“SIGN-ify: Wearable Glove to Translate Sign Language into Text and Speech”

by Sohini Joarder

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A PROJECT REPORT

On

"SIGN-ify: Wearable Glove to Translate Sign Language into Text and Speech"

Submitted to

KIIT Deemed to be University

In Partial Fulfilment of the Requirement for the Award of

BACHELOR'S DEGREE IN COMPUTER SCIENCE AND ENGINEERING

BY

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UNDER THE GUIDANCE OF

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SCHOOL OF COMPUTER ENGINEERING

KALINGA INSTITUTE OF INDUSTRIAL TECHNOLOGY

BHUBANESWAR, ODISHA - 751024

May 2023

KIIT Deemed to be University

School of Computer Engineering

Bhubaneswar, ODISHA 751024

CERTIFICATE

This is certify that the project entitled

"SIGN-ify: Wearable Glove to translate Sign Language into Text and Speech "

Submitted by

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is a record of bonafide work carried out by them, in the partial fulfilment of the requirement for the award of Degree of Bachelor of Engineering (Computer Science & Engineering) at KIIT Deemed to be university, Bhubaneswar. This work is done during year 2022-2023, under our guidance.

Date: **01/05/2023**

(**DR. AMBIKA PRASAD MISHRA**)

Project Guide

Acknowledgements

We are profoundly grateful to **DR. AMBIKA PRASAD MISHRA** of **Affiliation** for his expert guidance and continuous encouragement throughout to see that this project rights its target since its commencement to its completion. ....

SOHINI JOARDER

KISHAN KUMAR ALOK

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ABSTRACT

Sign language is an important tool for communication among the deaf and hard-of-hearing community. However, it can be a challenge for those who do not understand sign language to communicate with this community. In this project, we propose the development of a wearable glove that translates sign language into text and speech in real-time.

The wearable glove will be equipped with sensors and machine learning algorithms that recognize hand gestures and convert them into text and speech. The device will be designed to be portable and user-friendly, allowing the wearer to use it anywhere and anytime without hindering their mobility.

The main objective of this project is to bridge the communication gap between the deaf and hard-of-hearing community and the hearing community. By providing a means of real-time translation of sign language into text and speech, we aim to improve communication and enable better integration of the deaf and hard-of-hearing community in society.

The proposed wearable glove has the potential to revolutionize the way we communicate with the deaf and hard-of-hearing community. It has applications in education, healthcare, and everyday communication, and can make a significant impact on the lives of millions of people worldwide.

Keywords: Sign-Language, Translate, Wearable, Real-time, IoT

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CHAPTER 1: INTRODUCTION

Sign language is an essential tool for communication used by individuals who are deaf or hard of hearing. While sign language is a visual language that has its own grammar and syntax, it can often be challenging for those who have the knowledge, to understand or communicate effectively. However, technology has the potential to bridge this gap and improve communication accessibility for the acoustically challenged individuals.
One such innovation is the development of sign language to speech and text translator gloves that can translate sign language gestures into written format and read aloud.
These gloves use sensors to detect hand movement and finger bending whose data is then fed into a trained Machine Learning model that shows output on the app after translation. It uses Neural Network algorithms to recognize and translate sign language, making communication more accessible and efficient for the deaf and hard of hearing community. This project aims to explore the technology behind these gloves and their potential impact on the way we communicate with each other.

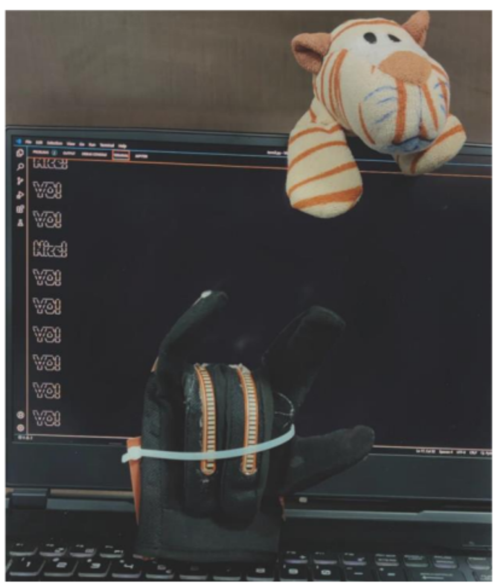

Figure 1.1: **Glove showing gesture "YO"**

1.1 Motivation

Sign language is a visual language used by millions of people worldwide as their primary means of communication. However, it can be challenging for those who do not understand sign language to communicate with those who do. This challenge can lead to feelings of isolation and exclusion for members of the deaf community, and it can also make it difficult for them to access essential services and information.

To address this issue, researchers have been developing wearable gloves that can translate sign language into text or speech in real-time. These gloves are equipped with sensors that can detect the movements of the wearer's hands and fingers as they sign, and then use machine learning algorithms and natural language processing to convert those movements into spoken or written words.

1.2 Background Studies

Sign language is a visual language used by millions of people worldwide as their primary means of communication. However, it can be challenging for those who do not understand sign language to communicate with those who do. This challenge can lead to feelings of isolation and exclusion for members of the deaf community, and it can also make it difficult for them to access essential services and information.

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CHAPTER 2: PROJECT BASICS

2.1 Basic Concept

Speech gloves and technologies that translate sign language into text or spoken language are available. The user's hand and finger movements are detected by sensors in these gloves, which then transform those gestures into words or sentences. People who are hard of hearing or deaf could benefit from improved accessibility and communication thanks to this technology. But modern technology frequently has trouble deciphering the subtleties of sign language, like facial expressions and body language, which can greatly affect the meaning of a message. Researchers are investigating the use of machine learning techniques and natural language processing to overcome these issues and enhance the accuracy and naturalness of translation. Improvements may also come from the development of more sophisticated sensors and speech synthesis technology.

2.2 Literature Review

Several studies have been conducted to evaluate the effectiveness of wearable gloves for sign language translation. A study conducted by researchers at the University of California, San Diego found that the Sign Aloud glove had an accuracy rate of 96.4% in translating American Sign Language (ASL) into spoken English. Another study conducted by researchers at the University of Washington found that the UNI glove had an accuracy rate of 98.63% in translating ASL into text.

[1] An open-source project has been developed to help the deaf community communicate more easily by displaying English alphabet symbols in American Sign Language on a smartphone screen. The project uses a glove with bend sensors and an accelerometer to detect hand movements, which are then translated by an Arduino Nano micro-controller and displayed on an Android app via Bluetooth. [2] Another device created by bioengineers at the University of California, Los Angeles (UCLA) uses gloves with thin, stretchable sensors to translate ASL into spoken English in real time. [3] The Language of Glove is a sensor-packed glove that translates the gestures of sign language into text.

CHAPTER 3: PROJECT OVERVIEW

3.1 Problem Statement

There is a communication barrier between the deaf and hard-of-hearing community and the hearing community. Sign language is a visual language that is not understood by everyone, and its lack of standardization further exacerbates the issue. This leads to a lack of access to information and opportunities for the deaf and hard-of-hearing community. Wearable gloves that can translate sign language into text and speech can address this problem by facilitating communication between the two communities, but the technology is still in its early stages and faces challenges such as accuracy, cost, and usability. Therefore, *the problem statement is to develop wearable gloves that are reliable, affordable, and widely accessible for effective communication between the deaf and hard-of-hearing community and the hearing community*.

3.2 Project Planning

The first step in the process is to identify the problem that the product is meant to solve, which in this case is improving communication for the deaf and hard of hearing community. Once the problem has been defined, the next step was to clearly define the scope of the project and set specific goals and timelines for its completion. Assembling our team and dividing the workload according to their abilities in the fields of engineering, design, and testing was also essential. Throughout the development process, it's important to conduct testing and quality assurance to ensure that the gloves are effective and meet the needs of the target audience. By following these steps, a successful prototype has been developed that has the potential to be a model that can make a significant impact on the lives of those who rely on sign language to communicate.

3.3 Project Analysis (SRS)

The development of sign language to text and speech gloves requires careful planning and analysis. The first step in the project analysis is identifying the problem and defining the scope of the project. The goal is to create gloves that can translate sign language into text or speech, allowing people with hearing or speech impairments to communicate more easily. The next step is assembling a team of experts in fields such as engineering, computer science, and linguistics. The team will work together to set goals and timelines for the project. During the development stage, testing and quality assurance will be conducted to ensure the accuracy and reliability of the gloves. By following these steps, a successful project can be developed that has the potential to make a significant impact on the lives of those who rely on sign language to communicate.

3.4 System Design

3.4.1 Requirement Specifications

SL No.	EQUIPMENT	QTY	DESCRIPTION
1	Glove	1	The wearable glove that we upgrade with sensors to translate
2	Flex Sensors 2.2’	5	A sensor mounted on the finger to record the amount of deflection(bending)
3	ESP 32 WROOM 32	1	A powerful generic Micro Controller Unit with inbuilt Bluetooth connection
4	MPU 6050	1	A 3-axis Gyroscope with Accelerometer
5	Vero Board	8 x 10cm	Single side print circuit board
6	Resistors(47KΩ)	5	To regulate current flow in circuit to the sensors
7	Connecting cables	10(thin), 4(wide)	To connect all the components

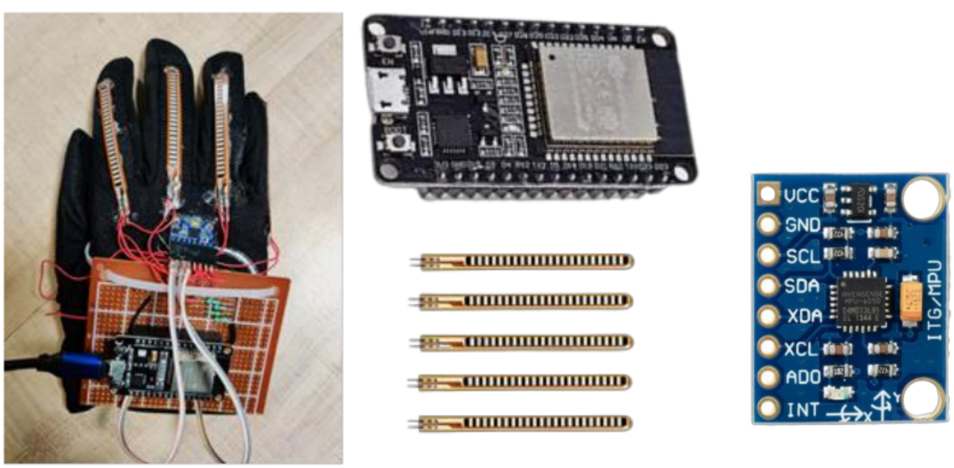

Figure 3.4.1: **Hardware and Components**

3.4.2 Design Constraints

These gloves must be designed to accurately translate sign language gestures into text or speech in real time, which requires advanced sensor technology and complex algorithms. They must also be comfortable and easy to wear, with sensors that are sensitive enough to capture even the slightest movements of the hands and fingers. Additionally, the gloves must be durable and long-lasting, with the ability to withstand regular use and daily wear and tear. Also, docking the entire system on your hand is a hectic job in itself. Meeting these design constraints will require careful planning and collaboration between engineers, designers, and experts in sign language and assistive technology in future.

3.4.3 System Architecture (UML) / Block Diagram

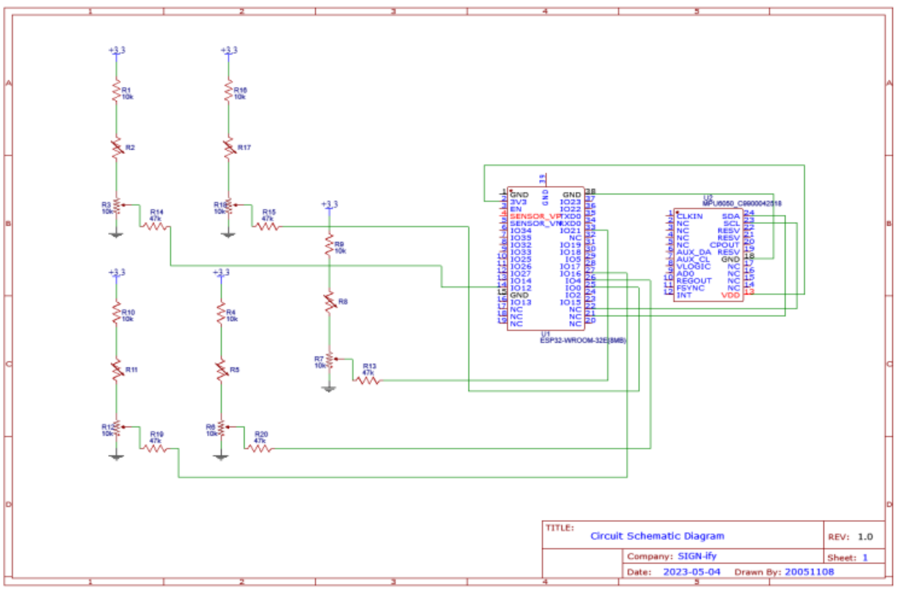

Figure 3.4.4.1: **Schematic Diagram**

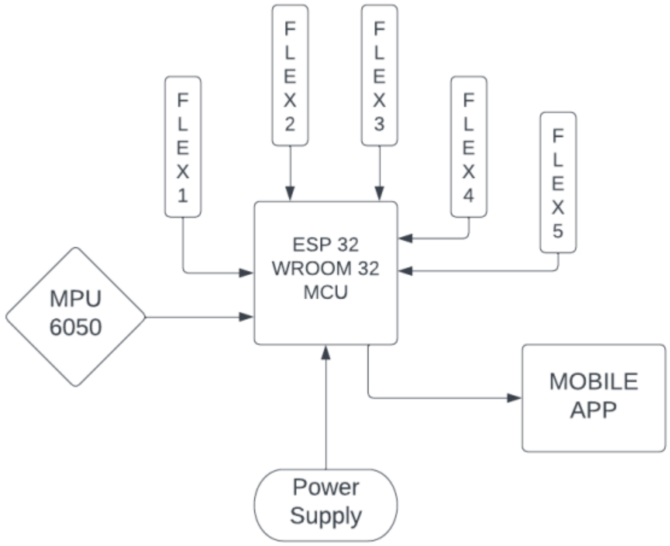

Figure 3.4.4.2: **Block Diagram (UML)**

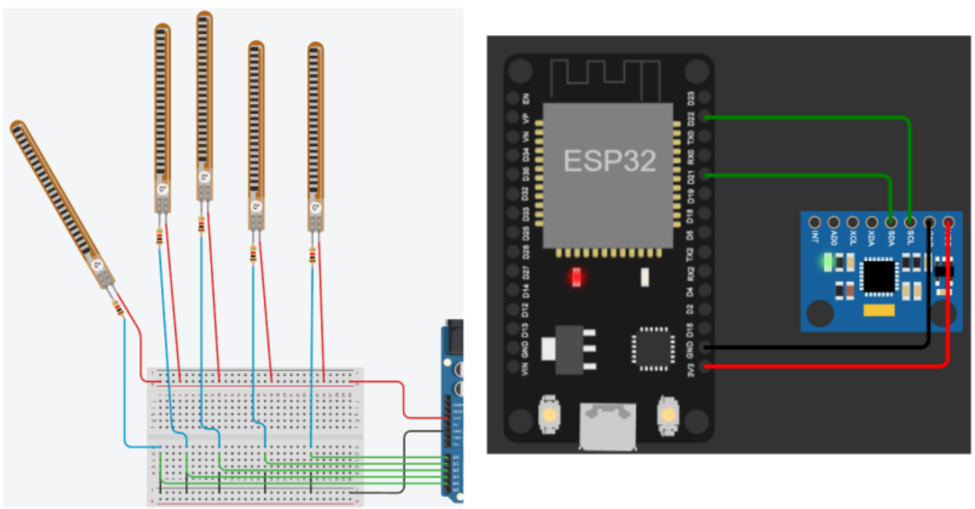

Figure 3.4.4.3: **Connections**

CHAPTER 4: IMPLEMENTATION

4.1 Methodology

Our wearable device is a simple module consisting of five 2.2-inch flex sensors that give a range of different values for every bend for five fingers of our hand. Along with that, we have the Accelerometer Gyroscope MPU6050 giving in total of 6 values, 3 axis values each for accelerometer and gyro and from there we are calculating 3 more values of g-force by using the formula of head, pitch and roll. Finally, we are collecting all these 13 columns of data from serial monitor, adding another column with gesture names and converting everything to csv files. Then after data cleaning and filtration, our model is trained based on that data using Random Forest Classification. At the end, the final python script is converted into a C code file and uploaded on the MCU. Our app on the other hand was supposed to connect to the MCU so that whenever a sign is made and interpreted by the trained model, it would show up as text on the app and read aloud.

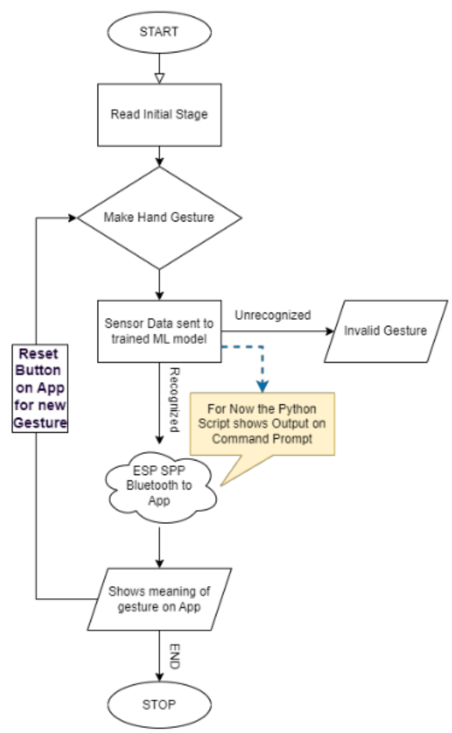

Figure 4.1.1: **Flowchart**

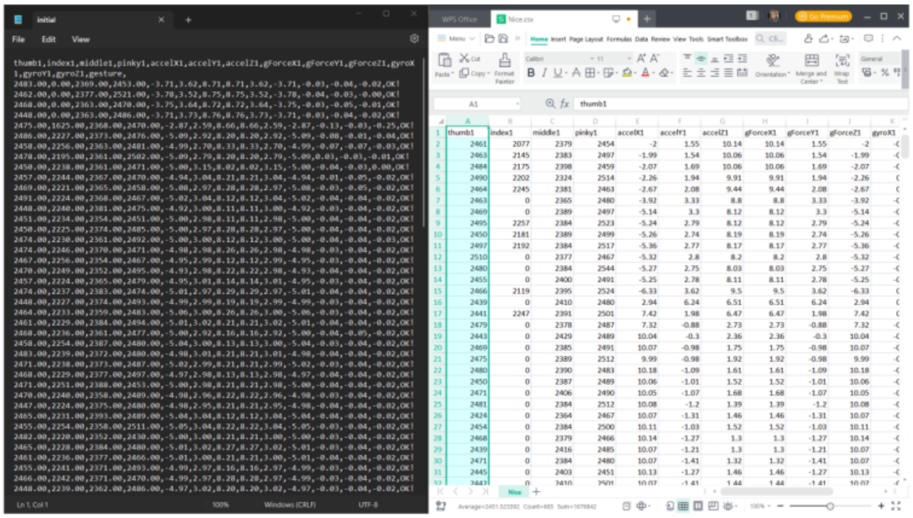

Figure 4.1.2: **Data Collection and conversion**

4.1.1 Data Processing

The dataset is pre-processed before training the model to improve its accuracy. Firstly, the raw data is read in using Pandas and stored as a dataframe. The dataframe is then concatenated with three additional dataframes, which contain information related to initial, nice, and OK gestures, respectively. After concatenation, the dataset is examined using the describe() method to get statistical information about each feature.

To prepare the data for model training, the target variable 'gesture' is separated from the rest of the features and stored in a separate dataframe. The feature dataframe, df_x, is then scaled using feature scaling to ensure that all the features are on a similar scale, which is necessary for certain machine learning algorithms such as KNN, SVM, etc.

Furthermore, the data is split into training and testing sets using the train_test_split() method from Scikit-learn. The test_size parameter is set to 0.12, meaning that 12% of the data is reserved for testing.

Finally, the pre-processed data is ready for model training, and the RandomForestClassifier algorithm is used to train the model.

4.1.2 Model Training

After data pre-processing and feature extraction, the next step is to train a machine learning model using the processed data. In this project, we used a Random Forest Classifier, which is an ensemble learning method that constructs a multitude of decision trees and outputs the class that is the mode of the classes of the individual trees.

To train the model, we used the processed data to split the dataset into training and testing data using the train_test_split() function from the sklearn.model_selection library. The training data was used to fit the Random Forest model, which was then tested using the testing data.

We set the number of decision trees in the Random Forest to 40 and used the default criterion for splitting, which is the Gini impurity. The random_state parameter was set to 42 to ensure reproducibility of results.

After training the model, we evaluated its performance using classification_report() and confusion_matrix() functions from the sklearn.metrics library. The model achieved an accuracy of around 95% on the testing data, indicating that it was able to generalize well to unseen data.

Finally, we saved the trained model using the joblib.dump() function from the joblib library. This saved model can be used in future to make predictions on new data without having to retrain the model every time.

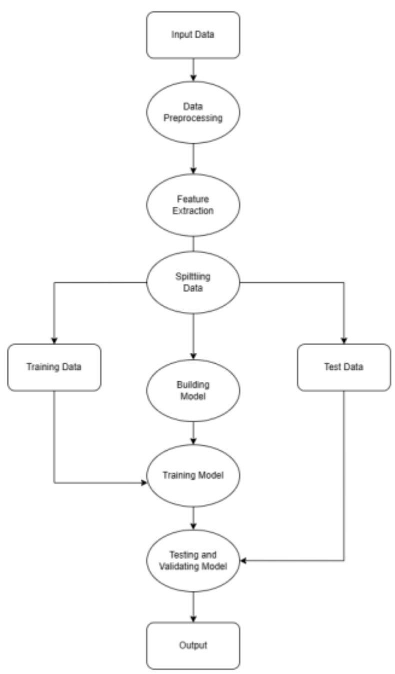

Fig 4.1.1.1: **Activity Diagram for Machine Learning**

4.2 Verification Plan

A key component in the creation of the sign language to text and audio gloves was the verification plan. The gloves underwent a stringent testing procedure to make sure they translated sign language into text and spoken correctly. The strategy included functional and performance testing to ensure the gloves accurately translated and recognized a variety of sign language motions. Additionally, user testing was done to make sure that people with different hand sizes and degrees of dexterity could wear the gloves easily and comfortably. Throughout the glove's development, the verification plan was a continuous process to find and fix any problems prior to the release of the finished product.

ID	Test Case Title	Test Condition	Precision	Error Reason
T01	Initial	Steady	1.0	NULL
T02	Ok	Thumbs up	1.0	NULL
T03	Nice	Thumb and Index connect	0.89	MPU value of "Nice" correlated to gesture "Yo"
T04	YO	Pinky, Index & Thumb up	0.82	

```
print(classification_report(y_test,y_test_predicted))

              precision    recall  f1-score   support

         Yo!       0.82      0.88      0.85        69
       Nice!       0.89      0.84      0.86        76
         OK!       1.00      0.98      0.99        51
   Steady...       1.00      1.00      1.00        53

    accuracy                           0.92       249
   macro avg       0.93      0.93      0.93       249
weighted avg       0.92      0.92      0.92       249
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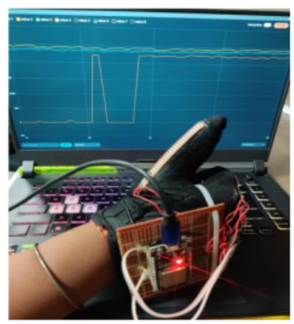

Figure 4.2: **Classification Report and Hardware generated graph**

4.3 Result Analysis

For now, since the app is still under construction, we are giving our final output on Windows Command Prompt using a very basic Python Script. It reads the values from sensors when a gesture is made, runs it through our ML model and shows the analysed meaning on cmd. For the first two gestures the results are a 100% accurate but for the ones where the MPU stays in the same plane, there is a slight discrepancy due to correlation.

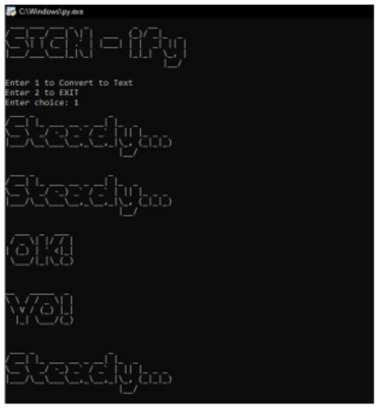

Figure 4.3: **Output (Result) Screenshots**

4.4 Quality Assurance

Quality assurance is a critical component of the development process for the sign language to text and speech gloves. The goal of quality assurance is to ensure that the gloves meet or exceed the standards set by the project's stakeholders, which includes accuracy, usability, and reliability. The quality assurance process for this project involved several steps, including the establishment of quality standards, creation of test cases, and the implementation of a comprehensive testing plan. The testing plan encompassed both functional and non-functional testing, including usability testing to ensure that the gloves were easy to use and comfortable for individuals with varying levels of dexterity. The quality assurance process was an ongoing effort throughout the development of the gloves, with regular testing and monitoring to ensure that any issues were identified and addressed promptly. Through this process, the team was able to ensure that the final product was of the highest quality and met or exceeded the expectations of the project's stakeholders.

CHAPTER 5: STANDARDS ADOPTED

The gesture recognition system was designed, coded, and tested in accordance with best practises and standards set by organisations like IEEE and ISO. Wireless communication has been recognised as a future area of work, despite the fact that it was originally intended to be a part of the wearable gloves. The system was created to be scalable and adaptable to allow for future advancements. We think that the system's robustness and dependability have been enhanced by the implementation of these standards.

5.1 Design Standards

We used the IEEE 1016-2009 standard for Software Design Documentation as our guide for the design guidelines we used for this project. The best practices for producing design documentation for software projects are outlined in this standard. It offers a structure for producing brief, understandable, and maintainable design papers. We adhered to this standard to make sure that our design documentation was of the highest caliber and adhered to accepted standards.

5.2 Coding Standards

The ISO/IEC 12207 standard, which offers a foundation for the software development life cycle processes, was followed whilst we were coding. We also followed the IEEE 829 standard for software testing, which establishes the structure for describing the procedures and outcomes of software testing.

5.3 Testing Standards

In terms of testing, we adhered to the IEEE 610 standard for software testing, which stipulates best practices for creating, implementing, and documenting software tests. The IEEE 29119 standard, which offers a foundation for software testing procedures and methods, was also employed.

CHAPTER 6: PROJECT CONCLUSION

6.1 Conclusion

In conclusion, it has been a difficult but worthwhile project to create the sign language to text and speech gloves. The team worked diligently to achieve the project's objective of developing a tool that could faithfully convert sign language into both text and speech. To produce a high-quality product that met or surpassed the expectations of the project's stakeholders, the project required substantial study, design, development, and testing. The gloves underwent extensive testing to make sure they were accurate, dependable, and simple to use for people with different degrees of dexterity. The team's accomplishment in finishing this project successfully shows the potential for technology to enhance the lives of people with disabilities.

6.2 Future Scope

Initially the prototype of the wearable translator glove is ready. However, it is not built up to its optimum potential. For the final product, we have planned 4 points of improvement in terms of future scope:

- **Expansion:** We will be updating it with more gestures and alphabets and will be upgrading our MCU to fit and integrate everything perfectly.
- **Ease of Use:** Once the app is ready, one can easily use our device anytime anywhere without any other requirement but their phones.
- **Comfort:** We will be designing a custom PCB and mount it on a bendable Veroboard made wristband for easy wear and comfort.
- **Better Understanding:** We have planned to implement the use of AI to read the context of speech and thus translate the gestures accordingly for optimised meaning.

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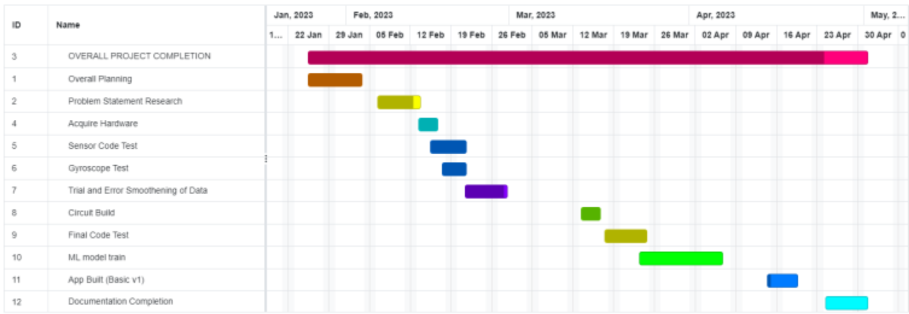
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5 Sensor Code Test
6 Gyroscope Test
7 Trial and Error Smoothening of Data
8 Circuit Build
9 Final Code Test
10 ML model train
11 App Built (Basic v1)
12 Documentation Completion

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