COMMUNICATION AID FOR SPEECH IMPAIRED PEOPLE USING FLEX SENSOR TECHNOLOGY

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Abstract - *This project aims to develop a communication aid system tailored to the diverse needs of individuals with disabilities, fostering inclusivity and independence in their daily lives. People with disabilities often face challenges in expressing themselves, hindering their ability to communicate their feelings effectively. Flex sensor-based gesture recognition involves using flex sensors, which are resistive devices that change their resistance based on the degree of bending. These sensors are commonly used to detect and measure the bending of fingers to derive the degree of the bend of a finger and produce a pattern to recognize and provide the required message.*

Key Words: Flex Sensor, Degree, Resistance, Gestures, Pattern, Message.

1.INTRODUCTION

This project aims to integrate the functionality of the flex sensor to help the people who cannot speak. This project aims to overcome their disability to speak and help them lead a normal life. So, they can convey their feelings without any difficulty.

A Flex sensor is a sensor which is used to measure the amount of deflection or bending. The resistance of the flex sensor increases with the amount of deflection. The carbon surface is arranged on a plastic strip, as this strip is bent then the sensor's resistance will be changed. The distance between the conductive materials are widened so that the resistance has increased due to the unavailability of conductive particles. Its varying resistance is directly proportional to the deflection on the sensor. This sensor works on the bending strip principle meaning whenever the strip is bent then its resistance will be changed. This can be measured with the help of any controller. The Voltage Divider rule can be applied to find the resistance across the sensor after the deflection. Usually, Voltage can be measured parallel to a component. In order to find the voltage across the flex sensor, the circuit is divided to find a parallel terminal to measure the voltage. That can be used to compute the resistance across the sensor. And the measured values are mapped to their similar angle values to obtain the degrees of deflection.

In this project, we aim to help the speech impaired people to communicate and express their feelings, thoughts and opinions freely like other humans, that can be understood by the other humans as well. The degrees of deflection of the flex sensors can be used to form a pattern, representing a sign language pattern. Various patterns are trained to understand the signs used by the speech impaired person and provide accurate feedback. So, they can be used not only on international sign language, on local sign language as well. This will improve the compatibility of the wearer with the algorithm, so better understanding of the patterns can be achieved and accurate outputs are provided.

Machine Learning algorithms are employed to increase the effectiveness of the algorithm. Several patterns are recognized and they are studied to find the most matching pattern which is similar to the predefined patterns. The accuracy can be improved by providing multiple inputs to train the algorithm.

1.1 Algorithm

The algorithm which we are using provides output based on the most matching pattern that could be formed. Predefined patterns are already stored in the database. When a pattern which exactly matches with the predefined patterns, then the output is provided.

2. PROPOSED TECHNOLOGY

Sign language pattern identification plays a crucial role in bridging communication gaps between individuals with hearing impairments. Flex sensor technology provides assist in developing sign language recognition systems by capturing hand movements and gestures.

2.1. Flex Sensors:

Sign language recognition aims to interpret hand movements, gestures, and expressions to translate them into understandable language or text. Flex sensor technology, which detects changes in resistance based on bending, is used to recognize the sign language patterns.

Figure 1 – Flex sensor

2.2. Sensor Placement and Configuration:

We need to identify and recognize the patterns which are performed by the hand with the movement of the fingers. So, placing them on the finger would be ideal.

Figure 2 – The Flex Sensor is attached to the glove

2.3. Arduino:

In this project, an Arduino is used as a microcontroller. It provides ease of use with the libraries provided within the system. We have used the Talkie library for text to speech conversion. It generates speech from a fixed vocabulary.

Figure 3 – The Arduino UNO

2.4. Machine Learning Algorithms:

Machine learning algorithms play a central role in classifying sign language patterns based on pre-defined inputs. It analyses the sign and rectifies the errors.

2.5. Performance Evaluation:

Performance evaluation is critical for understanding the effectiveness of sign language recognition algorithm. Common metrics include accuracy, precision, recall, F1 score, etc,.

2.6. Vocal Output:

A speaker with an amplifier circuit is provided to produce the output in the form of sound.

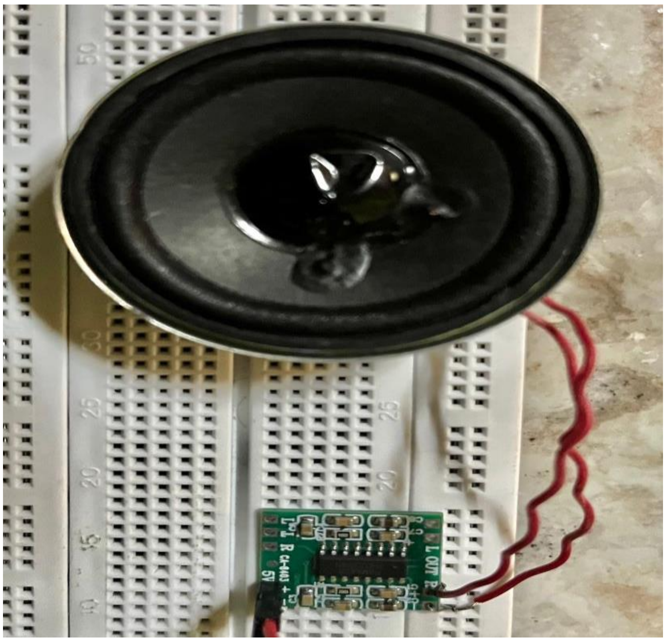


Figure 4 - A Speaker module with the amplifier circuit to produce output.

2.7. Future Directions:

Future research directions in this field will be focused towards the algorithm refinement and more precise means of data reception and processing.

2.8. Conclusion:

In conclusion, sign language pattern identification using flex sensor technology holds potential for enhancing communication accessibility for individuals with hearing impairments. Continued research on this topic will help them lead a normal life.

3. PROJECT OBJECTIVES

The following are the research objectives, which the team has framed in order to conduct the study.

- Facilitate communication and expression.
- Fostering human connection.
- Improving human interaction.
- Breaking down barriers to employment.
- Catalyzing further research and development.
- Improving educational opportunities.

4. PROPOSED METHODOLOGY

In our research on communication aid using flex sensor technology, we systematically processed the architecture of the project to be compact and weightless. The flex sensor is so brittle, so the encapsulation of the sensors is so crucial. We used a set of predefined patterns. The dataset was partitioned into train and test sets using a function, with 70% allocated for training and the remaining 30% for temporary data. This temporary data was further divided into a 40% validation set and a 60% testing set, all under a fixed random state of 42 for consistency. This approach ensures an effective evaluation of machine learning models, providing a solid foundation for learning, tuning, and assessing performance with reproducible results. The KNN model was employed in the classification phase to predict pattern which is made by the user. The model's effectiveness was evaluated thoroughly, comparing its performance with previously defined models. This approach ensures robust training, validation, and assessment, contributing to the reliability of the algorithm.

In order to conduct this particular research, the team has collected data from secondary sources of data collection. The secondary sources of data collection include online journals, scholarly articles from scholars and online brochures. The secondary sources of data are used as a reference as it helped the team to collect data at large volumes on the particular research topic. An algorithm is provided to understand the patterns formed by the sensors.

5. EVALUATION OF THE ALGORITHM

The algorithm already has a set of predefined values to train the algorithm. If the pattern formed by the sensors are similar to a particular value, then an output is provided. But if the values that didn't match, the controller searches for the similar values and sees if it can map the pattern to any available data in the controller. If a pattern which is totally unrecognizable is identified, then controller may read the new pattern and try to develop a similar output by comparing it with the other outputs which are already used in training the algorithm.

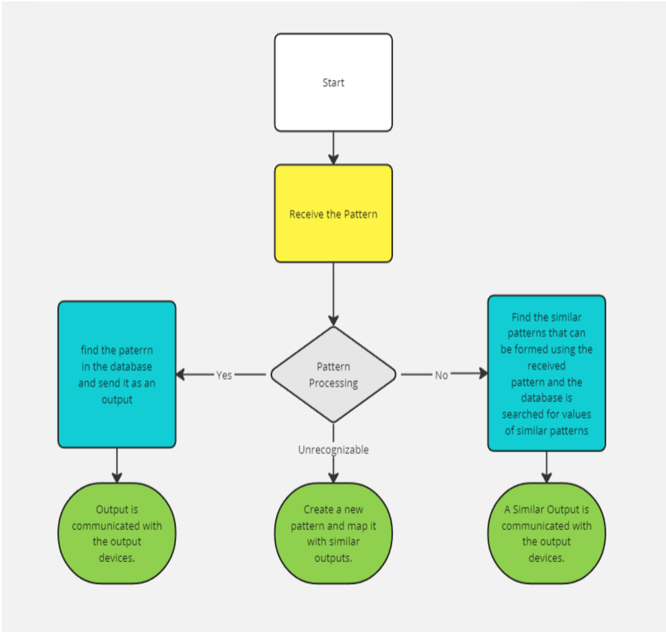


Figure 5 – The workflow of the system

5.1. WORKING OF THE ALGORITHM

Initially, during the time of reception of a pattern, the algorithm, first of all, it checks if it matches with any of the pre-defined patterns. If not, then it finds a set of a few patterns which matches according to it. It is arranged in a way that the most matching will be at top and the least matching will be at bottom. Those patterns along with the received pattern are sent to a function in which the patterns are compared with the help of the algorithm to check which pattern matches more with the received pattern. The resulted patterns are again sent to the same function to filter the best pattern. The accuracy can be increased by iterating the patterns multiple times until we find the most acceptable solution.

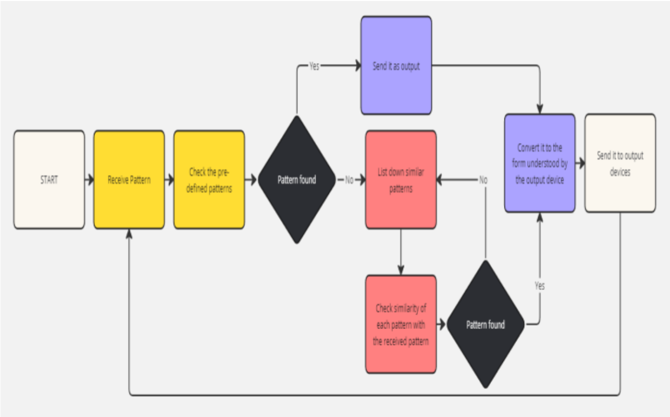
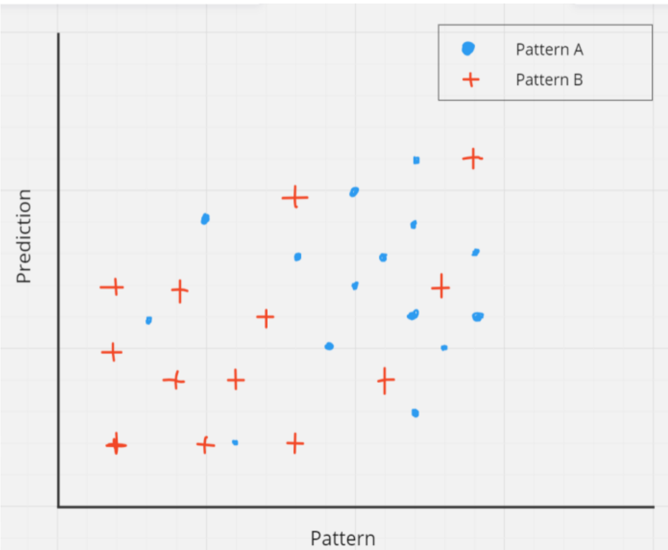


Figure 6 – Workflow of the algorithm

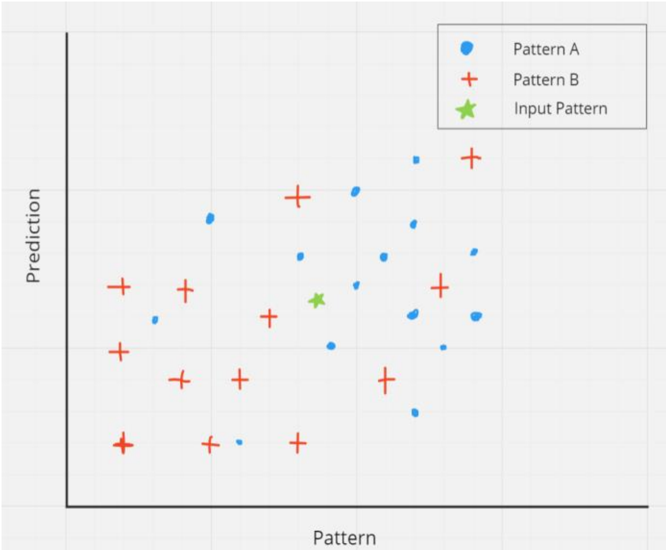
6. ANALYZING THE EFFECTIVENESS OF THE ALGORITHM

In this study, we've developed an algorithm to help convert hand signs into speech. Using advanced pattern recognition techniques, our algorithm analyzes hand signs using machine learning models and algorithms, achieving high accuracy. Through testing and training, we've refined the algorithm's ability to recognize patterns in hand gestures. Once the hand signs are identified, the algorithm produces speech output with high accuracy. To handle errors in the recognition process and pattern formation, the algorithm includes an error detection and correction mechanism. This mechanism identifies and fixes errors in real time, ensuring the speech output remains accurate even in challenging conditions. Additionally, the algorithm analyzes any errors encountered during recognition, using this information to continually enhance its performance. In summary, our project provides a reliable solution for converting hand signs into speech accurately and reliably.



Graph 1 – The mapped coordinates of two patterns denoted by plus and dot.

The algorithm receives the pattern as input and checks for similar patterns, then it marks a few similar patterns according to the dataset in the database. If the pattern exactly matches the pattern in the database, then the corresponding message is sent as an output. If not, the similar patterns are taken into account, then they are compared to obtain the most similar output. The above graph shows that, it has taken account of two patterns at a single time, and then the mapping of those prevoiusly entered values are provided. If the currently entered values falls near the set of patterns which has the most occurance around it, then it is chosen as the output.



Graph 2 – The Star coordinate depicts the newly received pattern

As it can be seen from Graph 2, it implies that it has recorded a new instance of a pattern, that is under recognition by the algorithm. The algorithm considers the newly recorded pattern as an unknown pattern. That will be under the recognition process. Then, it compares several patterns with similarity to the currently unknown pattern. Then, the algorithm chooses a few patterns to compare with the unknown pattern. The values of the algorithms are mapped and the unknown pattern is found using the K - nearest neighbors algorithm. Along with the newly studied pattern, the history of received similar patterns also stored.

7. ERROR HANDLING

There are pre-defined gestures in every sign language system. So, the probability of the occurrence of the error while producing the gesture is high. The algorithm handles it by finding the most possible gesture could have made compared to the received gesture. So, the error is automatically rectified and a correct output is provided. It could be found by comparing the two gestures. If the similarity is above 80% then the gesture is acceptable as a correct gesture. If it is less than 80%, then another gesture which is even more similar is compared.

8. ANALYZING THE FUNCTIONALITY OF THE FLEX SENSORS

Flex sensors are the type of sensors which can change its resistance when it is subjected to deflection. This is achieved by the arrangement of the conductive strips. When the sensor is bent, the conductive strip is elongated, leading to the increase in the distance between those conductive particles, thus increasing resistance. The value received from the flex sensor is based on the parallel resistance used while dividing the voltage. It provides a raw value that can be mapped to value in terms of degrees. The flex sensor can only be bent in a single direction. If it is subjected to bending on the other direction, the conductive layer may rupture and the resistance values change, disrupting the predefined values and the functionality of the project. As we have included a machine learning algorithm, it is easy for us to understand the change in the resistance values, so, the errors can be rectified. The errors due to the change in the resistance values are considered as the errors produced by the wearer. Since the wearer are expected to produce more errors.

9. ADVANTAGES AND DISADVANTAGES OF THE FLEX SENSOR

Table 1

Advantages	Disadvantages
Simple interfacing of the sensor with the controller	Subjected to permanent deformation
Derivation of the value is easy and requires less processing	Difficulty in acquiring a specific value
The derived values don't require any complex libraries to be converted into a degree.	Can only be bent on one side, bending on the other side crushes the conductive strip

10. EXPERIMENTAL SECTION

The values are received for each finger and can be derived as a string to identify patterns. Each pattern is included in a dictionary or a library. The dictionary is used to search for the pre-defined values, or similar patterns. A new value is added when the pattern arrived cannot be found.

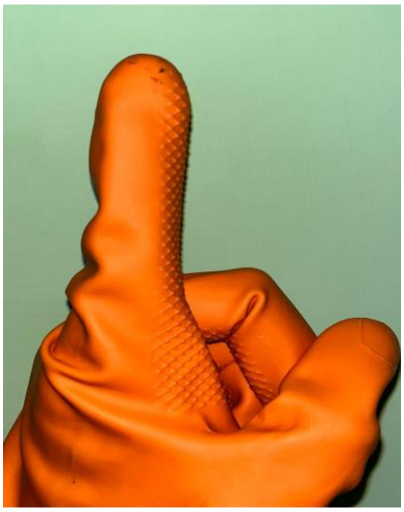
Table 2

The values to its corresponding angles.

Angle	Value
<30	1
>=30 & <=50	2
>=55 & <=75	3
>=80 & <=130	4
>=135 & <=180	5

Table 3

The values are depicted with the actual bend needed to be produced by the finger.

Value	Picture
1	 **Figure 7 –** The straight pointed finger having no bend
2	 **Figure 8 –** The finger with a minimal bend on the bottom

3	 **Figure 9 –** The finger bent in half
4	 **Figure 10 –** The curled finger with high bend
5	 **Figure 11 –** The finger bent to the maximum

The values will be acquired as a string value and they are paired up with relevant words or sentences. A structure is used to define a key-value pairs of data. For example,

11112 - Hello

55555 – Hold

51555 – Point / One

55555, 51111 – Anger

Where, each number in the string represents the level of bending of the finger.

11. CALIBRATION AND PERSONALIZATION:

The calibration and personalization are made easy with the help of the algorithm. Not everyone will produce the same sign with the exact gesture. There will be minimal deviations in the production of the hand sign. The algorithm analyzes it by considering it as an errored gesture and rectifies it. So, the gesture provided will be read by the algorithm and learns the errored gesture and provides the correct output. The probability of producing a wrong output depends upon the sensitivity of the sensor and it will later be rectified by the machine learning algorithm. This method calibrates the system automatically providing ease of use. Further development includes custom creation of a library that includes local sign languages and gestures. User defined gestures will be introduced in future updates.

12. RESULTS AND DISCUSSION

Preliminary results demonstrate the feasibility and effectiveness of the SLPI system in accurately identifying and interpreting sign language patterns using flex sensor technology. The system achieves high classification accuracy and real-time performance, enabling seamless communication between individuals proficient in sign language and those unfamiliar with it. User feedback and usability testing provide valuable insights for further refinement and optimization of the Sign Language Pattern Identifier system.

13. FUTURE DIRECTIONS

The project will further be improved to replace the flex sensor with even better alternatives with lesser drawbacks. Since, the flex sensor's conductive layer may deteriorate over time. So, this project needs improvement in data reception areas.

14. CONCLUSIONS

This paper described the design of flex sensor based pattern recognition system to aid audibly struggling people. The developed device is could read all the gestures and patterns of every finger. The read gestures are stored in a string. And identified, the sentences that are needed to be sent to the output device with the algorithm which is provided. It is identified that the cables might disturb the gestures and the accuracy could be reduced due to the rupture of the conductive layer. Therefore, in the future, usage of wires will be reduced and accuracy of the output is improved using machine learning algorithms to rectify errors caused by rupture of the conductive strip.

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