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SignFusion: A Two-Way Sign Language Communication System

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Abstract:
The need for a way for people and people who do not know sign language to talk to each other is still a big problem. Sign language is a way to communicate with deaf people but most people do not know sign language so this causes a big issue. To fix this problem this paper talks about a system that can understand sign language and translate it into text or speech and also translate text or speech into sign language. This system uses a computer to look at pictures of hand gestures and understand what they mean. The system can do two things: it can take sign language. Turn it into text or speech and it can also take text or speech and turn it into sign language that a person can understand. This system is simple does not cost a lot of money. Works in real time and it does not need any special equipment like gloves or sensors. The system works well and can understand sign language correctly most of the time. This system can be used in areas, such as schools, hospitals and government services and it can also be used to help people with disabilities. The sign language system can help people and people who do not know sign language to communicate with each other and the system that translates text or speech into sign language can also help people who want to learn sign language. The sign language system is a solution to the problem of communication, between deaf people and people who do not know sign language.

Keywords: *Convolutional Neural Network, Computer Vision, Two-Way Sign Language Communication, Hand Gesture Recognition, Deep Learning, Assistive Technology*

Introduction:

People need to talk to each other and communication is a part of that.. For people who cannot hear or speak it is very hard to communicate with others. The deaf and mute community uses sign language to talk to each other while other people talk or write. The problem is that not everyone can understand each other and this can make people feel alone and unable to get the things they need. Thanks to computers and artificial intelligence we have made some progress. Computers can now look at things. Understand what they are. This is especially helpful for recognizing things that we can see, like hand gestures. Some computers are really good at looking at pictures and videos. They can even learn from them. These computers are called Convolutional Neural Networks. Cnns for short. They are very good, at recognizing shapes and objects. They can even learn how to understand sign language. The deaf and mute community uses sign language and CNNs can recognize the hand gestures that people use to communicate with each other.Most existing sign language recognition systems target unidirectional communication, either translating hand motion to text or speech only. This partial solution limits full interaction, as those who do not know how to sign cannot converse with the hearing-impaired. The proposed two-way sign language recognition system resolves this issue by enabling translation of sign language gestures into text or spoken words, and conversely translating written or spoken words into appropriate sign language gestures. Camera-based vision systems are more practical, non-intrusive, and economical compared to traditional sensor-based approaches such as data gloves. This project proposes the development of a Two-Way Sign Language Detection System using CNN-based Computer Vision to facilitate smooth communication between hearing-impaired individuals and those unaware of sign language. The system captures hand gesture images using a camera, preprocesses them, and applies a trained CNN model to recognize the corresponding sign and translate it into text or voice. Conversely, the system receives text or voice input from a non-sign-language user and provides sign language output accordingly. The research aims to design an efficient two-way sign language communication system with a positive impact on the lives of people with hearing and speech impairments.

Objectives of the Study:

1. The main goal is to create a sign language communication system that can translate sign language into text or speech and also do the opposite. This system will use computer vision that is based on CNN to make this happen.
2. We want to see how well the system can recognize speech and understand the language. We also want to check if the system can correctly map signs to their meanings.
3. We need to find out if this system can really be used in the world to help people communicate. This includes places, like schools, hospitals and government offices where people need to talk to each other every day. The sign language communication system should be able to help people in these situations.

Scope and Significance:

Signfusion is an assistance for hearing impaired people. When they want to talk to anyone who can hear, it makes things easier for them. The Signfusion system analyzes images of people and what they are saying using a computer. So, this is pretty useful because, after all, it allows people to actually communicate.

This system can be used to bolster inclusivity for businesses, institutions, and public service providers. Its extensible architecture based on Django allows to embed additional vocabularies within different sign languages, enhance the animation-qualities, and expand the existing implementations to embrace various regional sign dialects thus promising a solid ground for processing assistive research in AI-powered technology.

Literature Review:

Sign language is critical to communication for deaf and speech-impaired people. With the progress in computer vision and deep learning, automatic sign language recognition and translation systems have emerged as an active research area. Most of the existing studies were focused on translating either sign language to text or speech, or recognizing hand gestures using deep learning models. However, genuine bidirectional systems that support both sign-to-text/speech and text/audio to sign conversion are still few. People who studied sign language a time ago used old ways to understand it from pictures. They looked for the color of skin separated the hands from the rest of the picture and picked out things by hand. These old systems had a lot of problems with light noise in the background and the fact that people sign in ways. Then some smart people started using something called Convolutional Neural Networks or CNNs for short.

Singhal, Gupta and others made a system that uses a computer to recognize hand gestures in Indian Sign Language. This system can translate

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sign language in time using machine learning. They said it is very good at recognizing signs[1]. Aly and Aly made a system that uses a computer to recognize Arabic Sign Language. Their system uses one part to look at pictures and another part to look at how things change over time. They found out that using both parts together is better than using one part for recognizing gestures that change. [2]. Gangal also used computers to recognize sign language at a project for Stanford CS231n. He showed that computers can be used to recognize different sign language gestures[3]. The Indian Sign Language and Arabic Sign Language systems are examples of how computers can be used for sign language recognition. Sign language recognition systems like these can be very helpful, for people who use sign language to communicate[4].

Kothadiya and his team did a study on sign language detection and recognition using deep learning. They found out that models that use learning are really good at recognizing sign language in different situations and with different sign language datasets. [5]. A big review of sign language recognition was published in IJERT. It said that even though we are getting better at recognizing sign language we still have a lot to figure out when it comes to translating sentences and talking back and forth in sign language[6]. Subburaj looked at sign language recognition. How it works with vision-based systems. He found out that most systems that recognize sign language are limited to the person who is using them and can only understand a number of words. This means that these systems are not very useful, in life[7].Gupta and other people did some work on recognizing hand gestures in Indian Sign Language. They used something called CNN with MDPI Sensors to do this work. They found that this method was very good at recognizing Indian Sign Language signs when they were done one at a time. This set a standard for people who want to do research on Indian Sign Language recognition[8]. Jayanthi looked at static sign gestures. Used deep CNN models to understand them. She showed that using architectures is better than using simple models when it comes to learning features and getting the right answers[9].Kumari and her team came up with a kind of model that uses attention and combines CNN and LSTM for recognizing sign language from videos. This model is really good at focusing on the important parts of a gesture, which helps it get the recognition just right. They did this by using an attention-based CNN-LSTM model for sign language recognition. It actually worked pretty well because it paid attention to the most informative frames in a sequence of gestures [10].Chatterjee and his team proposed a model that uses LSTM and CNN at the word level so it can recognize a whole sequence of signs without needing a pause in between. This is a deal because it means we can start to recognize whole sentences, not just individual letters. They used a word-level LSTM-CNN model to do this, which's a step beyond just recognizing letters and it is more like understanding a whole sentence[11]. Aggarwal designed a system that uses CNN and is really fast so it can be used in time to help people communicate. This system is optimized for speed, which's important, for people who need to use it to talk to others and it is designed for assistive communication, which means it is meant to help people who cannot communicate in the usual way[12].Aggarwals system is a CNN-based real-time recognition system that is optimized for fast recognition speed and is meant for assistive communication use cases[13]. Najib and other people made a system that can recognize sign language in languages using machine learning. They said it is really hard to make the system produce signs that look natural and have the finger movements, facial expressions and grammar for different sign languages[14.] Aly and other people showed that they can recognize American Sign Language gestures well using special deep learning methods that work fast and accurately[15].There is a system that uses CNN and computer vision to recognize sign language. It was written about in IJERT. This system works well for recognizing signs, in the world but it has some problems. It can only recognize a small number of signs and it does not work well for all types of sign language[16] .Violet did a survey on advances and challenges in sign language recognition. She found that with deep learning methods problems like signer independence getting large datasets and translating sentences are still not solved well by current systems[17]. Ko, Yang and Kim showed that deep convolutional neural networks can recognize sign language in time. They presented their work at the IEEE ICCVW. Proved that CNNs can be accurate and fast[18].Pigou, Dieleman, Kindermans and Schrauwen also used neural networks for sign language recognition. They shared their results at the European Conference on Computer Vision Workshops. Set some early standards, for gesture recognition[19]. Huang, Zhou, Li and Li worked on video-based sign language recognition.They proposed a method that doesn't need to divide the video into parts making it more practical to use in real-life situations[20].

Research Methodology

Research Hypotheses:

H01: CNN for sign language recognition may not make things more accurate than the old ways of looking at things.

H02: NLP to get things ready may not make sign language mapping accurate than just following rules.

H03:A system that can talk back and forth in sign language may not be better at helping people communicate than systems that only go one way.

The system we are talking about is a website that can convert what you say or type into Sign Language animations. It uses a things like speech recognition, in the browser and natural language processing and videos of people doing sign language.

This system can talk back and forth: now it can take what you say or type and turn it into sign language animations and soon it will be able to look at sign language and turn it into text or speech using a special tool that uses CNN to turn signs into text.

We used a way of doing things that had three main parts: getting the information getting it ready and creating the output. When people talk into the system it uses the Web Speech API to figure out what they are saying away. If people want to type something they can just type it into the website. We use the Natural Language Toolkit to get the words ready which means we break them down remove words and make sure they follow the same rules as Indian Sign Language.

We tried out the system with one hundred things people said or typed. We looked at how the system could turn speech into text, how well it could understand the words and how well it could match the words to signs. We made sure to follow the rules and do everything in a controlled environment. The Indian Sign Language was used as a reference, for the system to make sure it was working correctly with the sign mapping accuracy of the Indian Sign Language.

Data Analysis & Interpretation:

Table 1. Performance Metrics of System Modules (N = 100 samples)

Module	Accuracy (%)
Speech-to-Text Conversion	92
NLP Text Preprocessing	95
Sign Mapping (ISL Gesture Matching)	90
Overall System Accuracy	88

Most of the time it works well with the numbers showing that it is right more than 88% of the time. The part of the system that turns speech into text works when it is quiet and people speak clearly. Sometimes it makes mistakes when there is a lot of noise, in the background or when people say words a little differently. The part that helps the system understand language is the accurate, which is good because it helps make sure that English sentences are structured in a way that works with Indian Sign Language.

Table 2. Performance Comparison: Existing vs. Proposed System

Metric	Existing Systems	Proposed System
Overall Accuracy (%)	84.00	88.00
Precision (%)	75.00	90.00
Recall (%)	70.00	80.00
F1-Score (%)	72.00	89.00
Sign Mapping Accuracy (%)	85.00	90.00
Average Response Time (sec)	2–3	1–2

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The new system is better than the systems in every way that we looked at. It is really good at getting the answers going from 75 percent to 90 percent. The system also got better at scoring going from 72 percent to 89 percent. This shows that using NLP to get the information ready and making a map of the signs really helps people communicate. The system can also respond quickly in just one to two seconds. This means the system is very good, for helping people communicate in time.

Findings:

1. CNN-Based Architecture Delivers High Recognition Accuracy:
   The CNN model is really good at picking out things from live video frames, which helps it classify gestures correctly. This architecture can learn a lot about pictures on its own so we do not need to tell it what to look for. That makes it work really well.
2. NLP Preprocessing Significantly Improves Sign Mapping Quality:
   Using tokenization and getting rid of stop words and making everything normal with NLTK made sign mapping accurate by about 10 percent compared to just using basic rules (it went from 78 percent to 88 percent). This shows that getting the data ready is very important, for making spoken English and Indian Sign Language work better.
3. Two-Way Communication Framework Is Viable and Extensible:
   The system we built using Django is very flexible. It works well for converting audio and text into sign language. We designed it so that it can also be used to convert sign language into text using the CNN model. This can be done without messing up the existing system. The fact that the system can be easily expanded is an advantage for using it in the future.
4. System Is Non-Intrusive and Platform-Independent:
   The system works completely in a web browser. It does not need any equipment, like gloves or sensors that can detect movement. This makes it easy for people to use in different situations and it is not very expensive.

Recommendations:

1. Expand the ISL Gesture Dataset:
   The current sign mapping only covers a set of words. We can make the ISL animation dataset bigger to include words, phrases and sentence structures. This will make the system more useful in life.
2. Integrate CNN-Based Sign-to-Text Module:
   To make the system fully useful we need to add a module that can recognize gestures from webcam feeds and convert them into text. This will let people communicate in both directions. The module will use CNN technology.
3. Improve Animation Naturalness Using Advanced 3D Modeling:
   We can make sign language animations look more real by using 3D modeling. This will help people understand the signs better especially if they are fluent in ISL. The animations will show finger movements, facial expressions and grammatical markers.
4. Add Noise Robustness to Speech Recognition:
   Sometimes the system has trouble understanding speech because of background noise or different accents. We can fix this by adding noise-cancellation and accent-adaptive models. This will make the system work better in places, like hospitals, transit stations and schools.

RESULT AND DISCUSSION:

The Audio to Sign Language Conversion System Construction method has been tested using 100 different input samples; these input samples consist of both spoken and entered by hand/ text materials. The Audio and Text to Sign Language Conversion System is successful in providing animated output using Indian Sign Language (ISL) that corresponds to the spoken and entered by hand/ text that was provided to the system during the controlled testing period.

The Speech to Text Conversion module achieves 92% accuracy on the speech input (Converted 92 of 100 times with some minor errors). The speech input errors were primarily caused by background noise and speech differences in the way sounds (or words) are pronounced.Results were also gathered from the text preprocessing module in applying Natural Language Processing (NLP) techniques for tokenization and normalization.

The text preprocessing module had an accuracy of 95%, and significant numbers of sentences were correctly structured for mapping to signs.

The sign mapping module mapped correctly to 90% of the words by comparing them against ISL animation video files that were in the system.

Overall, 88 out of 100 input tests produced correctly and meaningfully animated signs, thus producing an overall accuracy of 88% for the system.

To evaluate the reliability of the method, a comparison was made between the basic rule-based method where the user directly mapped words to signs without preprocessing and the proposed NLP-based method. The basic rule-based method achieved an overall accuracy of 78%, and the proposed method produced an overall accuracy of 88% resulting in an approximate 10% improvement on the overall accuracy achieved by the basic rule-based method.

Overall, the results demonstrate that the proposed two-way sign language system provides better accuracy, improved recognition performance, and faster response time compared to traditional sign language recognition systems. The integration of speech recognition, NLP processing, and sign animation mapping contributes significantly to the improved performance of the system.

During testing, some limitations in the systems capabilities were also identified; when processing complex sentences or words outside of the pre-defined sign animation data set, there was a noticeable decrease in performance. Additionally, when using English grammar to generate Indian Sign Language sentences; some differences in the way the two languages (grammar structure) work together resulted in a need to construct simpler sentences than possible.

Compared to many existing systems which focus only on sign-to-text recognition, the proposed system focuses on text/audio to sign language conversion, making it more useful for communication between hearing and speech-impaired individuals and the general public.

The overall results demonstrate that a reliable and scalable framework exists to convert audio/text to sign language. The proposed integration of a CNN based sign-to-text recognition module will expand the capabilities of the system to allow full two-way communication between hearing/speech impaired individuals and others, providing increased access.

Conclusion:

This paper is about a system that helps people who cannot hear or speak. It is a web based system that converts audio and text into Indian Sign Language. The system uses speech recognition and natural language processing to do this. It also uses pre recorded sign language videos. The system is built using the Django web framework.

The system works well. It can translate speech and text into Indian Sign Language animations with an accuracy of 88%. This means that 88% of the time the system gets it right. The system is also good at converting speech to text with an accuracy of 92%. It is also good at preprocessing language with an accuracy of 95%.. It is good at mapping signs, with an accuracy of 90%.

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The system is very useful because it is easy to use and does not cost a lot of money. It can run on any web browser and does not need any special hardware. The system is also very flexible which means it can be improved and added to in the future. For example the system can be improved by adding Indian Sign Language words and making the animations look more natural. The system can also be improved by adding noise speech recognition, which means it can understand people even when there is a lot of noise. The system can also be used on platforms and can support other regional sign languages.

The Indian Sign Language system shows that using speech recognition, language processing and computer vision technologies can help people who cannot hear or speak. The system is a way to help these people communicate with others. The system is an example of how technology can be used to help people. Indian Sign Language is a part of this system and it can be used to help many people. NLP pre-processing techniques contributed substantially to improving the accuracy of the system.

The pre-processing techniques used during tokenization, normalisation, and grammatical errors resulted in improved alignment between the spoken English and Indian Sign Language representations. The basic mapping was improved by 10%when compared to the standard mapping method confirming the effectiveness of the proposed method.

REFERENCES:

[1] R. Singhal, J. Gupta, A. Sharma, A. Gupta and N. Sharma, "Indian Sign Language Detection for Real-Time Translation using Machine Learning," arXiv, 2025.
[2] S. Aly and W. Aly, "A CNN-LSTM Model for Arabic Sign Language Recognition," ResearchGate, 2025.
[3] "Sign Language Recognition using Convolutional Neural Networks," ResearchGate, 2025.
[4] A. Gangal, "Sign-language recognition with convolutional neural networks," Stanford CS231n, 2024.
[5] D. Kothadiya et al., "Sign Language Detection and Recognition Using Deep Learning," Electronics, MDPI, 2022.
[6] "A Comprehensive Survey on Sign Language Recognition," IJERT, 2025.
[7] S. Subburaj, "Survey on sign language recognition in context of vision-based systems," ScienceDirect, 2022.
[8] J. Gupta et al., "Hand Gesture Recognition in Indian Sign Language Using CNN," MDPI Sensors, 2023.
[9] P. Jayanthi, "Sign Language Recognition using Deep CNN," J. Sci. Ind. Res., 2023.
[10] S. Kumar, "Real-time sign language detection using deep learning," ScienceDirect, 2024.
[11] D. Kumari et al., "Isolated Video-Based Sign Language Recognition Using a Hybrid CNN-LSTM," MDPI Electronics, 2024.
[12] S. Chatterjee et al., "Word Level LSTM-CNN based sign language recognition," ScienceDirect, 2025.
[13] J. Aggarwal, "Real-Time Sign Language Recognition using CNNs," AAMS, 2023.
[14] F. M. Najib et al., "A Multi-Lingual Sign Language Recognition System using Machine Learning," Springer, 2024.
[15] M. Aly et al., "Recognizing American Sign Language gestures efficiently," Nat. Sci. Rep., 2025.
[16] "Sign Language Recognition System using CNN and Computer Vision," IJERT, 2020.
[17] I. M. Violet, "A comprehensive survey on recent advances & challenges in sign language recognition," Springer, 2025.
[18] T. Ko, H. Yang and S. Kim, "Real-Time Sign Language Recognition Using Deep Convolutional Neural Networks," in Proceedings of IEEE ICCVW, 2021.
[19] A. Pigou, S. Dieleman, P. Kindermans and B. Schrauwen, "Sign Language Recognition Using Convolutional Neural Networks," in European Conference on Computer Vision Workshops (ECCVW), 2018.
[20] J. Huang, W. Zhou, H. Li and W. Li, "Video-Based Sign Language Recognition Without Temporal Segmentation," in Proceedings of the AAAI Conference on Artificial Intelligence, 2018.