International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 6, Issue 6, pp 94-98, June-2022

https://doi.org/10.47001/IRJIET/2022.606012

Design and Implementation of Smart Glove for Sign Language Vocalization

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***Abstract* - Spoken language is the prevalent way of communication. For deaf and dumb people, it becomes impractical to implement. So, they use sign language for communication which is not a prevalent communication medium for normal people. It leads to a communication barrier between signers and non-signers. Smart gloves for sign language vocalization are a research project that aims to present an easy communication medium for signers and non-signers. In this research project, a wearable sign-to-speech translation system is designed and developed that uses machine learning for classifying different signs and can accurately translate the hand gestures of Sign Language into speech. This research project uses potentiometer to detect bending of fingers and combination of Accelerometer and Gyroscope for hand orientation and movement, and provides a real-time translation of signs into spoken words.**

Keywords: Sign-to-speech translation, smart glove, communication medium, hand gesture, nepali sign language, machine learning.

I. INTRODUCTION

1.1 Background

In Nepal, 16.6 percent of the population suffers from some kind of hearing problems, one of the highest in Asia.[1] Hearing disability is the third most common disability, only after physical and visual disability. Due to the hearing disability, it is impossible for them to communicate using spoken language. So, the most efficient way for communication between deaf population and the normal population is sign language. But everyone has no prior knowledge of sign language. This problem can be solved using a translation system that can convert the hand gesture of sign language into speech.

The main purpose of our project is to make a device which can detect the gesture and the movement, recognize the sign and output it via display as text and via a speaker as sound. Using this device, deaf people who know sign language can easily communicate with normal people who don't know sign language.

This research project uses a sensor-based system which senses the analog signal of hand gesture. The sensed signal is read by the microcontroller and with the assistance of a machine learning model, signal data for different sign gestures are fed into the model for training it. After successful training of the model, it is used to recognize the gestures signalized by the hand in real time. The predicted gesture is vocalized with the help of the speaker.

1.2 Problem Statement

Signed languages are conveyed by the hands, face, and body, and are primarily perceived visually. However, without prior knowledge of sign language, it is difficult for non-signers to receive and understand this conversational medium. This creates a communication barrier between signers and non-signers.

Due to this, signers have to face a lot of difficulties while communicating with the rest of the world. People when learning sign language require them to stop thinking in straight English and rely on abstraction and other skills to communicate both dynamically and accurately.[4] The biggest disadvantage of signed languages is its access, availability, and stigma.

Sign languages are difficult to rise from basic level. Mastery requires extensive exposure and practice. For sign language users it will be similar to communicating with people who are unaware of the language which he or she can speak. This case arises in the case of visiting foreign countries or even in some local places.

As a solution to this problem, there is a need a sign language translation system which can accurately translate the hand gestures of Sign Language into speech

1.3 Objective

The main objective of this research project is to accurately translate the hand gestures of Sign Language into speech in real time. This research project can help deaf and dumb people to communicate well to the world.

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II. LITERATURE REVIEW

2.1 Recent Survey

According to the recent survey by the WHO (World Health Organization), around 5% of the world's population, that is over 430 million people worldwide, have hearing problems from which 16.6% of Nepalis suffer from hearing problems, which is one of the highest in Asia. It is estimated that by 2050 over 700 million people, that is one in every ten people, will have disabling hearing loss.[5] Normal parents of deaf children or vice versa use gesture-based conversation other than deaf population.

2.2 Earlier Employments

One of the earliest employments of gesture-based communication is from the 5th century BC, in Plato's Cratylus. In 1620, Juan Pablo Bonet proclaimed, Reduction of letters and art for instructing mute individuals to talk which is said to be the 1st present day investigation of communication via gestures, mounting out a strategy for voice training for hard of deaf individuals and a standard letter set. [2]

2.3 Use of Gloves to Recognize Gestures

Thomas Pryor and Navid Azodi are UG understudies who made the Gloves that make an interpretation of communication via gestures into text and speech known as signaloud. They had won Lemelson-MIT understudy cost for this venture.[2] The First-Hand oration mittens was constructed by Ryan Patterson in the year 2001. This model had constraints that a PC or a workstation was constantly required for its working which made it less convenient and less portable.

In 2006, Nguyen Dang Binh et.al proposed "A New Approach Dedicated To Hand Gesture Recognition" utilized Thai communication via gestures acknowledgment with the strategy 14 ultra-data-glove which was fixed with 10 sensors for fingers and rest 4 sensors among the fingers which estimates variations and appropriation respectively. But, he got the 94% outcome set. He utilized another new Pseudo 2-D concealed markov model (P2DHMM) structure committed to the time series acknowledgment.

In this procedure T-com P2DHMM structure was utilized to build up a total word of 36 gestures including the ASL letter spelling letters in order and digits and got 96% outcome set.[2] "Hand Gesture Recognition System" Swapnil D. Badgujar, Gourab Talukdar, Omkar Gondhalekar, Feb. 2014. Implemented by continuous gesture recognition a client can control a computer by making the gestures for which we want to convey using a camera which is linked to the computer. [6]"Sign Language Speech conversion" Aarthi M, Vijaylakshmi P, 2016. Implemented a framework for changing over gesture based communication to speech utilizing LCD to show the communication through Sign language to text.[7]

M. Mohandes et al. proposed an image based system for recognizing Arabic sign language. It detects the signer's face and hand movement.[8]Tushar Chouhan et al. implemented a wired interactive glove, interfaced with a computer running MATLAB or Octave, with a high degree of accuracy for gesture recognition.[9]

III. METHODOLOGY

3.1 Hardware Arrangements

Open-source 3D model parts of mechanical gloves are printed and arranged as shown in figure to capture the movement of hand using potentiometer.[3]

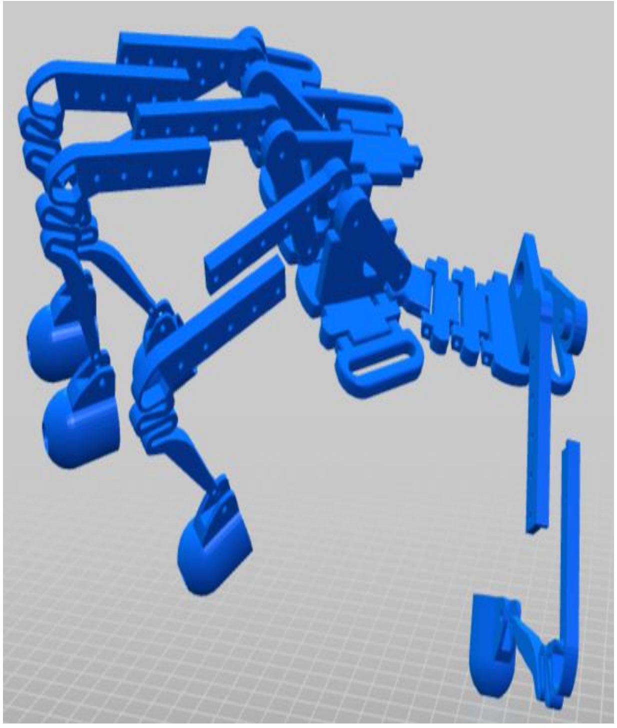

Figure 1: 3D Image of Mechanical Design

The hardware components are linked using PCB and different cables which are represented in the given block diagram.

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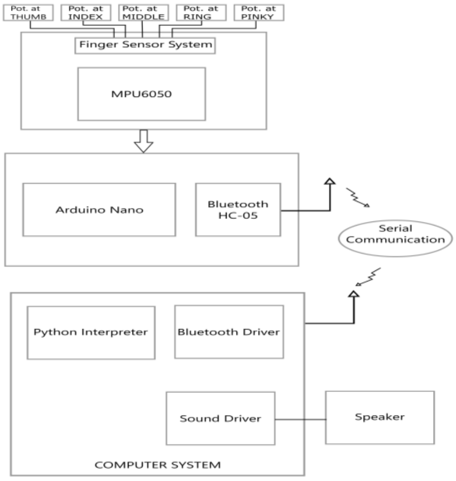

Figure 2: Block Diagram of Electronics System

Five potentiometers are attached at the end of each finger to detect their bending. Resistors were connected in series with potentiometers to get bending data in voltage signals which together form a fingers sensor system. In advance, Accelerometer and Gyroscope were used to define the orientation of the hand. The sensory system is then connected to the microcontroller. For serial communication, the Bluetooth module is connected to the microcontroller. Python is selected as an interpreter for programming for our AI logic. All the training and prediction programs are written in python language. A speaker is used to vocalize the voice for the respective sign language.

On combining both the mechanical and electronic design, the overall design of our project is shown below.

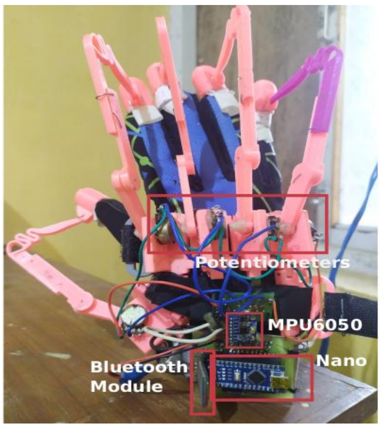

Figure 3: Complete Assembly of the System

3.2 Dataset Preparation

We are focusing on Nepali Sign Language (NSL). The datasets of our sensors (potentiometers, accelerometer and gyroscope (angular form)) for NSL are not available in advance. So, we need to prepare our own dataset. The flowchart for preparation of dataset for different sign language gesture is shown below:

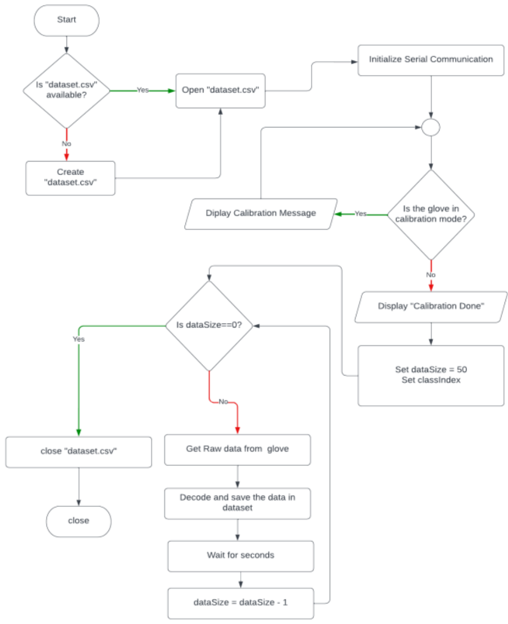

Figure 4: Flowchart of Dataset Preparation

3.3 Dataset Training

The combined value of all sensors will be used to recognize the gestures. Each gesture representing the sign language, will be sent to the python interface using serial communication which will collect and save dataset in CSV format.

Then the datasets will be fed into the machine learning algorithm and the model will be trained. The final trained model will be saved in files.

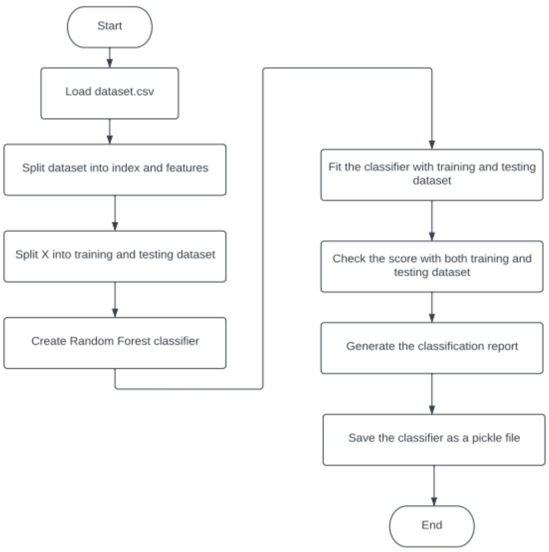

Figure 5: Flowchart of Dataset Preparation

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3.3 Prediction of Sign Language

The sensory system will give eight features i.ef_t, f_i, f_m, f_r, f_p, a_r, a_p, a_y which represent the hand gesture. Sampled data will be extracted and fed to a trained model for prediction. The predicted value is converted to speech.

Figure 6: Flowchart of Prediction of Sign Language

IV. RESULTS AND DISCUSSIONS

4.1 Result

The datasets were prepared focusing on Nepali Sign Language (NSL). The datasets for words and letters were prepared separately. At first the flex sensor was used for collecting the data of the fingers but it was inaccurate so the requirement of our project could not be met by the flex sensor so the flex sensor was replaced by potentiometer. The potentiometer gave the accuracy of approximately ±2° to ±5° bend of finger which could meet the requirement of the project. All the datasets were combined and trained using ML. After training, the predicted output was played on the speaker. As per testing the accuracy of our model was obtained to be 100 percent during training and 98 percent during testing.

4.2 Analysis

In this research project, 9 words and 5 letters were trained. For each sign, around 250 datasets were created for increasing training accuracy. Each dataset includes 8 data values (thumb, index, middle, ring, pinky, roll pitch and yaw) which are the features of the dataset. Data was taken every 500 milliseconds and saved in a file. Figure 7 shows the demonstration of the sign language gestures with respective output.

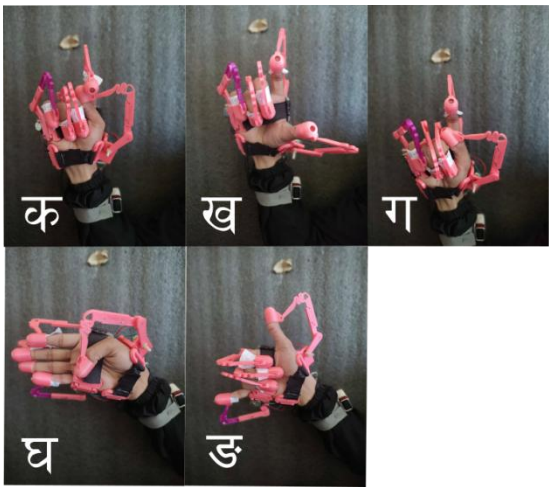

Figure 7: Sign Language Gestures of NSL and Their Corresponding Output

The correlation matrices as shown in figure 8, 9, 10, 11, 12 were plotted for each of the sign languages which represent the statistical relationship between the datasets. From the correlation graph, it can be analyzed that data from the thumb and pinky fingers are highly uncorrelated with other data features in most of the classes. They may make the prediction quite inaccurate otherwise the dataset looks fine.

Figure 8: Correlation Matrix of letter Ka

Figure 9: Correlation Matrix of letter Kha

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Figure 10: Correlation Matrix of letter Ga

Figure 11: Correlation Matrix of letter Gha

Figure 12: Correlation Matrix of letter Nga

IV. CONCLUSION

The research throws light on the “Smart Glove for Sign Language Vocalization” which focuses on being a major helping hand for deaf and dumb communities in case of communication. It tries to eliminate the gap between sign language and normal language which without it was being done by a middle man translating the sign and normal language. Just like adding new words into a dictionary, the sign language symbol can be added with its corresponding normal language for making it better and better. The accuracy of system can be improved by increasing the number of datasets in future.

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Citation of this Article:

Amrit Aryal, Basanta Gyawali, Divakar Aryal, Roshan Shrestha, Hari K.C., “Design and Implementation of Smart Glove for Sign Language Vocalization” Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 6, Issue 6, pp 94-98, June 2022. Article DOI https://doi.org/10.47001/IRJIET/2022.606012

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