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AnguliLekha: Real-Time ISL Interpreter with Learning Module

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Abstract: *Barriers in communication between the deaf community and hearing individuals often hinder effective interaction, particularly in educational and learning environments. This paper introduces a real-time Indian Sign Language Recognition (ISLR) system designed to support ISL gesture learning. The system uses a webcam to capture live hand gestures, which are then preprocessed and classified accurately using a Long Short-Term Memory (LSTM) model. It features a structured learning module with progressive levels of alphabets, words, and sentences allowing users to gradually build their ISL proficiency. Evaluated in terms of accuracy, response time, and user satisfaction, the system demonstrates strong potential as an educational tool for promoting Indian Sign Language literacy. This work addresses the limitations of current ISLR systems by offering a robust, user-friendly platform specifically tailored for ISL education*

Keywords: Indian Sign Language (ISL), Sign Language Recognition, LSTM, Real-Time Gesture Recognition, ISL Education, Human-Computer Interaction, Accessibility, Machine Learning, OpenCV

I. INTRODUCTION

Indian Sign Language (ISL) serves as a vital communication medium for many individuals within India's deaf and hard-of-hearing community. However, accessible and structured platforms focused on ISL education remain limited. *AnguliLekha* is a real-time ISL learning system created to bridge this gap. Leveraging machine learning and computer vision technologies, the system identifies hand gestures and offers instant feedback, promoting effective learning. The platform provides an interactive learning path that begins with alphabets and progresses to words and full sentences, catering to users at different stages of their learning journey. By encouraging self-paced learning and offering progress tracking, *AnguliLekha* strives to make Indian Sign Language education more inclusive, engaging, and effective for modern learners.

II. PROBLEM STATEMENT AND OBJECTIVES

Problem Statement

Indian Sign Dialect (ISL) is basic for empowering communication among the hard of hearing and hard-of-hearing populace. All things considered, there's a critical need for intuitively and effectively available assets for learning ISL. Most existing solutions tend to signal acknowledgment to upgrade communication, frequently dismissing the need for well-structured, learner-centric instructive encounters. In addition, current stages rarely utilize step-by-step instructing strategies or offer prompt input, which would help clients in progressing their marking capacities. This insufficiency in solid instructive assets makes it troublesome for tenderfoots to pick up capability in ISL.

Objectives

- To form a real-time ISL learning stage that helps clients in advancing from essential to progressed marking aptitudes.
- To plan a motion acknowledgment framework utilizing LSTM models for exact distinguishing proof and translation of hand signals

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- To organize the learning encounter into dynamic stages, beginning with letters and moving towards words and total sentences.
- To provide moment criticism and track client execution to improve learning adequacy.
- To winner inclusivity by making ISL instruction accessible to people without any earlier information of sign dialect.

III. LITERATURE REVIEW

Table 1: Literature Survey Table

Sr. No	Title	Methodology	Disadvantages
[1]	ML-Based Sign Language Recognition by Amrutha K and Prabu P	Uses image preprocessing, feature extraction, and ML classifiers (SVM, KNN) for gesture recognition	Lacks real-time capability, limited dataset diversity, no support for continuous signing
[2]	Real-Time American Sign Language Recognition Using CNN-LSTM Networks	Combines CNN for spatial feature extraction and LSTM for temporal modeling	Focuses on ASL, not applicable to ISL; no structured learning approach
[3]	Vision-Based Hand Gesture Recognition for Indian Sign Language	Utilizes skin color detection and contour extraction methods with simple classifiers	Prone to errors in varied lighting/backgrounds; not scalable to large vocabularies
[4]	A Deep Learning-Based ISL Gesture Recognition System Using CNN	Uses CNN on static image datasets of ISL gestures for classification	Only works with static images; doesn't capture gesture dynamics; no feedback or learning module
[5]	An Interactive Learning Platform for ASL Education	Implements game-based progression and gesture feedback for American Sign Language learning	Focused on ASL; lacks real-time gesture recognition and Indian cultural adaptation

As shown in Table 1, the reviewed studies highlight key limitations such as the lack of real-time dynamic gesture recognition, limited support for Indian Sign Language (ISL), and the absence of interactive learning features. Most approaches focus on static recognition without addressing gesture variation across users. Additionally, existing systems rarely incorporate progression-based learning or feedback mechanisms essential for educational use

IV. METHODOLOGY

As appeared within the flowcharts (Figure 1 and Figure 2), Anguli Lekha implements a well-organized approach to supply and lock in and viable encounter for learning Indian Sign Dialect (ISL).

1. **Client Interaction and Level Determination:** Users start by entering the application, where they got to enlist and select their wanted learning level Alphabets, Words, or Sentences. This choice permits for a customized learning way based on the user's current aptitudes.
2. **Real-Time Signal Capture:** After selecting a level, the framework actuates the webcam to capture live hand developments. Each outline is handled instantly utilizing OpenCV, which applies preprocessing strategies such as resizing, foundation subtraction, and form discovery to precisely disconnect the hand region.
3. **Demonstrate Handling and Signal Expectation:** The handled outlines are input into a pre-trained CNN-LSTM show built with TensorFlow and Keras. The demonstration classifies the motions and matches them to the significant ISL signs agreeing to the chosen learning level.

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4. **Criticism and Learning Circle:** The distinguished motion is appeared to the client together with moment input. On the off chance that the motion is erroneous, the framework empowers the client to undertake once more, advancing an intelligently learning cycle that cultivates hone and reinforcement.
5. **Advance Following:** The framework keeps track of the user's advance, noticing completed signals and exactness rates. This following permits learners to see their development over time and return to troublesome signs as fundamental

V. SYSTEM DESIGN

The design of AnguliLekha focuses on creating an interactive, web-based learning experience by utilizing contemporary-end technologies and machine learning frameworks that are compatible with various browsers. It effectively integrates user engagement with real-time gesture recognition for structured Indian Sign Language (ISL) education.

1. **Frontend and Backend:** The user interface is crafted with React.js and leverages Vite for rapid building and deployment. It incorporates standard web technologies such as HTML, CSS, and JavaScript to provide an engaging and user-friendly learning space.
2. **Machine Learning & Gesture Recognition:** The system employs Teachable Machine for training the model, while TensorFlow.js is used to execute gesture recognition directly in the browser. This setup eliminates the necessity for server-side processing, ensuring immediate performance on user devices.
3. **Model Integration:** The ISL recognition model, once trained in Teachable, is exported and integrated into the web application via TensorFlow.js, allowing for real-time predictions of hand gestures captured by the webcam.
4. **Dataset**: Training for the model is conducted using a carefully assembled dataset of Indian Sign Language gestures, which includes letters, frequently used words, and basic phrases, gathered from various users

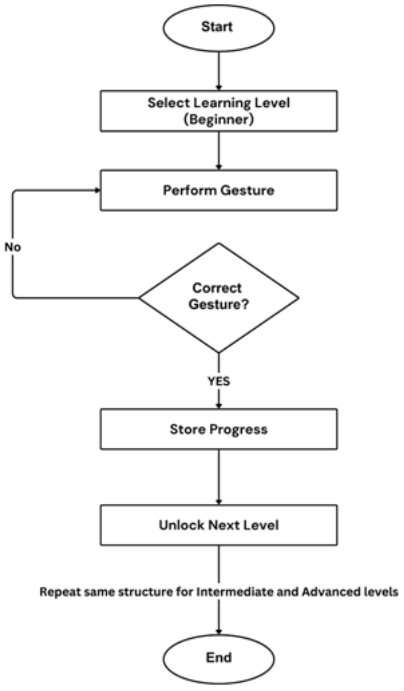

Fig 1: User Flow for ISL Level Selection and Interaction

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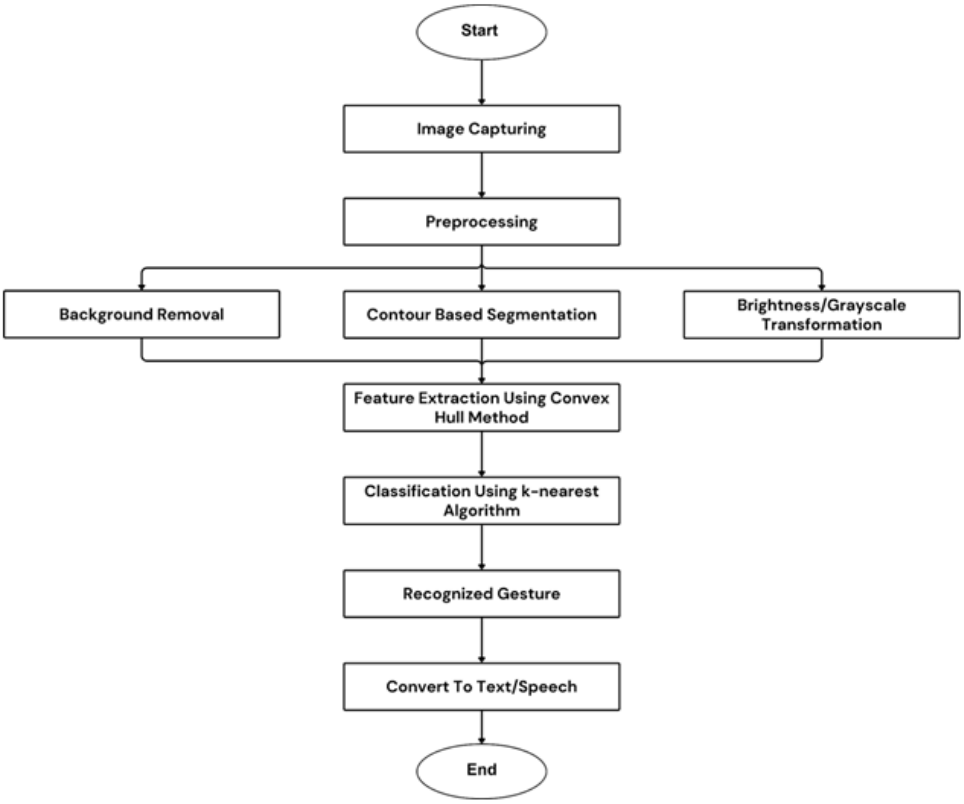

Fig 2: System Workflow for ISL Gesture Recognition

VI. RESULTS AND ANALYSIS

Fig 3: Home Screen of AnguliLekha Platform

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As shown in Fig. 3, the home screen of the AnguliLekha platform offers a welcoming interface that introduces users to various features including Learn, Quiz, Speech to Sign, and Admin sections. The layout is designed to guide users toward exploring ISL in a progressive manner. This screen sets the tone for the platform's educational and accessibility goals, helping learners navigate the system with ease while promoting engagement through its modern, interactive design

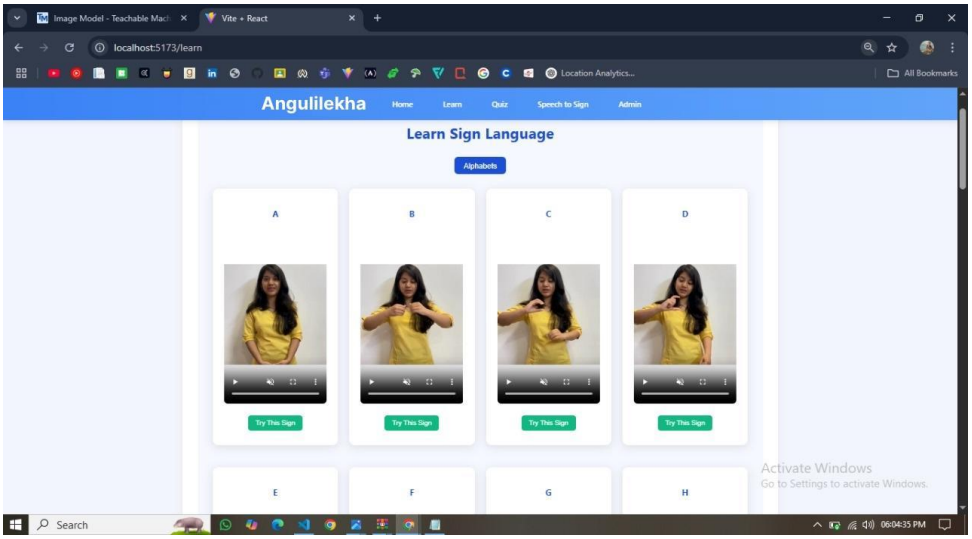

Fig 4: ISL-Alphabet-Learning-Module

As shown in Fig. 4, the ISL learning module of the AnguliLekha platform presents users with a structured layout for exploring the Indian Sign Language alphabet. Each letter is represented with an instructional video and a "Try This Sign" button, encouraging interactive learning. This module enables learners to visually compare their own gestures with standard ISL signs, reinforcing recognition and muscle memory. Such a user-friendly interface bridges the gap between passive content consumption and active practice, making it easier for users to internalize the sign language alphabet.

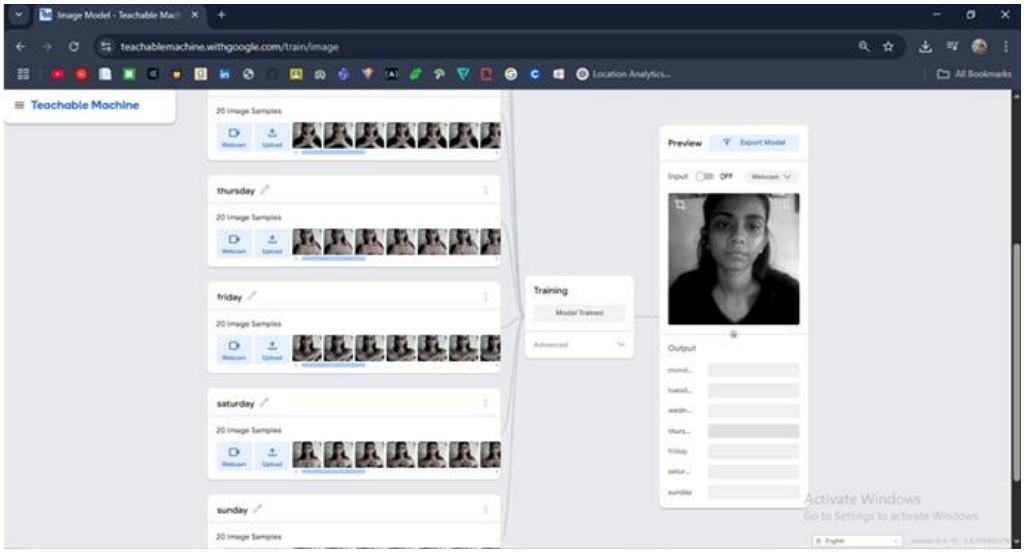

Fig 5: Training Phase using Teachable Machine

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As shown in Fig. 5, the Teachable Machine interface demonstrates the training phase of the gesture recognition model used in AnguliLekha. The interface includes labeled classes for each day of the week, with 20 image samples captured per class via webcam. The system uses these samples to train a classification model that can identify Indian Sign Language (ISL) gestures in real-time. This hands-on model-building experience allows learners to understand how image-based machine learning is applied for gesture classification, supporting the backend functionality of the AnguliLekha platform.

VII. CONCLUSION AND FUTURE SCOPE

AnguliLekha is a structured Indian Sign Language (ISL) learning platform that enables users to practice and improve their signing skills through real-time gesture recognition. By organizing content into three progressive levels—alphabets, words, and sentences—the system supports a step-by-step learning approach. Using LSTM models and OpenCV for gesture recognition, it provides instant feedback to enhance user engagement and learning efficiency. The platform promotes accessibility and inclusivity by making ISL education interactive and self-paced.

The future development of AnguliLekha aims to enhance its usability, accuracy, and reach. Expanding the existing dataset to include regional variations of Indian Sign Language will allow the system to better recognize and adapt to diverse signing styles across different parts of India. To support more natural and expressive communication, the system will be extended to handle complex, dynamic, and two-handed gestures. Additionally, incorporating gamified elements such as quizzes, badges, and progress tracking can improve user engagement and motivation. Cross-platform compatibility, especially for mobile devices, will further increase accessibility and convenience for learners. Collaborating with certified ISL experts will also ensure that the platform remains accurate, culturally relevant, and aligned with recognized ISL standards.

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