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# SURVEY ON SIGN LANGUAGE DETECTION USING SMART GLOVES FOR DISABLED PEOPLE

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***Abstract:*** Communication, in today's world facilitates the exchange of information and ideas , enabling individuals to connect , express and provides access to multiple opportunities. But this communication becomes challenging when it comes to disabled community, particularly those who are mute. These people heavily rely on sign language, but many people are unfamiliar with such language which leads to misunderstandings. This survey paper aims to research and examine various models, attributes including sign language variation, sensor configuration, classification method using Machine Learning algorithms, Neural Network techniques and their performance metrics are analyzed and compared. The literature survey also focuses on analyzing studies that use wearable sensor-based systems. Results from this literature analysis will aid in the development of user-centered and robust wearable sensor-based systems for sign language recognition.

***Index Terms* - wearable sensor-based systems, sign language, performance metrics, Machine Learning, Neural Network**

## Introduction

Communication is of paramount importance in various aspects of human life, as it serves as the foundation for effective interaction, understanding, and collaboration. Communication is essential for sharing ideas, thoughts, and information. It allows people to convey their knowledge, experiences, and insights, facilitating the transfer of knowledge and learning. Effective communication is the cornerstone of building and maintaining relationships. Whether in personal or professional settings, open and clear communication fosters trust, empathy, and understanding between individuals. Mute individuals may have difficulty in speaking or producing vocal sounds, but they can still engage in effective communication through various alternative means. For them, traditional means of communication, such as speech, may not be an option. This limitation can create significant challenges in their daily lives, including difficulties in expressing their thoughts, emotions, and needs. Smart hand gloves have emerged as a groundbreaking solution, designed to empower mute individuals by providing them with an alternative means of communication.The gloves empower mute individuals to express themselves more effectively, promoting better understanding and engagement with others. These gloves enable greater independence for users in various aspects of life, from daily communication to accessing information and services. Smart gloves can be a game-changer for mute students and professionals, facilitating their participation in educational settings and the workplace. Smart hand gloves are equipped with a variety of sensors, including Arduino, gyroscopes, and flex sensors, placed strategically across the glove's surface. These sensors detect the wearer's hand movements and gestures in real-time. The interpreted gestures can be displayed as text on a screen or, more commonly, converted into audible speech using text-to-speech (TTS) technology. This speech can be heard through built-in speakers or headphones, allowing others to understand the user's communication.

## I. LITERATURE SURVEY

| Ref. No. | Paper Title and Publication Details | Methodology Used | Dataset Used | Accuracy | Research Gap Identified |
|---|---|---|---|---|---|
| [1]Shingirirai Chakoma,Philip Baron | Title: Converting South African Sign Language to Verbal<br><br>Journal: SAIEE Africa Research Journal (Volume: 114, Issue: 2, June 2023) | Five flex sensors that measure handshape, an IMU which measure hand motion. Both transmitted to a receiver box. | South African Sign Language manual 26 alphabet | 69% | Flex sensors measure finger flexion, not abduction and adduction, means that they are not accurate at signing letters like "U" and "V".<br><br>Flex sensors are susceptible to wear and tear , reducing sensitivity. |
| [2] Joseph DelPreto ,Josie Hughes , Matteo D'Aria, Marco de Fazio, and Daniela Rus. | Title: A Wearable Smart Glove and Its Application of Pose and Gesture Detection to Sign Language Classification<br><br>Journal: IEEE Robotics And Automation Letters, Vol. 7, No. 4, October 2022 | Resistive sensor, knitted pattern glove, Accelerometr, ML technique on microcontroller to process and classify data.<br><br>By pre-training a LSTM neural network running on ST microcontroller. | Poses and Gestures of 24 letters, words of ASL(American Sign Language) (11 static poses and 13 dynamic) | 96.3% | 7-fold cross-validation has been used, so 7 different networks have been trained which increases computational cost and time, as it requires training and testing the model multiple times.<br><br>Scope: Augmenting the glove with additional modalities could unlock applications ranging from healthcare to sports. |
| [3] M. Teja Sai Chand1 , D. Dilip Kumar 2, E. Sai Koushik3, L.V.R Chaitanya Prasad4 | Title: Gesture based smart hand gloves for disabled persons<br><br>Journal: IRJET 2022 | Designing the Glove, Analog to Digital Conversion, Signal Processing, Integration with GSM Module | It is possible that the authors collected their own dataset or used an existing dataset related to sign language or hand gestures | Here is no specific data or performance metrics provided in the context to determine the acc uray | Limited Information on Dataset, Lack of Detailed Performance Evaluation, Wireless Communication Limitations, Limited Scope of Hand Gestures |
| [4] Dr. Anupama H S, Dr. | Title: Automated Sign Language Interpreter | The system uses a flex sensors which are recorded by Arduino and are | English Alphabets and some phrases | 93% | More optimization is needed. |

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| Usha B A, Spoorthy Madhushankar, Varsha Vivek, Yashaswini Kulkarni | Using Data Gloves<br><br>Journal: 2021 International Conference on Artificial Intelligence and Smart Systems (ICAIS) | processed using K nearest Neigbhor ML algorithm | | | |
| [5] R. Senthil Kumar, P. Leninpugalhanthi, S. Rathika, G. Rithika, S. Sandhya | Title: Implementation of IoT Based Smart Assistance Gloves for Disabled People<br><br>Journal: 7th International Conference on Advanced Computing & Communication Systems (ICACCS), 2021 | designed with flex sensors, detect finger gestures, and the system, implemented using Arduino Uno and Raspberry Pi, communicates wirelessly for secure data transmission and a GSM module sends alert messages | Not used | Not mentioned | Using both Arduino and Raspberry Pi can be costly. |
| [6] Rajarshi Bhadra, Subhajit Kar | Title: Sign Language Detection from Hand Gesture Images using Deep Multi-layered Convolution Neural Network.<br><br>Journal: IEEE Second International Conference on Control, Measurement and Instrumentation (CMI), India,2021 | Data Preprocessing, Deep Multi-layered CNN Architecture, Classification Task | For the static gestures, a dataset with 36 classes of hand gesture images was used. For the dynamic gestures, a separate dataset was used. It includes 23 classes of dynamic hand gesture images. | 99.89% | Limited exploration of other methodologies, Lack of diversity in the dataset, Lack of user interaction and feedback, Evaluation of real-world performance |
| [7] Zhexiang Zou, Qinyu Wu, Yuhang | Title: Design of Smart Car Control System for Gesture Recognition | Hidden Markov Models (HMM), Motion Control Design, Control of Mobile Robots Based on | The paper does not provide explicit information | 85% | The maturity of gesture recognition technology, the complexity of dynamic gesture recognition, application to real-world environments, and the path |

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| Zhang and Kaiyuan Wen. | Based on Arduino.<br><br>Journal: IEEE 2021 | Dynamic and Static Gestures, Human-Computer Interaction Research Methods, Gesture-Based Remote-Control Technology for Unmanned Platforms | about the dataset used. | | towards commercialization. |
| [8] Hrishikesh P Athreya, G. Mamatha, R. Manasa, Subhash Raj and R. Yashwanth | Title: Smart Glove for the Disabled: A Survey<br><br>Journal: CiiT International Journal of Programmable Device Circuits and Systems. in the journal's Vol. 13, No. 2 issue in February 2021 | Uses Accelerometer, Flex-sensor, Raspberry-Pi, Firebase, Google-Search-API for its implementation. | The database set contained signs and gestures, along with samples, for the recognition system. | 85% | Limited amount of signs and gestures, along with samples, in the existing database set for the recognition system using smart gloves , the importance of expanding the available dataset for more comprehensive and accurate gesture recognition using smart gloves. |
| [9] Zaw Hein Thet Paing Htoo Bawin Aye Sai Myo Htet Kyaw Zaw Ye | Title: Leap Motion based Myanmar Sign Language Recognition using Machine Learning<br><br>Journal: 2021 IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering | Feature extraction method and recognition using machine learning. proposed system is based on skin color detection by using YOLO CNN and recognition process will be based on deep learning. | National Sign Language of Myanmar | 95.47% | Skin color-based segmentation is used, so unnecessary portion of body is also captured. |
| [10] Dushyant Kumar Singh, Anshu Kumar, Mohd. Aquib Ansari | Tile: Robust Modelling of Static Hand Gestures using Deep Convolutional Network for Sign Language Translation<br><br>Journal: 2021 International Conference on Computing, | Proposed CNN model is inspired from the VGG16 base architecture which is used to classify these signs into their respective classes. | 10,500 images of static signs corresponding to 25 English alphabets ('A'-'Y') | 96.7% | Potential application of the model for partially paralyzed individuals is mentioned, but the paper does not delve into the specific challenges and adaptations required o address this population's unique needs |

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| | Communication, and Intelligent Systems (ICCCIS) | | | | |
| [11] Thanekar Aadit, Jha Deepak, Patil Janhavi, Deone Jyoti | Title : Video Chat Application for Mutes<br><br>Journal: 2021 International Conference on Emerging Smart Computing and Informatics (ESCI) | Deep Learning CNN algorithm. | ASL (American Sign Language) and ISL (Indian Sign Language | 85% | Lack of utilization of gloves or special-purpose cameras, Limited recognition of one-handed gestures,<br>Time required for image capture, Lack of comparative analysis. |
| [12]Akash Kumar Panda, Rommel Chakravarty, Soumen Moulik | Title: Hand Gesture Recognition using Flex Sensor and Machine Learning Algorithms<br><br>Journal: 2020 IEEE EMBS Conference on Biomedical Engineering and Sciences (IECBES) | proposed a mechanism of hand gesture recognition using flex sensors and Arduino UNO. Hand gestures are analysed with the help of different traditional machine learning algorithms. An adversarial learning approach is made that performs better classification in comparison with these traditional learning models. | American Sign Language dataset | 88.32% | paper does not explicitly address potential drawbacks, constraints, or scenarios where the proposed approach may face difficulties. |
| [13]Pavan Telluri, Saradeep Manam, Sathwic Somarouthu, Jayashree M Oli, Chinthala Ramesh | Title: Low cost flex powered gesture detection system and its applications<br><br>Journal: 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA) | system makes use of flex sensors, on-board gyroscope and accelerometer. | Standard American Sign language | Not mentioned | NA |

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| [14] Jieming Pan , Yuxuan Luo, Yida Li, Chen-Khong Tham, Chun-Huat Heng, Aaron Voon-Yew Thean | Title: A Wireless Multi-Channel Capacitive Sensor System for Efficient Glove-based Gesture Recognition with AI at the Edge<br><br>Journal: IEEE Transactions on Circuits and Systems II: Express Briefs ( Volume: 67, Issue: 9, September 2020) | sensor data is captured by a 16-channel CDMA-like capacitance-to-digital converter for training/inference at the edge device. Proposed system approach takes advantage of the capability of the machine learning (ML) algorithms and directly processes the code-modulated signals without demodulation. | 10 American Sign language dataset | 99.7% | investigation into its performance in real-world scenarios, considering variations in environmental conditions and user dynamics, could be valuable. |
| [15] Wentao Dong, Lin Yang, Giancarlo Fortino | Title: Stretchable Human Machine Interface Based on Smart Glove Embedded With PDMS-CB Strain Sensors<br><br>Journal: IEEE SENSORS JOURNAL, VOL. 20, NO. 14, JULY 15, 2020 | High Deformability With the Bending Action of Fingers. High Sensitivity for Detecting the Bending Action of Fingers and the Motion Control of Robot Fingers. PDMS-CB strain sensors Smart sensor systems, human machine interface, sensor arrays, stretchable electronics, smart glove, PDMS-CB strain sensor. STRETCHABLITY ANALYSIS FINGER MOTION DETECTION HRI algorithm | Strain data from the smart glove with different fingers bending; Photos of the smart glove with fingers bending action | 96% | The paper proposes a design and principle for this smart glove, but it does not explicitly mention any existing solutions or technologies that address this specific application. Therefore, the research gap could be the lack of a comprehensive and reliable HMI system for controlling robot fingers using stretchable strain sensors integrated into a glove. |
| [16] Dipon Talukder, Fatima Jahara. | Title: Real-Time Bangla Sign Language Detection with Sentence and Speech Generation<br><br>Journal: 2020 23rd | Image Capture , object detection algorithm used in this project is YOLOv4 ,Google Text-to-Speech (gTTS) API | American Sign Language (ASL) Dataset, Thai Sign Language Dataset | 97.95% | Lack of Comparison with Existing Methods , Limited Dataset,User Interaction and Usability,Evaluation Metrics |

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| | International Conference on Computer and Information Technology (ICCIT) journal | | | | |
| [17] Francesco Pezzuoli Dario Coron Maria Letizia Corradini | Title: Recognition and Classification of Dynamic Hand Gestures by a Wearable Data-Glove<br><br>Jornal: Springer Nature 2020 | Random Forest and Neural Network. Position tracker. | Publicly available dataset. | 97.4% | Scope: Further studies will be carried out on compressing data, trying to maintain the BLE antenna or upgrade it to the next BLE generation standard. |
| [18] Ajay Suri, Dr. Sanjay Kumar Singh, Rashi Sharma, Pragati Sharma, Naman Garg, Riya Upadhyaya | Title: Development of Sign Language using Flex Sensors.<br><br>Journal: IEEE-2020 | Flex Resistors, Pressure Sensor, Touch Sensor, Spinners, Accelerometers | Couldn't find any specific information about the dataset used | 92% | Communication between individuals with hearing impairments or speech disabilities and the general population. The context mentions that the goal is to develop a cost-effective system that can provide a voice to those who are unable to verbalize their thoughts and communicate effectively. |
| [19] José nrique Mejía GamarraMartín ,Alonso Salazar CubasJunior David Sosa Silupú Carlos Enrique Córdova | Title: Prototype for Peruvian Sign Language translation based on an artificial neural network approach.<br><br>Journal : IEEE 2020 | Artificial neural network approach, Arduino – Excel interface, a database of a test user was compiled for training and validation, an artificial voice algorithm developed in the MATLAB software was used to reproduce the recognized lyrics, 6 flex sensors. | Peruvian Sign dataset | The prototype developed has an accuracy of 94.60% for the training set and 94.32% for the validation set | since the anatomy of the hand differs in each person, causing the sensors are out of adjustment or do not adapt to the movement of the signal, in addition to this, it is proposed to include a portable artificial voice in the prototype. |

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| Chirinos | | | | | |
| [20] M. Arun Kumar, S.Jayachithra, G. Aravind, M.Bhuvaneswari | Title: An Efficient Finger Gesture Recognition System Using Image.<br><br>Journal: IEEE 2020 | Computational Finance, Computational Biology, Control Systems, Image and Video Processing, Signal Processing and Communications. | Marcel Triesch dataset. It consists of hand gestures with a low resolution of pixels. | 94% | The research gap identified in the paper is that previously proposed methods for hand gesture recognition either require the reconstruction of low-resolution images to higher resolutions or involve the use of classifiers that require training, which can slow down the system's performance. |
| [21] Soma Shrenika, Myneni, Madhu Bala. | Title: Sign language recognition using template matching technique.<br><br>Journal : 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA) | image-processing techniques Edge detection algorithm template matching technique | American Sign Language (ASL) data set | 95.5% | Based on the information provided in the context, it is not explicitly mentioned what specific research gap has been identified in the paper |
| [22] Rahib Abiyev, John Bush Idoko, Murat Arslan | Title: Reconstruction of Convolutional Neural Network for Sign Language Recognition<br><br>Journal: Proc. of the 2nd International Conference on Electrical, Communication and Computer Engineering (ICECCE) 12-13 June 2020, Istanbul, Turkey | First module of single shot multi-box detector (SSD) used for hand detection. The second module constitutes CNN plus a fully connected network utilized to classify the signs into text. | American sign language fingerspelling dataset. | 92.21% | It lacks exploration of the broader ASL vocabulary and expressions |
| [23] Karma Wangc | Tile: Bhutanese Sign Language Alphabets | The proposed model was designed with 6 | Shaped Dzongkha alphabets | Highest training and | Misclassifications were obtained because of varying angles & |

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| huk, Panom khawn Riyamo ngkol, Rattapo om Waranu sast | Recognition Using Convolutional Neural Network<br><br>Journal: 2020 IEEE- 5th International Conference on Information Technology (InCIT) | convolutional layers stacked similar to VGG architecture followed by ReLU and max-pooling layers. | dataset created from 1200 videos recorded from 40 people from 5 countries | validatio n accuracy of 98.27% and 99.72% respectiv ely. | perspective transformation at the time of recording the videos and capturing the images. |
| [24] Ammar Abdull ah, Nurul Ashikin Abdul-Kadir, Fauzan Khairi Che Harun | Title: An Optimization of IMU Sensors-Based Approach for Malaysian Sign Language Recognition<br><br>Journal: 2020 6th International Conference on Computing Engineering and Design (ICCED) | Inertial measurement unit (IMU) sensors required to perform an accurate conversion. and output of each RNN stage is combined inside the fully-connected layer to produce a prediction | Malaysian Sign Language dataset | 98% | Potential to simplify the hand glove design by reducing the number of deployed sensors while maintaining accuracy |
| [25] YuFei Zhang ,Bin Liu, Zhiqia ng Liu | Title: Recognizing Hand Gestures with Pressure Sensor based Motion Sensing<br><br>Journal : IEEE Transactions on Biomedical Circuits and Systems ( Volume: 13, Issue: 6, December 2019) | Pressure-parameter adaptive updating strategy is designed to improve the robustness of the system to cope with different hand positions, different users and re-wear scenarios | Define a typical set of gestures which consists of the gestures for different motion amplitudes and different states | 95.28% | It is difficult to determine the specific research gap identified in the paper, it does mention several contributions of the paper, such as designing a real-time recognition framework for static and dynamic gestures, proposing a pressure parameter adaptive updating strategy, exploring the robustness of different sensors |

## II. ALGORITHMIC SURVEY

| Ref No. | Paper Title | Algorithm Name | Time Complexity | Space Complexity | Accuracy |
|---|---|---|---|---|---|
| [2] | Real-Time Bangla Sign Language Detection with Sentence and Speech Generation. | (YOLOv4) You Only Look Once version 4 | O(L * N^2), where L is the number of layers and N is the size of the input image (width or height). | The space complexity is influenced by the size of the activation maps. | 97.95% |
| [4] | Automated Sign Language Interpreter Using Data Gloves | KNN- K-Nearest Neighbor. | O(N * D + N log N), where N is the number of data points, and D is the dimensionality of the data. | O(N * D), where N is the number of data points, and D is the dimensionality of the data. | 93% |
| [6] | Sign Language Detection from Hand Gesture Images using Deep Multi-layered Convolution Neural Network. | CNN- Convolution Neural Network | O(L * W * H * K), where K is the average number of filters or neurons in a layer. | O(P), where P is the total number of parameters in the CNN. | 99% |
| [12] | Hand Gesture Recognition using Flex Sensor and Machine Learning Algorithms. | ANN- Artificial Neural Network | O(E * L * N^2) | O(P + N * D) | 88.32% |
| [16] | A Wearable Smart Glove and Its | LSTM Neural Network | O(E * T * H * D), where E is the | O(H * D + H^2 + 4 * H) | 963% |

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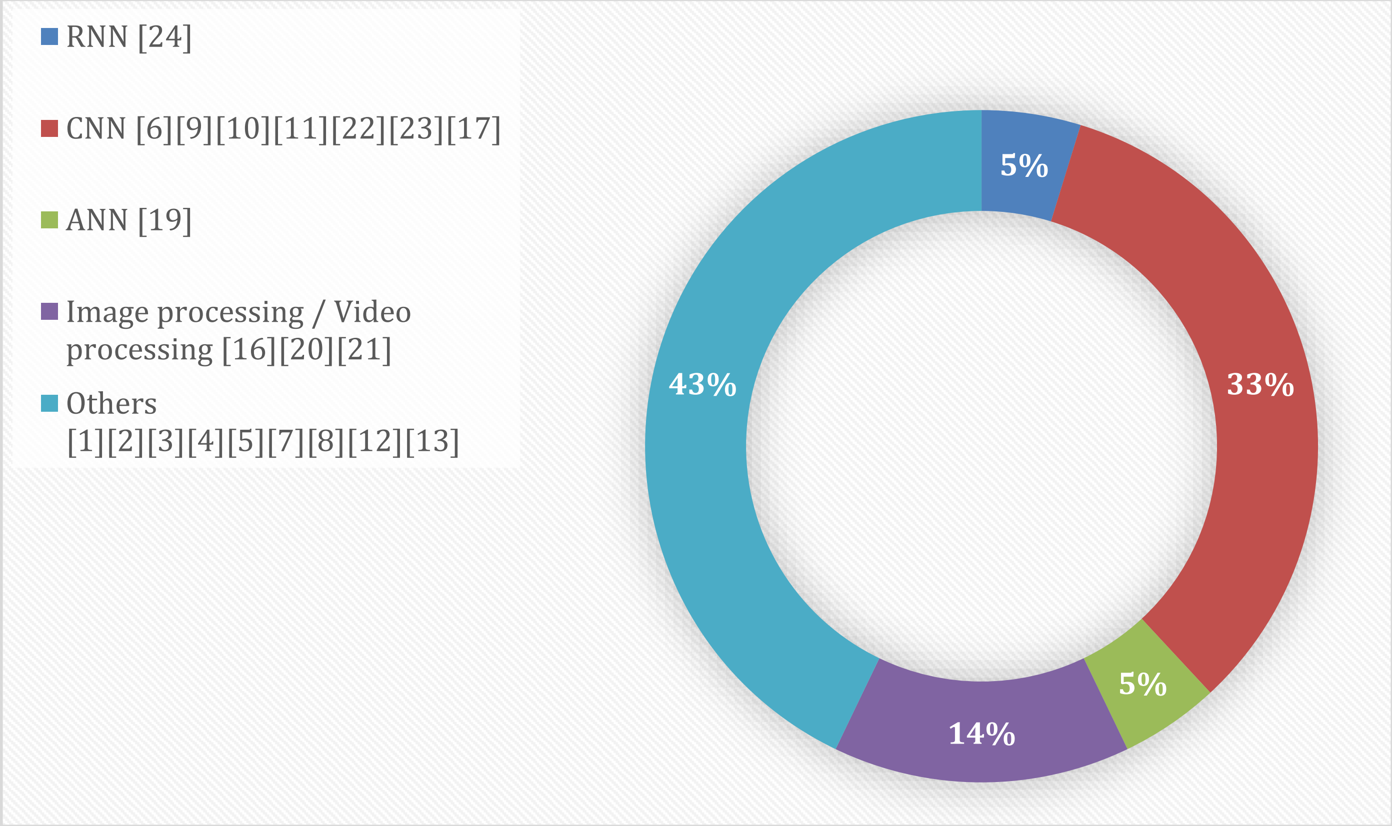
| | Application of Pose and Gesture Detection to Sign Language Classification | | number of training epochs | | |
| [17] | Recognition and Classification of Dynamic Hand Gestures by a Wearable Data Glove. | Random Forest | O(n_samples * n_features * log(n_samples)) | *O*(*K*·number of nodes) | 97.4% |
| [20] | An Efficient Finger Gesture Recognition System Using Image | K-Means Cluster | O(I * N * K * D), where I is the number of iterations. | O(N * D + K * D) | 94% |
| [22] | Reconstruction of Convolutional Neural Network for Sign Language Recognition. | CNN-Computational Neural Network | O(L * W * H * K), where K is the average number of filters or neurons in a layer. | O(P), where P is the total number of parameters in the CNN. | 92.21% |
| [24] | An Optimization of IMU Sensors-Based Approach for Malaysian Sign Language Recognition | RNN-Recurrent Neural Network | O(T * N^2), where T is the sequence length and N is the hidden state size. | O(N^2) for the weight matrices, where N is the hidden state size. | 98% |
| [25] | Recognizing Hand Gestures with Pressure Sensor based Motion Sensing | Support Vector Machine | O(N^2) to O(N^3) | O(K * D + N * D + N^2) | 95.28% |

## III. METHODOLOGICAL SURVEY




1. **Neural Networks (ANN, CNN, RNN):**

- **Artificial Neural Networks (ANN):** General-purpose and flexible, they can be used for basic conversion tasks but might lack efficiency in handling complex spatial data like sign language gestures due to limited pattern recognition abilities.

- **Convolutional Neural Networks (CNN**): Ideal for image-based tasks, such as recognizing hand gestures in images. They excel in capturing spatial features, making them suitable for static sign language recognition.

- **Recurrent Neural Networks (RNN):** Best suited for sequential data. RNNs can capture the sequential nature of sign language, enabling interpretation of gestures that form words or sentences.

2. **Image and Video Processing Algorithms:**

- **Image Processing Algorithms:** Utilized to analyze static images of hand gestures. These algorithms focus on recognizing patterns and shapes, which is crucial in sign language interpretation.

- **Video Processing Algorithms:** For dynamic hand gestures, video processing can be more effective. These algorithms handle temporal information, providing a continuous interpretation of sign language movements.

3. **Sensor-Based Approach:**

- **Flex Sensors and Gyroscopes:** Physical sensors capturing hand movements and orientation. These can detect the intricacies of sign language gestures.

- **Algorithmic Interpretation:** Once sensor data is collected, specific algorithms process this data to recognize and interpret the hand gestures into meaningful text and audio representations.

## IV. CONCLUSION

The analysis of three different approaches to converting sign language into text and audio reveals a spectrum of methodologies, each with its strengths and considerations. Neural networks, including CNNs for image-based recognition and RNNs for sequential understanding, offer effective solutions in the domain of pattern recognition and sequential data processing. Image and video processing algorithms provide an alternative route, catering to the static and dynamic aspects of sign language interpretation, making them suitable for image or video-based inputs. Additionally, the sensor-based approach employing flex sensors and gyroscopes grants a more hands-on, real-time interpretation of gestures, potentially capturing fine details that might not be easily attainable through visual analysis alone.

The ideal approach would likely involve a combination of methods, leveraging the strengths of neural networks for high-level pattern recognition, image or video processing for visual interpretation, and sensor-based systems for real-time input. Combining these approaches could provide a comprehensive and accurate conversion of sign language into text and audio, addressing various nuances of gestures and movements. The specific application and context would determine the most suitable approach or a fusion of multiple methods for optimal accuracy and usability in facilitating communication for mute individuals. Further advancements in smart glove technology can lead to more accurate and robust sign language detection. It can be integrated into educational tools and platforms. Smart gloves can empower deaf or hearing-impaired individuals to live more independently. This technology can also facilitate communication in different settings, such as schools, workplaces, hospitals, and public spaces.

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**[5]** R. Senthil Kumar, P. Leninpugalhanthi, S. Rathika, G. Rithika, S. Sandhya, 7th International Conference on Advanced Computing & Communication Systems (ICACCS),2021
**[6]** Rajarshi Bhadra, Subhajit Kar, IEEE Second International Conference on Control, Measurement and Instrumentation (CMI), India,2021
**[7]** Zhexiang Zou, Qinyu Wu, Yuhang Zhang and Kaiyuan Wen., IEEE 2021
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**[10]** Dushyant Kumar Singh, Anshu Kumar, Mohd. Aquib Ansari, 2021 International Conference on Computing, Communication, and Intelligent Systems (ICCCIS)
**[11]** Thanekar Aadit, Jha Deepak, Patil Janhavi, Deone Jyoti, 2021 International Conference on Emerging Smart Computing and Informatics (ESCI)
**[12]** Akash Kumar Panda,Rommel Chakravarty, Soumen Moulik. 2020 IEEE-EMBS Conference on Biomedical Engineering and Sciences (IECBES)

**[13]** Pavan Telluri, Saradeep Manam, Sathwic Somarouthu, Jayashree M Oli, Chinthala Ramesh, 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA)

**[14]** Jieming Pan , Yuxuan Luo, Yida Li, Chen-Khong Tham, Chun-Huat Heng, Aaron Voon-Yew Thean, IEEE Transactions on Circuits and Systems II: Express Briefs ( Volume: 67, Issue: 9, September 2020)

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**[20]** M. Arun Kumar, S.Jayachithra, G. Aravind, M.Bhuvaneswari, IEEE 2020

**[21]** Soma Shrenika , Myneni, Madhu Bala., 2020 International Conference on Computer Science, Engineering and Applications (ICCSEA)

**[22]** Rahib Abiyev, John Bush Idoko, Murat Arslan, Proc. of the 2nd International Conference on Electrical, Communication and Computer Engineering (ICECCE)12-13 June 2020, Istanbul, Turkey

**[23]** Karma Wangchuk, Panomkhawn Riyamongkol, Rattapoom Waranusast, 2020 IEEE- 5th International Conference on Information Technology (InCIT)

**[24]** Ammar Abdullah, Nurul Ashikin Abdul-Kadir, Fauzan Khairi Che Harun, 2020 6th International Conference on Computing Engineering and Design (ICCED)

**[25]** YuFei Zhang ,Bin Liu, Zhiqiang Liu, IEEE Transactions on Biomedical Circuits and Systems ( Volume: 13, Issue: 6, December 2019)