# Real-Time Sign Language Recognition for Communication and Education

**Navyasri Gabbita**
**Information Technology (IT)**
**Shri Vishnu Engineering College for Women, Bhimavaram (JNTUK)**
**Bhimavaram, India**
**gabbitanavyasri@gmail.com**

**Geddam Sirisha**
**Information Technology (IT)**
**Shri Vishnu Engineering College for Women, Bhimavaram (JNTUK)**
**Bhimavaram, India**
**sirishageddam40@gmail.com**

**Gandham Rajyalakshmi**
**Information Technology (IT)**
**Shri Vishnu Engineering College for Women, Bhimavaram (JNTUK)**
**Bhimavaram, India**
**rajigandham.1@gmail.com**

**Golla Uma Satya Sri**
**Information Technology (IT)**
**Shri Vishnu Engineering College for Women, Bhimavaram (JNTUK)**
**Bhimavaram, India**
**umasatyasrig@gmail.com**

**Mrs.M.Suma Bharathi**
**(Assistant Professor)**
**Information Technology(IT)**
**Shri Vishnu Engineering College for Women,Bhimavaram (JNTUK)**
**Bhimavaram,India**
**suma.thota@svecw.edu.in**

***Abstract*—The incorporation of machine learning in recognizing sign language has potential to enhance communication and learning experiences, for people with hearing impairments. This study focuses on creating a system that can recognize sign language digits from 0 to 9 in time. Using networks (CNNs) as the primary machine learning algorithm we have developed a system that accurately interprets hand gestures in real world situations. The training and evaluation dataset comprised images of hand gestures representing the digits. This research showcases the feasibility and effectiveness of using machine learning methods to facilitate interpretation of sign language digits ultimately improving accessibility and educational outcomes for individuals with hearing impairments.**

**Keywords--real time sign language recognition, machine learning, convolutional neural networks, communication, education, accessibility.**

## I. INTRODUCTION

The rise of machine learning technologies has brought about an era of inclusivity and accessibility in the field of communication, for people with hearing impairments. In this research we set out to use machine learning to tackle the task of recognizing sign language in time specifically focusing on numerical hand gestures from 0 to 9. The significance of this effort is seen in its potential to transform how individuals with hearing impairments communicate and interact with the world around them. While there have been advancements, in sign language recognition systems the challenge remains in interpreting gestures instantly. This research seeks to address this issue by using neural networks (CNNs) and a carefully selected dataset containing images of hand gestures that represent numbers. The goal is to improve communication accessibility and help people with hearing impairments navigate settings.

The main goal of this study is twofold; to create and put into action a real time system that recognizes gestures in sign language and to assess how well it works in real world scenarios. Our aim is to show how machine learning algorithms can help interpret sign language in time promoting communication, for everyone. As we explore the details of our method and share our results we welcome readers to join us on this path toward the future.

## II. LITERATURE REVIEW

Studies on recognizing gestures in real time sign language although not as extensive as those on American Sign Language (ASL) provide perspectives on the issues and possibilities in this field. Various research works have investigated methods and strategies for identifying signs with a specific emphasis, on datasets containing numbers from zero to nine in different sign languages.

Chen and colleagues, in 2019 introduced a model that blends recurrent neural networks to identify numerical gestures in Chinese Sign Language (CSL). Their research showed accuracy in recognition yet faced difficulties when applying the model to various sign languages because of differences in sign structure and grammar[1].

In a research conducted by Kumar and colleagues in 2020 they explored how depth sensors and skeleton based models could identify gestures, in Indian Sign Language (ISL). Their method showed encouraging outcomes in capturing hand motions and performing well in recognizing gestures in dynamic settings[2].

In a study, by Park and colleagues (2021) they delved into using attention mechanisms and temporal modeling methods to enhance the accuracy of recognizing signs in Korean Sign Language (KSL). The research emphasized the significance of considering context in sign language recognition and put forth designs to effectively capture temporal relationships[3].

In their study, Smith, Johnson, and Brown (2018) examined the feasibility of real-time recognition of American Sign Language (ASL) gestures using convolutional neural networks (CNNs)[4].

In their exploration of sign language recognition, Wang, Zhang, and Li (2021) proposed a novel Transformer-based architecture tailored to the challenges posed by limited data availability. This approach represents a departure from traditional convolutional and recurrent neural network models commonly employed in the field[5].

Despite these advancements the field of real time numerical sign language recognition still encounters obstacles. One key challenge lies in the scarcity of datasets that represent gestures across different sign languages hindering the development and assessment of robust recognition models. Moreover, dealing with the diversity of sign languages and regional variations adds complexity to creating recognition systems.

To sum up existing literature on real time numerical sign language recognition underscores the importance of crafting machine learning models and datasets to tackle the features and difficulties posed by numerical gestures in diverse sign languages. Future studies should concentrate on expanding and standardizing datasets exploring feature representations and designs well as conducting thorough evaluations, under varied linguistic and environmental circumstances.

## III. RESEARCH DESIGN AND METHODOLOGY

### 3.1 Data Collection and Analysis

The information for this research was gathered from databases that focus on sign language datasets. It includes images of hand gestures depicting numbers from zero to nine in sign languages like American Sign Language (ASL) Chinese Sign Language (CSL) and Indian Sign Language (ISL). There are a total of 112500 images in the dataset.

Data Analysis: Before training the model we carefully examined the data to make sure all images had resolution, lighting and hand poses. We used techniques to explore the data and check for any irregularities or discrepancies.

### 3.2 Materials: Experimental Design

Experimental Design: The study design adhered to a method for machine learning assignments. The data collection was divided into training, validation and testing subsets employing a strategy to maintain a distribution of each digit category, across the subsets. The training subset consisted of 70% of the data with the validation and testing subsets each containing 15%.

### 3.3 Methods

#### 3.3.1 Data Preprocessing:

Data preprocessing went through stages to improve the datasets quality and compatibility, with machine learning algorithms. The process involved resizing images to a resolution converting them to grayscale, for computation and normalizing pixel intensity values to maintain consistency.

#### 3.3.2 Feature Extraction and Model Architecture:

The process of extracting features involved utilizing a network (CNN) design. This CNN model comprised pooling layers along, with fully connected layers, for categorization. To avoid overfitting and capture hierarchies within the images max pooling and dropout layers were integrated.

### 3.4 Results and Findings

Results: The CNN model that was trained successfully reached an accuracy rate of, than 95% when tested showcasing its ability to recognize numerical sign language gestures in real time. Various performance metrics, including accuracy, precision, recall and F1 score were utilized to assess the effectiveness of the model.

### 3.5 Discussion and Comparative Study

Discussion: The results, from our experiments show how well the new method can recognize sign language gestures in sign languages and different hand poses. The CNN design was successful in identifying features and patterns in the hand gesture images.

Comparison Study: We compared our CNN model with methods mentioned in studies. The results of this comparison showed that our model performed better in terms of accuracy and efficiency proving the strength of our approach.

In general our experiments highlight how machine learning CNNs can improve communication accessibility for individuals with hearing impairments by recognizing numerical sign language gestures in time.

## IV. CONCLUSION

In summary this research highlights the role of machine learning, particularly convolutional neural networks (CNNs) in improving real time recognition of numerical hand gestures in sign language. Our study demonstrates that our proposed method is successful, in interpreting signs across different sign languages enhancing communication accessibility for those with hearing impairments. By addressing the need for recognition systems we have made a contribution to bridging technology and accessibility. While our approach has been successful challenges like the availability of datasets indicate areas

for investigation. Future research could focus on expanding datasets, refining model structures and addressing real world implementation issues. In essence our results emphasize how machine learning can positively impact inclusivity and accessibility efforts advancing communication technologies for individuals with disabilities.

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