallel Spatio- Temporal Pyramid Pooling (2DPSTPP) features with deep learning methods reduces the size of the map, minimizes training complexity, and by paying attention to more details, improves detection performance. The effectiveness of the proposed method is evaluated using regular cross-validation tests on six datasets, namely American Sign Language (ASL), the NUS hand posture data set I, the NUS hand posture data set II, the digits data set, the hand gesture data set, and the leap gesture recognition data set.

2. Dynamic hand gesture recognition using multi-branch attention-based graph and genral deep learning model

ASH Miah, MM Hasan, J. Shin et al investigated in detail in the IEEE Access December 2022 about the multi-branch attention-based graph and a general deep-learning model to recognize hand gestures by extracting all possible types of skeleton-based features. We used two graph- based neural network channels in our multi-branch architectures and one general neural network channel. In graph-based neural network channels, one channel first uses the spatial attention module and then the temporal attention module to produce the spatial-temporal features. In contrast, we produced temporal-spatial features in the second channel using the Reverse sequence of the first branch. The last branch extracts general deep learning-based features using a general deep neural network module.

3. Accuracy enhancement of hand gesture recognition using CNN

G Park, V. Kumar Chandrasegar, J. Koh et al. discussed in detail in IEEE Access February 2023 that recognizing human gestures using radar requires obtaining meaningful information from the received signal, which is challenging to do in big datasets containing a variety of human gestures. To overcome this issue, 2D-Fast Fourier Transform was utilized to convert the data into 2D data with essential properties in the radar systems. And a convolutional neural network (CNN) was used to classify the results. The results show that CNN is effective in learning from image data a combination of 2D-FFT and convolutional neural networks (CNN).that the accuracy of human-machine interactions is improved by using Ultra Wide Bandwidth (UWB) radar to acquire image data, then transforming it with 2D-FFT and bringing it into CNN for classification. The classification results of the proposed method revealed that it required less time to learn than prominent models and had similar accuracy. Although it cannot always be asserted that all pre-processing increases accuracy, experiment results show that classification accuracy is increased when combining 2D-FFT pre-processing with the CNN deep learning model.

4. A wearable smart glove and its application of pose and gesture to sign language classification

DelPreto, M Aria et al. in IEEE Robotics and Automation Letters October 2022 detailed that advances in soft sensors coupled with machine learning are enabling increasingly capable wearable systems. Since hand motion in particular can convey useful information for developing intuitive interfaces, glove-based systems can have a significant impact on many application areas. A key remaining challenge for wearables is to capture, process, and analyze data from the high-degree-of freedom hand in real time. We propose using a commercially available conductive knit to create an unobtrusive network of resistive sensors that spans all hand joints, coupling this with an accelerometer, and deploying machine learning on a low- profile microcontroller to process and classify data. This yields a self-contained wearable device with rich sensing capabilities for hand pose and orientation, low fabrication time, and embedded activity prediction. To demonstrate its capabilities, we use it to detect static poses and dynamic gestures from American Sign Language (ASL). By pre-training a long short-term memory (LSTM) neural network and using tools to deploy it in an embedded context, the glove and an ST microcontroller can classify 12 ASL letters and 12 ASL words in real time. Using a leave-one-experiment-out cross validation methodology, networks successfully classify 96.3% of segmented examples and generate correct rolling predictions during 92.8% of real-time streaming trials.

5. American sign language recognition using RF sensing

SZ Gurbuz, AC Gurbuz, EA Malaia et al. in IEEE Sensor Journal September 2020 have explained that human-computer interaction have been designed for hearing individuals and depend upon vocalized speech, precluding users of American Sign Language (ASL) in the Deaf community from benefiting from these advancements. While great strides have been made in ASL recognition with video or wearable gloves, the use of video in homes has raised privacy concerns, while wearable gloves severely restrict movement and infringe on daily life. This paper proposes the use of RF sensors for HCI applications serving the Deaf community. A multifrequency RF sensor network is used to acquire non-invasive, non-contact measurements of ASL signing irrespective of lighting conditions. The unique patterns of motion present in the RF data due to the micro-Doppler effect are revealed using time frequency analysis with the Short-Time Fourier Transform. Linguistic properties of RF ASL data are investigated using machine learning (ML). The information content, measured by fractal complexity, of ASL signing is shown to be greater than that of other upper body activities encountered in daily living. This can be used to differentiate daily activities from signing, while features from RF data show that imitation signing by non-signers is 99% differentiable from native ASL signing. Feature-level fusion of RF sensor network data is used to achieve 72.5% accuracy in classification of 20 native ASL signs.

III. PROBLEM STATEMENT

The existing system is for identification of the number of fingers opened in a gesture representing an alphabet of the Binary Sign Language. The idea consisted of designing and building up an intelligent system using group of flex sensor, machine learning and artificial intelligence concepts to take visual inputs of sign language's hand gestures and generate easily recognizable form of output. Based on the literature the existing system has focused only on isolated static hand gestures, and they have used MPU9250 and MPU6050 accelerometer sensor that has the main disadvantage that it cannot read the coordinate. In previous work combination of algorithm has been used creating complex and expensive output.

Disadvantage of Existing System

Flex sensor is very brittle, algorithm is complex, isolated sign language recognition is only studied and expensive. Based on the above drawbacks associated with current research on sign language we develop an intelligent system that eliminate all the above disadvantage. In this work dynamic gesture with continuous type of sign recognition, usage of ADXL335 accelerometer sensor and simple FAST algorithm is used. Instead of identifying a word we are developing a speaking gesture translator between the sign language and the spoken language dynamically and can make a effective communication between people with hearing impairment and normal people. After recognizing the gesture, the output is expressed in terms of voice and text for display. This system act as a aid for deaf-dumb people and reduces the communication gap between the normal people and disabled people.

IV. METHODOLOGY

Hardware components

Arduino Uno board, Accelerometer sensor (e.g. ADXL335), Bluetooth module (e.g. HC-05), LCD display (e.g. 16x2), Android smartphone or tablet

Software components

Arduino

Hardware design

- Design the circuitry to connect these components effectively.
- Develop the glove with the accelerometer sensor embedded in it, ensuring comfort and usability.
- Select and procure the necessary hardware components: accelerometer sensor, Arduino Uno microcontroller, Bluetooth module, and LCD display.

Hand gesture recognition algorithm:

- Design an algorithm to recognize predefined hand gestures using accelerometer data.
- Consider the orientation of the hand with respect to gravity and the corresponding voltage levels from the accelerometer sensor.
- Define thresholds or patterns for gesture recognition.

Arduino programming

- Write the code to read data from the accelerometer sensor and process it on the Arduino Uno.
- Implement the gesture recognition algorithm within the Arduino code.
- Set up communication protocols with the Bluetooth module for data transmission.

Android application development

- Develop an Android application (Speaking Gestures) to receive data from the Arduino via Bluetooth.
- Design the user interface for displaying recognized gestures and providing voice and text output.
- Implement the logic to convert received data into text and speak it out using the device's built-in speech synthesis capabilities.

Integration

- Integrate the hardware and software components.
- Test communication between the Arduino and Android application via Bluetooth.

Testing and validation

- Conduct extensive testing of the entire system to ensure accuracy and reliability in recognizing gestures and generating appropriate outputs.
- Validate the system's performance with real users, gathering feedback for further improvements.

Documentation and deployment

- Document the entire development process including hardware schematics, software architecture, and user manuals.
- Deploy the system for real-world use, providing necessary support and maintenance.

Continuous improvement

- Gather feedback from users and stakeholders to identify areas for improvement that iteratively enhance the system's functionality and use

Wearable devices produced from this approach have rich sensing capabilities for orientation and pose of the hand, low fabrication times, and embedded activity prediction capabilities. The accelerometer sensor detects the movement of the hand and sends the data to the Arduino board. The Arduino board processes the data and sends it to the Android application via Bluetooth. The Android application analyzes the data and recognizes the gesture. The Android application generates voice and text output based on the recognized gesture. The Android application displays the recognized gesture and the output on the Android screen. The LCD display on the Arduino board displays the recognized gesture.

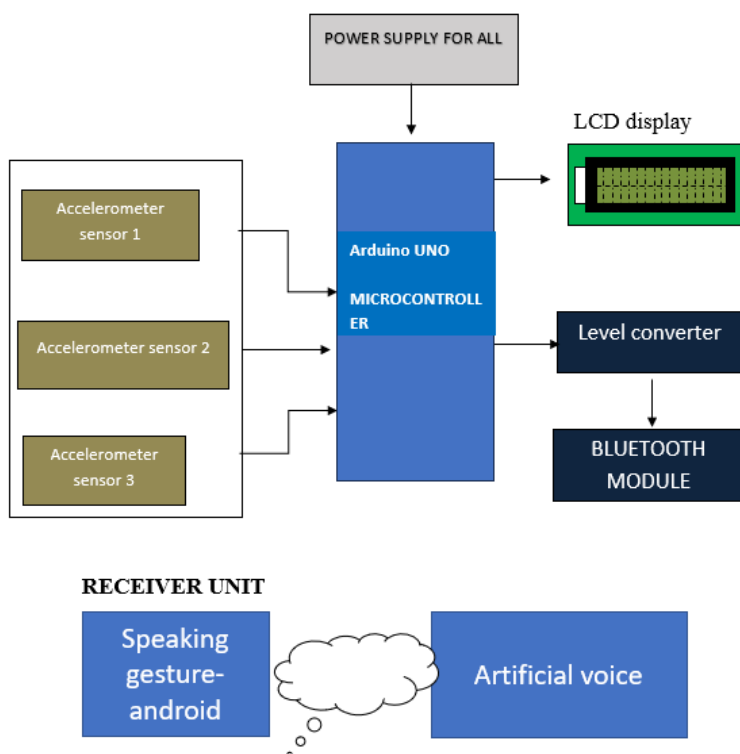


Fig 1. Block Diagram for Hand Gesture

V. RESULT

The system has MEMS sensor for detecting the hand motions. The sensor values are stored on the microcontroller unit. Based on the hand motions the stored outputs are displayed on the LCD and also played through the speaker. Embedded C language is used to write the microcontroller program. Arduino software is used to develop the system. In this system is detect the hand motions in few seconds and also this system is got 99% accuracy. The proposed system successfully recognized different hand gestures and generated voice and text output based on them. The accuracy of the gesture recognition depends on the sensitivity and calibration of the accelerometer sensor. The response time of the system depends on the processing speed of the Arduino board and the Bluetooth connection. The LCD display provided a visual confirmation of the recognized gesture. The proposed system provides a low-cost and simple solution for gesture recognition without the need for complex machine learning algorithms. The system can be used for various applications

such as home automation, gaming, and healthcare. However, the accuracy of the system can be improved by using more advanced sensors and machine learning algorithms. Additionally, the system can be made more user-friendly by providing a calibration feature for the accelerometer sensor and by adding more gestures and corresponding output.

VI. CONCLUSION

The proposed system for gesture recognition using an accelerometer, Arduino Uno, Bluetooth module, LCD display, and Android application that generates voice and text output is a lowcost and simple solution for recognizing different hand gestures without the need for complex machine learning algorithms. The system can be used for various applications such as home automation, gaming, and healthcare.

The system workflow involves the accelerometer sensor detecting the movement of the hand and sending the data to the Arduino board, which processes the data and sends it to the Android application via Bluetooth. The Android application analyzes the data and recognizes the gesture, generates voice and text output based on the recognized gesture, and displays the recognized gesture and the output on the Android screen. The LCD display on the Arduino board displays the recognized gesture.

The accuracy of the system depends on the sensitivity and calibration of the accelerometer sensor, and the response time of the system depends on the processing speed of the Arduino board and the Bluetooth connection. The system can be made more user friendly by providing a calibration feature for the accelerometer sensor and by adding more gestures and corresponding output.

Overall, this proposed system provides a simple and affordable solution for recognizing hand gestures and generating voice and text output based on them, making it a promising technology for various applications. Thus, a portable communication system has been designed using the accelerometer sensors, microcontroller and an android mobile. The limited communication abilities of the existing systems are overcome by the use of an android mobile application for speech synthesis. Also the vocabulary and accuracy is relatively good when compared to other speech synthesizers. Hand gesture recognition is very helpful for deaf and dumb peoples to communicate in a free and comfortable manner, and this Android phone act as an artificial tongue to facilitate effective social interaction.

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