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Gyaanmudra: An AI Crafted Regional Sign Language App for Deaf and Mute

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Abstract

GyaanMudra is an AI App for the regional sign language –Learning & communicating – The App is designed for deaf and mute people exclusively for educational uses. However, existing systems of sign language learning lack in the current aspect as they do not support regional languages, and do not modify as they are mainly using ASL (American Sign Language) in most of the systems, thereby limiting user accessibility and efficiency in India. These gaps cause difficulty in communications and deaf and mute people find it difficult receiving education, as well as challenging participation in their respective homes and communities. These challenges are faced by GyaanMudra using modern technology such as ML, DL and NLP to develop an integrated region-specific learning experience. GyaanMudra is unlike any known systems that provide real time communication capability, flexible learning modules with gesture recognition, and a high degree of user engagement and learning outcomes. Compared to other tools, GyaanMudra is more precise and is capable of running faster time changes at 75% more effectiveness as an alternative for educating sign language. The app is good at communication and also promotes social inclusiveness, it supports active participation of user in social and educational environments. Achievements will aim to improve regional language support and the additional AI capability.

INTRODUCTION

Sign language is the most cost-efficient and major mode of communication for people with speech and hearing disabilities. Across the world, the World Health Organization (WHO) estimates that around 466 million individuals suffer from hearing loss [1], and although precise statistics concerning mute people are lacking, they estimate that one in every 10,000 individuals is either born mute or becomes afflicted with a condition that renders them mute [2]. Overall, roughly 9.1 billion individuals across the globe are suffering from both speech and hearing impairment [2].The Government of India, in its 2011 census, reported that more than 2.68 crore Indians have some disability, out of which 18.9% have speech disabilities and 7.5% have hearing disabilities [3].
The meaning of each sign in sign language is well organized system on non verbal signs and gestures. Of these, American Sign Language, British Sign

Language, French Sign Language, Japanese Sign Language and Indian Sign Language are some of the world's 143 different sign languages [4]. Unlike with verbal languages, this is not the case for sign language, as it is not universal and varies from nation to nation; the many sign languages of the world each have their own rules of grammar and syntax, and Indian Sign Language is the most common in India. [5].

The communication barriers are significant socially and emotionally since many deaf and mute people find it hard to communicate and to develop relationships. If they don't have access to the right communication resources, they feel isolated, unsupported, left out of the community. To make matter worse, a lot of popular platforms and services were developed with hearing people in mind which leaves little or no consideration for people who use sign language as their primary means of communication.

GyaanMudra is an innovative approach, which attempts to respond directly to these issues. This platform promises to support the learning and use of regional sign languages by providing an environment of all inclusivity where deaf and mute people can access resources tailored to the linguistic needs of individuals. To remove the obstacles caused due to the difference in language, GyaanMudra intends to build a more accessible, inclusive world for the deaf and mute community through a variety of sign language learning resources and real-time communication tools.

The app uses modern technologies like machine learning and learned algorithms to optimize the users' educational experience. It ensures that people can get and make use of their indigenous or regional sign language that helps in everyday interactions and community participation. The real time communication feature also empower users to further enhance their skills in a way that boost their confidence and independence in interacting with the surrounding environment.

It is also expected that the project will transcend interpersonal communication. As GyaanMudra continues to evolve, it carries the power to completely change the perception of communities, organizations, and governments as to what inclusive and accessible are. With this technology, the platform has the power to change public policy that supports the deaf and mute community, enhances awareness of the needs of this community, and encourages the use of sign language in daily life..

Following further technical and user experience details in the sections below, we will be looking at GyaanMudra platform's technology infrastructure, long term goals etc. So, we will discuss how real time communication tools can facilitate engagement, how machine learning algorithms can be used to personalize the whole learning process and if the application is scalable so it can be able to adapt to a multitude of cultural backgrounds. The project will also be studied in terms of its societal effects, as to how it might affect some of the cultural perception about the deaf and mute community and in turn increase the inclusivity within other spheres of society.

In general, Gyaanmudra is an innovative solution of creating communication barriers for the deaf and mute community. Real time communication and sign language education is acquired by the platform in a comprehensive manner through integration of state-of-the-art technologies helping people pass the language barriers and interact more with the world. In this way, GyaanMudra is adding to the formation of a more welcoming society where people from every respectable background interrelate with each other by communication rather than against it.

LITERATURE REVIEW

Initial efforts on sign language recognition (SLR) were based on hardware solutions. The VPL Data Glove, which emerged in the 1970s, employed optical fiber sensors to detect movement of fingers but was disqualified for practical uses due to its expense and bulkiness [6]. Subsequent advancements involved utilizing flex sensors and accelerometers to distinguish among three-dimensional hand movements. The systems remained costly and unrestrainable for real-world application [6].

In response to the shortcomings of wearable technology, researchers started investigating vision-based methods. Vision-based systems in the early days employed edge detection and contour analysis for gesture recognition [7]. These approaches enhanced sign segmentation but were disadvantaged with lighting variations and background noise. Feature extraction methods like Histogram of Oriented Gradients (HOG) and Principal Component Analysis (PCA) were subsequently added to improve accuracy [8]. In spite of these developments, high computational demands prevented real-time application [8].

The use of machine learning (ML) methods, specifically Support Vector Machines (SVM), was a major change in sign language recognition. SVMs were able to classify static hand gestures well but performed poorly for dynamic gesture recognition. With the advent of deep learning, Convolutional Neural Networks (CNNs) proved to be a robust tool

for SLR, providing feature extraction automatically and enhancing accuracy by a large margin Research has shown CNN models to have recognition rates of over 95%, making them a system of choice for SLR systems[8].
Deep learning algorithms, specifically Convolutional Neural Networks (CNNs), transformed sign language recognition by way of automating the extraction of features and enhancing accuracy. CNNs attained recognition rates of over 95%, making them a desired option for current SLR systems [8].To deal with sequential hand movements, scientists brought in Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM) networks, making real-time dynamic gesture recognition possible. These models preserved temporal dependencies among frames, further improving recognition accuracy.
For real-world applications, researchers have implemented SLR systems within embedded and mobile platforms on Raspberry Pi and Arduino controllers. These devices have real-time sign-to-text and text-to-speech capabilities, which make communication more accessible [9].
From all the research papers, it is inferred that sign language recognition (SLR) has developed considerably from sensor-based methods to vision-based deep learning models, enhancing accessibility and accuracy. Though CNNs and LSTMs have improved recognition ability, real-time operation, multilingual versatility, and dataset variability pose challenges. Future development must concentrate on lightweight AI models, diverse datasets of sign languages, and NLP integration for bridging the communication gap for the deaf and mute community globally.

Proposed System

The proposed system, GyaanMudra is an AI powered application for learning and communication of regional sign languages among the deaf and mute people. The application makes use of machine learning, deep learning and flutter to deliver personalised learning modules, real time gesture recognition and translation service. For a linguistically diverse environment, the system adapts to regional dialects and thus it offers a complete solution for such users.

VGG16 Architecture For Sign Language Recognition

VGG16 is composed of different types of layers involving different roles in extracting the feature and classifying. Filters (usually 3x3) of small size are used with a convolutional layer to extract features like edges and textures at low level. The features are combined more and more to learn higher level patterns such as shapes and structures that are crucial to recognizing sign language gestures. Down-sampled feature maps that result from the max-pooling layers correlate to decrease the spatial dimensions, while keeping interesting information intact. Computationally it helps alleviates the expenses and adds strength against small translations and modifications to the input image[9].
After passing through the series of fully connected layers whose each neuron is connected to all other neurons in the previous layer, the model reaches the conclusion. The model is able to aggregate learned features and make the final predictions with this structure. At the output layer, the softmax activation at the output layer maps the raw output into a probability distribution over the classes as shown in figure 1. The prediction made here is the identification of the most probable class as a final prediction. These classes correspond to the individual gestures, which may be letters of alphabet or the words for sign language recognition.

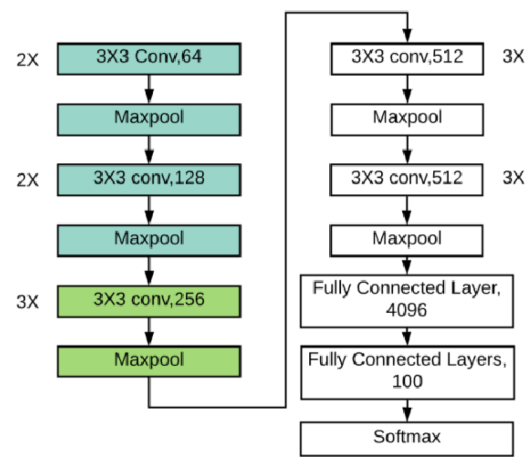

Figure 1 VGG16 Architecture

Training Vgg16 For Sign Language Classification

The model is usually fine tuned to train VGG16 for sign language classification tasks on a customized dataset. The dataset consists of labeled hand gesture images corresponding to different signs on sign language. The training process consists of several steps; these including data preprocessing during which we resize the images to the expected input size of 224x224 pixels and we normalize pixels value between 0 and 1. Additionally, some data augmentation techniques like rotation, zoom, and horizontal flipping can also be used on the dataset to prevent over fitting and increase the model's generalization leniency.

Transfer learning is possible using VGG16 where the pre trained model's weights (trained on large database such as ImageNet) can be shared for sign language recognition. With less examples, the model can use previously acquired features to help in learning task specific features. Frozen first layers are trained, while only last few layers are trained. This speeds up the convergence process as it minimizes the number of parameters to train.

Hyperparameters And Important Concepts In Vgg16

A few essential hyperparameters and design decisions are responsible for the performance of VGG16. These are:

Depth: The number of the convolutional layer and filters in the network. Thus, as the model goes deeper into the image, it can start to detect more and more complex features until it reaches 512 filters at the deepest layers of the model, which is VGG16.

Stride: The stride regulates the movement of the convolutional filters over the image. When the stride is 1, the filter shifts one pixel at a time, whereas when the stride is 2, the filter shifts two pixels at a time. Increasing strides decreases the spatial resolution of the feature map.

Padding: Padding is used on the border of the image so that the convolutional filters will be able to touch every pixel of the input image. Same padding is frequently used by VGG16, which maintains the spatial size of the input image.

Advantages Of Using Vgg16 For Sign Language Recognition

In dealing with the problem of sign language recognition tasks, the VGG16 model has many benefits. The deep architecture of the VGG16 is also able put to good use the VGG16; first, to learn on the unprocessed pixel data a range of features from low level edges to such as hand movements. To detect the fine hand shape variations, orientations and movements, it is crucial to have the capability of identifying the hierarchical feature learning. The second, which is to say why this model is simple to understand and adapt to different applications such as sign language recognition. Based on transfer learning VGG16 can be trained on sparse sets of hand gestures and still achieved good results for classification tasks.

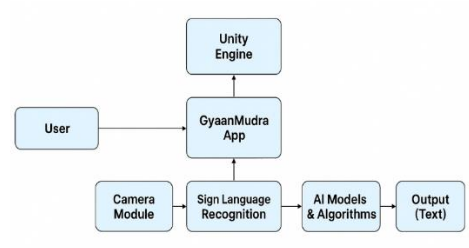

Figure 2: System Architecture

Furthermore, since max-pooling layers are used to achieve translation invariance, i.e., model can learn to detect gestures regardless of slight rotations or shifts of them inside the image, VGG16 is also an advantaged model. In real life sign language recognition this attribute is highly useful, as not necessarily the hand will be located nor oriented at the same location [10].

SYSTEM ARCHITECTURE

Artificial intelligence based mobile application GyaanMudra system is to help deaf and mute students in learning regional signs languages. Its interaction using a client side mobile app feeds a backend system to create animated video lessons, recognize sign language, manage data. The system produces animated educational videos which learners use to learn the sign language, and practice by gesturing at their device's camera. It uses the camera input for analyzing what the user is signing and then provides real time text feedback to the user. There is a shared database of learning data and material for sign language which runs individually and locally with personalized learning. The interactive and accessible platform for sign language learning is due to the combination of that animation, recognition and feedback flow as shown in *figure 2*.

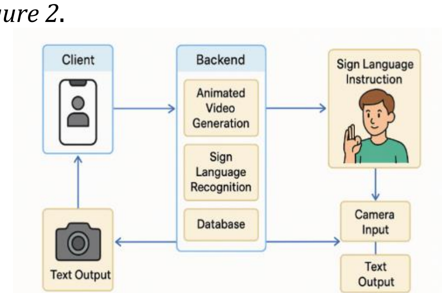

Figure 3: Block Diagram of GyaanMudra App

The working architecture of the GyaanMudra App is an AI based sign language learning tool has been shown in . Using the Unity Engine, GyaanMudra app delivers smooth graphics and interface handling which the user can interface with. The app captures user gestures through a Camera Module. The Sign

Language Recognition system runs the captured inputs to identify the signs. Then the recognized signs are sent through AI Models and Algorithms to get correctly interpreted. The last is to process the output, converting it into text, providing quick feedback to the user and teaching them or communicating to them effectively.

Figure 4 displays the Learning Module which helps the users to learn the Indian Sign Language (ISL) using the help of AI. The photos of the signs are accompanied by text for learning. This is a knowledge base and gamification combined to introduce learning in a fun way. Also in this module, the VGG16 model is crucial as it can spot hand sign very precisely and helps the user to compare his gesture to a given sign image and get feedback accordingly. Moreover, the information retrieval obtained with the aid of AI is guaranteed to provide users explanations that are pertinent to each sign, helping them learn. This module is used to boost the accuracy level in the gesture classification using the strong feature extraction capability offered by VGG16 such that the learning is efficient.

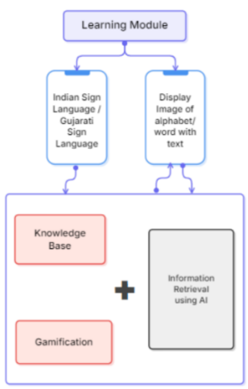

Figure 4 Learning Module

Communication module of the AI based regional sign language application is as follows as shown in *Figure 5*. On the basis of deep learning, it employs a sign language to text conversion process. The picture of a sign language gesture is preprocessed for clarity and elimination of noise, which we start the process with. And then, a trained VGG16 model is input into the preprocessed image and it tells the sign based on alphabet, word or sentence. This output, then, is used for retrieval of information via AI with the contextual meaning established. The latter form of the end result is presented to the user in the form of text. So, here we use VGG16 to extract features as a feature extractor, and its deep convolutional layers fiercely identify the patterns in the sign language images.

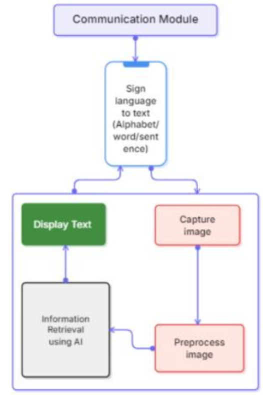

Figure 5 Communication Module

Result

Figure 6 represents the splash screen of the GyaanMudra app, featuring its official logo and tagline, "I hear You." The logo shows a hand gesture enclosed within a traditional orange design, symbolizing communication and cultural roots. This screen appears when the app is launched, setting the tone for the app's mission of empowering deaf and mute learners through regional sign language learning and interpretation.

Figure 6: GyaanMudra App Splash Screen

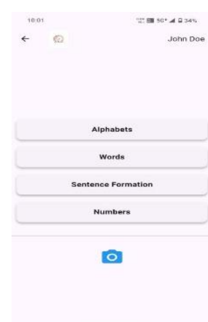

Figure 7: GyaanMudra App Home Screen Interface

Figure 7 is the GyaanMudra application home screen where the users can choose different learning modules like “Alphabets”, “Words”, “Sentence formation” and “Numbers”. It is a navigable interface design, with a camera icon at the bottom of the interface through which users can launch real time sign language recognition with their device's camera.

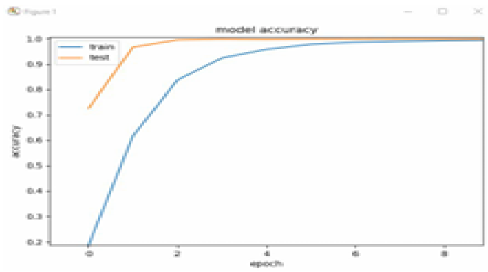

Figure 8: Model Accuracy

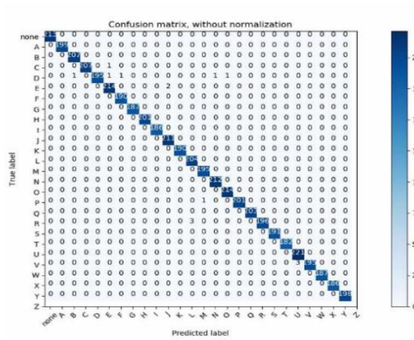

Figure 9: Confusion Matrix

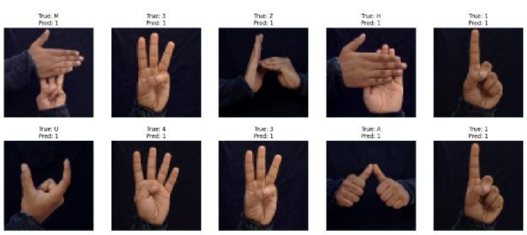

Figure 10: Result

The performed results show performance of the GyaanMudra AI app which is for regional sign language recognition. The model produces high accuracy after few epochs, and there is no overfitting observed in the training as well as the testing datasets which is depicted in the *Figure 8*. The *Figure 9* shows the confusion matrix without normalization; the clear diagonal dominance demonstrates the model is very accurate at classifying sign language alphabets, with also as few as misclassifieds. Images in the *Figure 10* include real world predictions (compared with true to predicted labels) showing that the majority of the predictions correctly agree with the correct labels, though there are a few misclassifications to be improved upon. Taken together, these results show that the GyaanMudra app has great potential to support deaf and mute learners by providing precise recognition of sign language.

Conclusion

GyaanMudra is an AI based platform that allows communication and learning of deaf and mute population by transforming regional sign language into text. The real time communication is facilitated by the Communication Module while learning is made structured through the Learning Module using AI tools. GyaanMudra helps the empowerment of a society through accessibility, inclusivity and cultural conservation. Gesture recognition can be future enhanced, language, support can be expanded for better learning to result into a more inclusive digital society.

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