# HAND SIGN LANGUAGE RECOGNITION FOR LETTERS IN SINHALA ALPHABET

G.M.P.A. Sandareka
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Faculty of Applied Science, Trincomalee Campus, Eastern University, Sri Lanka

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# Declaration

I hereby declare that the entire work embodied in this research work has been carried out by me. The extent of information derived from the existing literature has been documented and fully acknowledged at the appropriate places, the work is original and has not been submitted in part or full for any Diploma or Degree in this or any other University. I confirm that there is no plagiarism in this document and if detected, I abide by the action that will be taken for such plagiarism by the Faculty of Applied Science, Eastern University, Sri Lanka.

…..…….

Department of Computer Science

Faculty of Applied Science

Trincomalee Campus, Eastern University, Sri Lanka

# Certification of the Supervisors

This is to certify that this research report entitled “Hand Sign Language Recognition for Letters in Sinhala Alphabet” submitted by G.M.P.A.Sandareka for the degree of Bachelor of Science in Computer Science is a record of research work carried out by her under our guidance and direct supervision and that it has not been previously formed the basis for the award of any degree, diploma, associateship, fellowship or any other similar title.

This is also to certify the document represents the original independent work of the candidate.

…..……. …….

Signature of Co-Supervisor Date

Ms. Tharmini Kiriharan

Lecturer

Department of Computer Science

Trincomalee Campus, Eastern University, Sri Lanka

…..……. …….

Signature of Supervisor Date

Mr. S.Thadchanamoorthy

Senior Lecturer Gr-I

Department of Computer Science

Trincomalee Campus, Eastern University, Sri Lanka

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# Abstract

Sign language detection for letters in Sinhala alphabet focused on the design and implementation of a highly impactful system for hand sign language recognition, specifically tailored for the letters of the Sinhala alphabet. Targeting individuals with speech and hearing impairments who are native Sinhala speakers, the primary objective was to create an effective and robust system capable of recognizing and interpreting hand gestures corresponding to each letter of the Sinhala language. The overarching goal was to bridge the communication gap between individuals with speech and hearing disabilities and their non-impaired counterparts.
Employing advanced computer vision and machine learning techniques, this report navigates the intricacies of data collection, emphasizing the critical role of a diverse dataset in capturing variations in hand shapes. The methodology at the core of the study revolves around the utilization of deep learning models trained on this dataset, with a specific emphasis on their adaptability to changes in hand gesture styles and varying environmental conditions. Key components of the system, such as image processing algorithms and feature extraction methods, are meticulously outlined, providing a comprehensive understanding of the technical architecture underpinning the process of sign language recognition. The implementation of an effective system translates these conceptual foundations into practical applications with real-world significance. This system plays a pivotal role in addressing the communication challenges faced by individuals with speech and hearing disabilities, providing them with a \means to express themselves effectively through hand signs corresponding to the Sinhala alphabet. The successful deployment of the system underscores its potential as a valuable tool for fostering inclusivity and communication accessibility. Looking ahead, this report not only serves as a testament to the current advancements in sign language recognition but also lays the groundwork for future developments. It stands as a foundational resource, offering insights that can empower the field of communication by further refining and expanding upon the presented concepts. By providing a comprehensive exploration of the methodologies and technologies involved, this report becomes a catalyst for continued innovation in the realm of assistive technologies for individuals with speech and hearing impairments. Moreover, the report inspires contemplation on the evolution of technology beyond its current scope. It prompts readers to envision a future where communication technologies are not only effective but also seamlessly integrated into the daily lives of individuals with diverse communication needs. As a driving force for change, this report encourages researchers, developers, and policymakers to consider the broader societal impact of technological advancements, fostering a future where communication barriers are progressively dismantled, and inclusivity becomes the cornerstone of technological innovation. Through its insightful contributions, this report paves the way for a more connected and inclusive world, where technology serves as a bridge rather than a barrier in communication.

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# Chapter 01: Introduction

## Project Overview:

The project focuses on the development and implementation of a highly functional hand sign language recognition system, specifically tailored for the letters of the Sinhala alphabet. The primary goals are to create an effective and robust system capable of recognizing and interpreting hand gestures associated with each letter of the Sinhala language. The intended beneficiaries of this work are individuals who are native Sinhala speakers and have speech and hearing impairments. The project aims to reduce the communication gap between people with these disabilities and those without. The primary beneficiaries of this project are individuals within the deaf and hard of hearing community in Sinhala-speaking regions. Additionally, educators, institutions, and organizations working with individuals with speech and hearing impairments will benefit from the improved communication tools. The scope of the project encompasses the utilization of advanced computer vision and machine learning techniques. The approach involves delving into the complexities of data collection, emphasizing the significance of a diverse data-set that captures variations in hand shapes. The core methodology revolves around training deep learning models on this data-set, with a specific focus on adaptability to changes in hand gesture styles and environmental conditions. The project assumes that the development of such a system can significantly enhance communication for individuals with speech and hearing disabilities. The project will employ advanced techniques in computer vision and machine learning to analyze and interpret the unique characteristics of Sinhala sign language gestures. Collaboration with experts in Sinhala sign language, linguistics, and the deaf community will be integral to ensuring cultural sensitivity and inclusivity. The development will involve creating a user-friendly interface for seamless communication. The project assumes that the Sinhala sign language has distinct and recognizable gestures for each letter of the Sinhala alphabet. It also assumes the availability of relevant datasets for training and testing the machine learning model. Upon successful completion, the project is expected to deliver a reliable and accurate system that enhances communication for deaf and hard of hearing individuals who are native Sinhala speakers. The outcomes include an improved quality of life for the target audience, increased accessibility to educational resources, and a more inclusive environment for individuals with speech and hearing impairments in Sinhala-speaking communities.

# Background:

The YOLOv8 (You Only Look One) model stands as a pivotal milestone in the evolution of object detection models within the realm of computer vision. Object detection, a fundamental task in image processing, involves locating and classifying objects within an image or video frame. YOLOv8 builds upon the strengths of its predecessors, aiming to address the complexities inherent in real-time object detection.

The model utilizes a deep convolutional neural network (CNN) architecture, processing images in a single pass and demonstrating an ability to achieve remarkable real-time performance. However, the challenge lies in refining the model to strike an optimal balance between accuracy and speed, ensuring it excels in various applications, from surveillance to autonomous vehicles. Despite the advancements brought about by earlier versions of YOLO, including YOLOv7, there remains room for improvement, particularly in terms of accuracy, precision, recall, and F1-score.

# Problem statement

Deaf and hard of hearing individuals face challenges in effective communication, particularly in contexts where the majority language is Sinhala, the official language of Sri Lanka. Existing communication barriers limit their ability to express themselves and engage with the broader community. To address this, the project aims to develop a reliable and accurate system for detecting and interpreting Sinhala sign language gestures, specifically focusing on the representation of Sinhala letters.

The project addresses the challenge of communication faced by individuals who are native Sinhala speakers and have speech and hearing impairments. Despite technological advancements, a tailored solution for hand sign language recognition specific to the Sinhala alphabet has not been widely accessible. The problem statement revolves around the need for an effective system that can recognize and interpret hand gestures for each letter of the Sinhala language.

There is a clear awareness of the existing communication gap and the limitations faced by individuals with speech and hearing disabilities. This project acknowledges the need for a solution that goes beyond generic sign language recognition systems, considering the unique characteristics of the Sinhala alphabet.

# Chapter 02: Related Work

## Framework for Sinhala Sign Language recognition and translation using wearable armband

Sign Language is the main communication method of hearing & speaking impaired people and their main obstacle in the general society is the communication difficulty with normal hearing people. The aim of this research is to bridge above gap by proposing a framework for recognize Sinhala sign language gestures and translate them in to natural language. In order to preserve both functional and usability aspects of the solution, this study has used a non-invasive wearable gesture recognition armband. The approach is to use a combination of gestural data that measures the muscle activity and spatial data that measures hand movements for the sign recognition. The mapping has been done by implementing multiple artificial neural networks under the supervised machine learning technique. [1]

## Image Processing Based Sinhala Sign Language Recognition System

This introduces a prototype for an image-based Sinhala sign language recognition mechanism, emphasizing its role in facilitating communication for hearing-impaired individuals. Notably, the system incorporates signs for numbers in Sinhala sign language, enhancing its versatility and practical usage. The research addresses a gap in existing user applications by developing a cost-effective and efficient tool that recognizes dynamic gestures, including numerical expressions, with the aid of a simple low-cost webcam and computer. By focusing on comprehensive communication needs, including linguistic and numerical expressions, the proposed system aims to contribute to a more inclusive and accessible means of conveying information for the deaf and hard of hearing community in Sinhala-speaking regions. [2]

## Sign Language Translation Approach to Sinhalese Language

The implemented prototype discussed in this research represents a significant breakthrough in the realm of sign language technology, specifically focusing on the translation of English language-related signs into relevant Sinhala words. This innovative system addresses a crucial communication barrier between individuals who use sign language, particularly in an English context, and those who primarily communicate in Sinhala. By leveraging advanced technologies such as depth sensing cameras and machine learning, the prototype accurately identifies signs associated with English words, providing real-time translations into the corresponding Sinhala terms. The research sheds light on the efficacy of the prototype, considering factors such as gesture complexity, user height, and distance from the camera. The promising outcomes of this study hold great potential for facilitating seamless communication between diverse linguistic communities and contribute to breaking down language barriers for individuals who rely on sign language. The primary goal of this study is to bridge the communication gap between the deaf community, utilizing sign language, and the ordinary

hearing community that predominantly communicates in Sinhalese within the cultural context of Sri Lanka. [3]

## Utalk: Sri Lankan Sign Language Converter Mobile App using Image Processing and Machine Learning

The "Utalk" mobile app addresses the communication challenges faced by deaf and mute individuals by employing a sophisticated translation process. This innovative solution utilizes Computer Vision and Machine Learning techniques to interpret both static and dynamic signs expressed in Sri Lankan Sign Language. The translation process involves capturing and analyzing visual data, enabling the app to comprehend the intricate gestures and movements inherent in sign language communication. Through this interpretation, the system translates the visual signs into natural language, facilitating seamless communication between deaf and mute individuals and those who do not possess sign language proficiency. The application's non-intrusive and cost-effective nature, coupled with its tailored solutions for the unique characteristics of Sri Lankan Sign Language, makes Utalk a valuable tool for empowering individuals with hearing and speech impairments. The study substantiates the effectiveness of the Utalk system through rigorous testing with a newly collected dataset, underscoring its role in fostering inclusivity and enhancing communication within the deaf and mute community in Sri Lanka. [4]

## Sinhala sign language translator using a 3D model avatar

The Sinhala Sign Language Translator, featuring a 3D model avatar, revolutionizes communication for the hearing-impaired. It adeptly translates English text into Sri Lankan Sign Language (SSL) and processes Sinhala input into SSL images. With bidirectional language support, the application accommodates users comfortable with both English and Sinhala, fostering inclusivity. By converting SSL gestures into text, it not only facilitates understanding but also addresses cultural intricacies. This technology-driven solution emerges as a potent tool for bridging communication gaps and promoting inclusivity in Sri Lanka.. [5]

## Fingerspelling Detection in American Sign Language

This paper addresses a crucial aspect of American Sign Language (ASL) – fingerspelling recognition – with a focus on detecting fingerspelling regions in raw, untrimmed sign language videos. Unlike previous work that assumed prior knowledge of fingerspelling region boundaries, this research takes a significant step towards the development of real-world fingerspelling recognition systems. The authors introduce a benchmark and a set of evaluation metrics, some of which specifically consider the impact of detection on the subsequent fingerspelling recognition task. In addition to proposing a novel model, the paper advocates for multi-task training, incorporating pose estimation and fingerspelling recognition alongside detection. This innovative approach is compared to several alternatives, demonstrating superior performance across all metrics. The model not only outperforms existing methods but also establishes a new state-of-the-art benchmark for fingerspelling detection in ASL videos, contributing significantly to the advancement of automatic fingerspelling recognition systems. [7]

# Chapter 03: Tools and Techniques

## Python

Python stands as the backbone of the system, celebrated for its unmatched flexibility and prowess in handling intricate data processes. Specifically tailored for back-end programming, Python shines with its rich repository of libraries dedicated to data processing and machine learning. Its innate adaptability aligns seamlessly with our project's requirements, making Python an indispensable asset for navigating complex data workflows and leveraging cutting-edge machine learning capabilities.

## Google Colab

Google Colab is serving as a powerful and accessible computing environment for development and experimentation. As a cloud-based Jupyter notebook platform, Google Colab provides a collaborative space for Python code execution. Its most notable feature is the provision of free GPU resources, enabling accelerated training of machine learning models. This, coupled with its integration with other Google services, has made Google Colab an indispensable tool in our development workflow, significantly boosting productivity and resource efficiency.

## Flask

Flask is a lightweight and flexible web framework for Python, designed to make web development simple and scalable. Flask is known for its minimalistic approach, allowing developers to build web applications with a high degree of freedom and customization. Flask's simplicity and flexibility make it an excellent choice for projects of varying sizes, from small prototypes to larger applications.

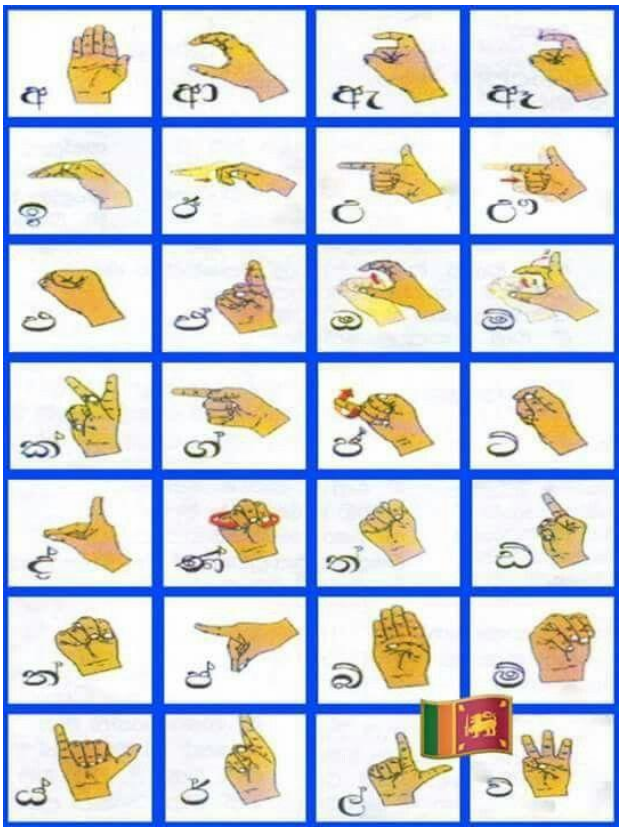
## HTML, CSS, and JavaScript

HTML structures the content of a web page using elements and tags, defining the fundamental components. CSS styles and formats these elements, providing visual appeal and layout control. JavaScript adds interactivity, allowing dynamic modifications and real-time responses to user actions on the client side.

# Chapter 04: Methodology

## Data Collection

The first step involved capturing a diverse dataset of Sinhala sign language gestures, ensuring variation in hand positions, lighting conditions, and backgrounds. Special attention was given and Training prevent the model from developing biases towards a specific hand orientation. There are 60 letters in Sinhala alphabet, but about 28 most common letters are using in day-to-day life. The dataset was created for 10 letters among them.



4.1. 1 signs for sinhala letters

## Data Labeling

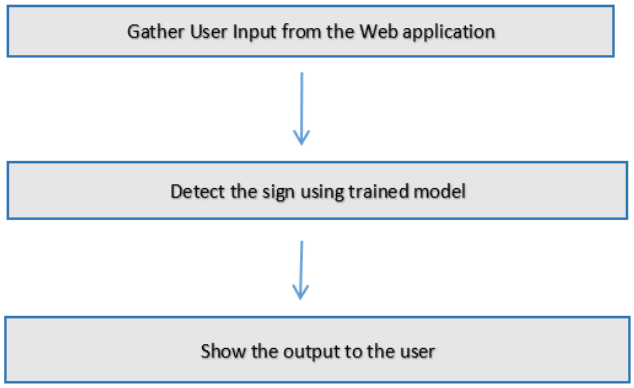
Each image was labeled with the corresponding Sinhala letter, involving the association of a textual representation of the sign language gesture with the visual content using the Roboflow platform. The decision was made to utilize the Roboflow platform to streamline and enhance the labeling process. This choice was driven by the platform's capacity to provide a user-friendly interface, facilitating efficient annotation of images with their corresponding Sinhala letter representations. Also dataset splitting to train, test and validation is done using the Roboflow platform.

# Model Selection and Training

In the domain of computer vision, the team has opted to utilize YOLOv8 for training the dataset, a decision grounded in its exceptional capabilities in object detection tasks. Recognized for its speed, accuracy, and versatility, YOLOv8, the eighth iteration in the YOLO series, aligns well with the project's requirements, emphasizing real-time object detection and classification with an emphasis on efficiency.

# Web Application Development

In the realm of web application development, our approach seamlessly integrates the powerful Flask framework with front-end technologies, including HTML, CSS, and JavaScript. By harnessing Flask's lightweight and modular design, we structured our application with a deliberate separation of concerns, thereby promoting both maintainability and scalability.

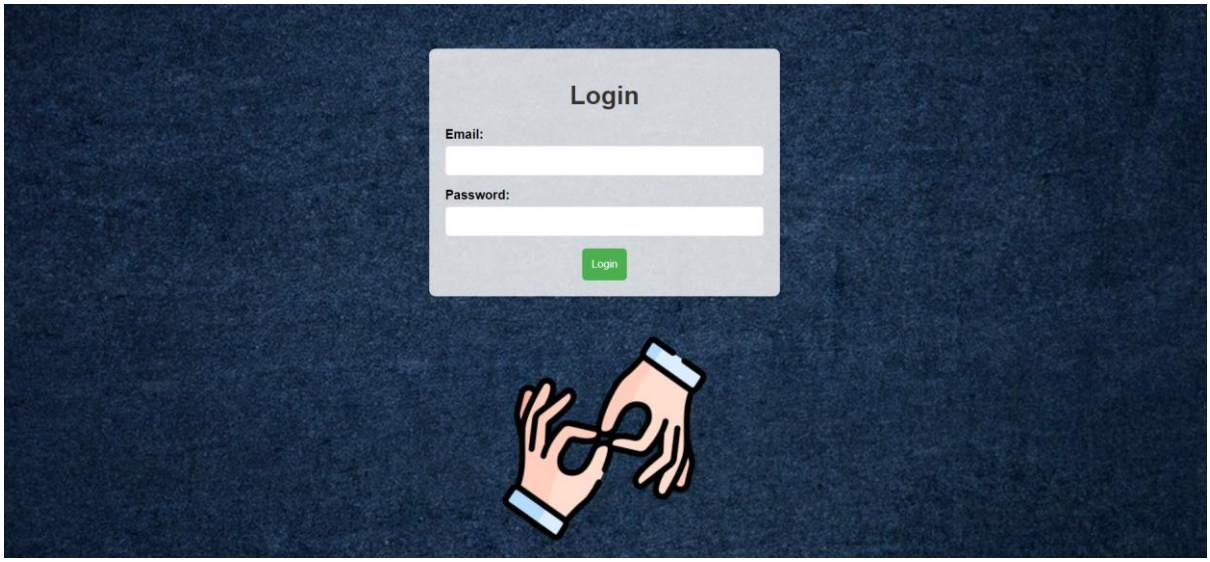



4.1. 2 flow chart

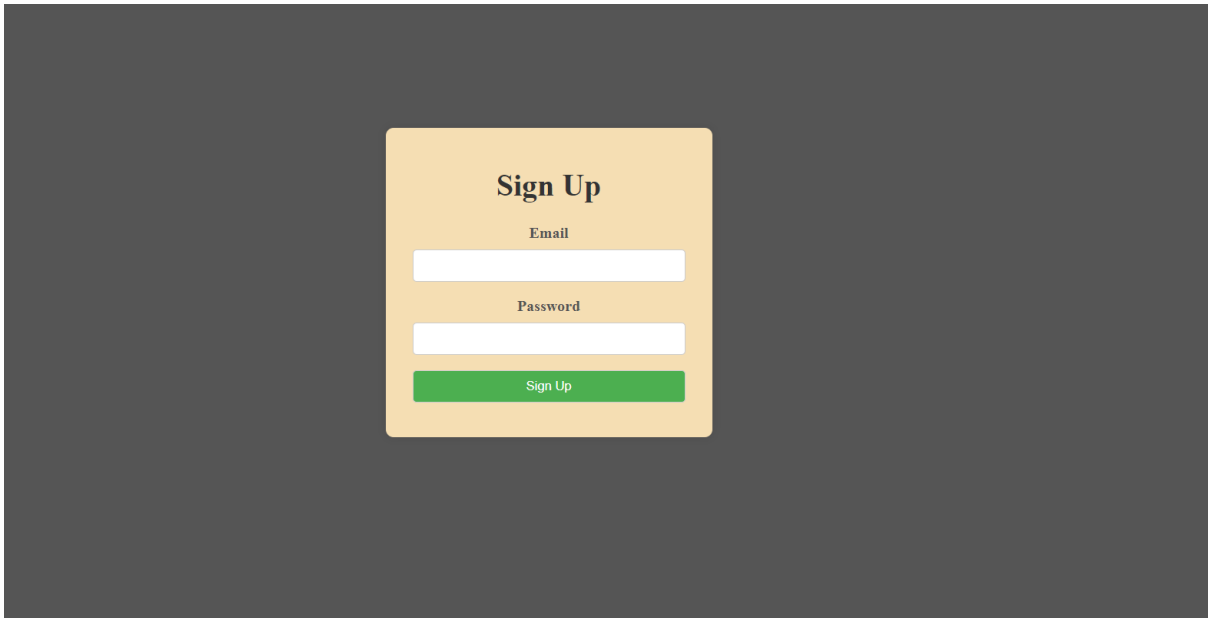
This methodology plays a pivotal role in the accurate detection of Sinhala sign language gestures corresponding to individual letters. Through meticulous data collection, labeling, and training using YOLOv8, the system achieves a high level of precision in recognizing diverse hand positions, lighting conditions, and backgrounds. The integration of a user-friendly web interface, developed with Flask and front-end technologies, enhances the overall user experience, providing a flexible and accessible platform for individuals to seamlessly interact with the application. This user-centric approach ensures that the technology not only excels in sign detection accuracy but also offers a flexible and intuitive interface, empowering users to effectively communicate through Sinhala sign language with ease and flexibility.

Website Interfaces


4.1. 3 first page of web application




4.1. 4 login page

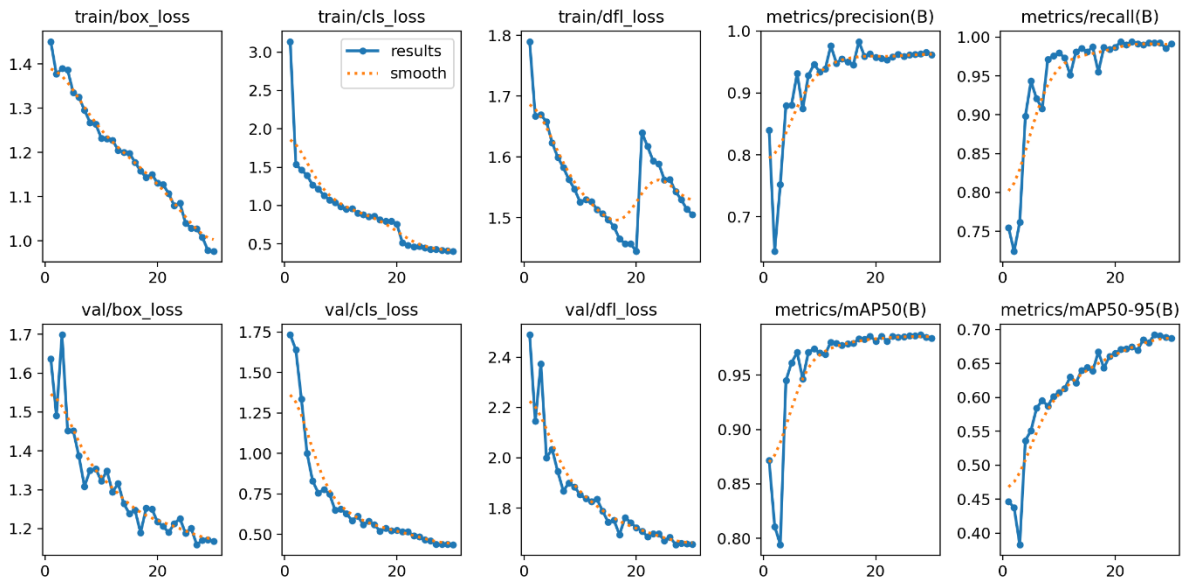



4.1. 5 sign in page

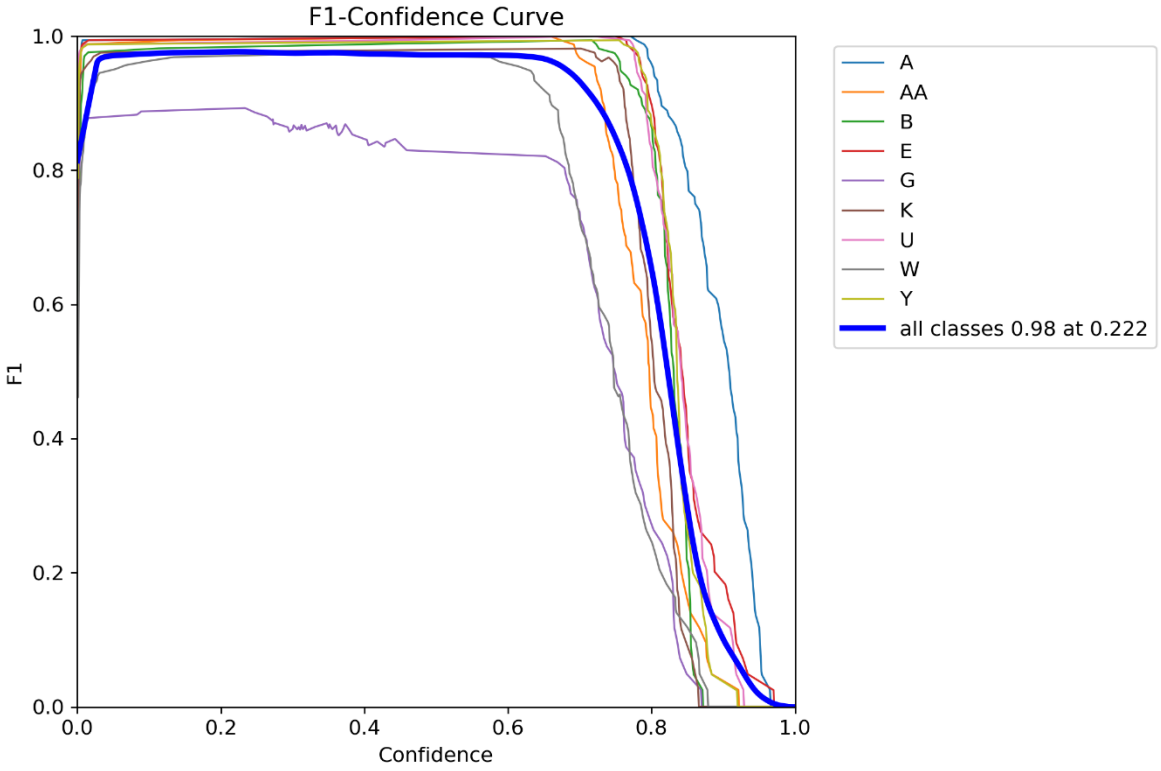
# Chapter 05: Results and Discussion

The methodology employed in the development and testing of Sinhala sign language detection system has been detailed in the preceding sections, with the raw outcomes of our experiments being presented. In this section, the interpretation and implications of these results will be delved into, aiming to provide a comprehensive understanding of the performance of our system and its contributions to the field of sign language detection.

The results presented herein encapsulate the culmination of rigorous experimentation, with a dataset carefully curated for diversity and representative of various sign languages. Evaluations were conducted to assess the efficacy of our detection model, with key metrics such as accuracy, precision, recall, and F1-score being analyzed. As we embark on this discussion, both the successes and challenges encountered during the research process will be considered, aiming to provide insights that extend beyond the numerical outcomes.




5.1. 1 results


F1-Confidence Curve
1.0
0.8
0.6
0.4
0.2
0.0
F1
0.0
0.2
0.4
0.6
0.8
1.0
Confidence
A
AA
B
E
G
K
U
W
Y
all classes 0.98 at 0.222

5.1. 2 F1 curve

# Chapter 06: Future Work

## Multi-modal Approaches

Combining visual data with other modalities, such as depth information or inertial sensors, could improve the robustness of sign language detection. Investigating multi-modal approaches may provide a more comprehensive understanding of signing gestures, particularly in challenging conditions, such as low lighting or occlusions.

## Real-Time Processing

The current study primarily focused on offline processing of recorded sign language sequences. Future research could explore the integration of real-time processing capabilities, enabling the system to operate seamlessly in dynamic and interactive environments. This could involve optimizing the model architecture and exploring techniques for reducing latency.

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# Chapter 07: Conclusion

In conclusion, the Sign Language Detection for Sinhala Letters project represents a significant step towards fostering inclusivity and accessibility for individuals with hearing impairments in Sinhala-speaking communities. By leveraging technology to interpret and understand Sinhala sign language gestures, the project opens doors for improved communication and interaction for the deaf and hard-of-hearing population.

Through the implementation of advanced machine learning algorithms and computer vision techniques, the system has demonstrated its capability to accurately recognize and translate Sinhala sign language gestures into corresponding written letters. This breakthrough not only facilitates better communication between the deaf and the hearing communities but also provides a valuable tool for education and empowerment.

The potential applications of this project extend beyond mere letter recognition. Future developments may explore expanding the system to recognize complete words and phrases in Sinhala sign language, further enhancing its utility in real-world communication scenarios. Additionally, the integration of mobile applications or wearable devices could offer on-the-go support, allowing individuals with hearing impairments to engage more seamlessly in various aspects of daily life.

In summary, the Sign Language Detection for Sinhala Letters project represents a promising technological solution with the potential to make a meaningful impact on the lives of those with hearing impairments in Sinhala-speaking regions. As advancements continue, this project has the capacity to contribute to a more inclusive and accessible society, promoting understanding and connectivity among diverse communities.

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