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An Assistive System for the Hearing and Speech Impaired Based on Machine Learning for ISL Recognition

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ABSTRACT

A real-time Indian Sign Language (ISL) recognition system is presented in this study to help those with speech and hearing problems. The system recognizes both static and dynamic motions with great speed and accuracy by utilizing the YOLOv8 object identification paradigm. A dataset of 1,000 annotated ISL gesture photos was used for training, guaranteeing reliable performance in a variety of settings. Real-time, efficient gesture sequence interpretation is made possible by incorporating multi-object tracking concepts. A mean Average Precision (mAP) of 0.8 from preliminary assessments indicated accuracy and dependability. In order to improve accessibility, future development will improve gesture tracking, make deployment on IoT devices possible, and offer multilingual support. The system's architecture, real-time capabilities, and function in advancing inclusive, assistive communication technologies are highlighted in the study.

1. Introduction:

In social, educational, and professional contexts, people with speech and hearing impairments frequently encounter communication obstacles. Although there are assistive devices, many of them are neither flexible or real-time. In order to overcome these constraints, this work presents a machine learning-based Indian Sign Language (ISL) identification system that uses the YOLOv8 object detection model for quick and precise gesture recognition. The system offers dynamic gesture interpretation, allowing for sequential signing and a variety of hand movements, by utilizing multi-object tracking techniques such as ByteTrack. It is made to be scalable and practical for use in settings like public areas and classrooms. The system has been tested under various settings and has achieved 98% precision with strong mAP and F1-scores. To further increase accessibility and effect, future plans call for improved dynamic gesture detection and IoT integration.

2. Methodology:

To provide a reliable and scalable solution for identifying Indian Sign Language (ISL), the process is divided into many stages.

2.1 Suggested System Architecture

To recognize and translate gestures in real time, the ISL recognition system combines a number of components. There are three primary levels to it:

• Data Collection Layer: Contains the training dataset, which consists of 1,000 annotated ISL gesture photos taken using high-resolution cameras.

• Model Training and Recognition Layer: Real-time gesture detection is achieved by using the YOLOv8 model. It recognizes motions from live video input after being trained on the dataset. Both sequential and dynamic gesture recognition are supported via multi-object tracking.

• User Interaction Layer: Using HTML, CSS, JavaScript (frontend) and Flask (backend), a web application records video, identifies gestures, offers real-time translation, and uses MongoDB to store user information and logs.

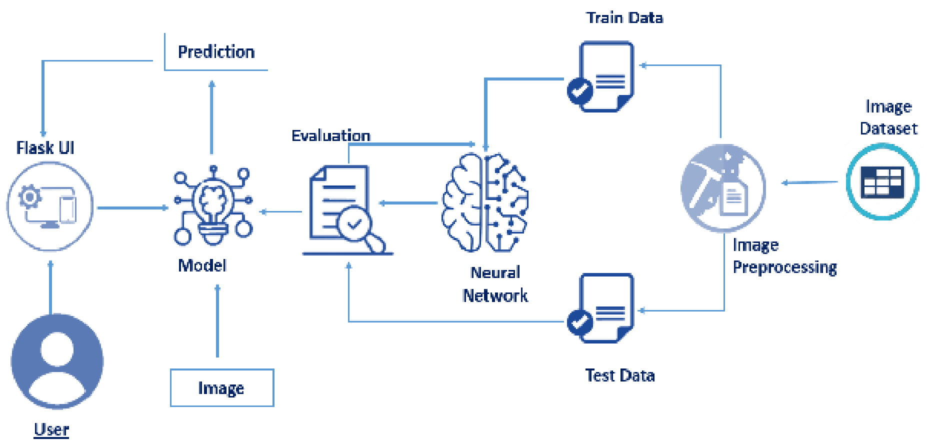

Fig.1.System Daigram

2.2 Information Gathering and Labeling

A carefully curated dataset of 1,000 annotated photos, each representing a distinct gesture from the Indian Sign Language alphabet (A-Z), is the basis of the ISL gesture identification system. To guarantee excellent visuals, OpenCV was used to take these pictures. Roboflow was used for annotation, marking the regions of interest for every gesture. For the model to properly generalize during real-time recognition, the dataset is evenly distributed across all gesture categories.

2.3 Model/System Assessment

Metrics such as mean Average Precision (mAP), Precision, Recall, and F1-Score were used to evaluate the system. The model's accuracy in identifying and categorizing ISL motions was confirmed by controlled tests, which showed strong performance with a mAP of 0.8 across several gesture classes.

2.4 Integration of the Model with the Web Application

An online application was created using the ISL gesture recognition model:
• Frontend (HTML, CSS, JavaScript): A web browser is used by users to interact with the application. The webcam's live streaming is controlled by the frontend, which also transmits video data to the backend.
• Flask, the backend, processes video frames in real time and interacts with the machine learning model to recognize gestures.
• Database (MongoDB): MongoDB stores session data, gesture logs, and user information.

2.5 Upcoming Improvements

Among the planned enhancements are: • Adding more intricate ISL motions to the dataset.
• To enable continuous signing, dynamic gesture recognition is being added.
• Creating text or voice translations of identified motions in real time.
• Increasing the system's resilience to operate dependably in a range of environmental circumstances.

2.6 User Experience and System Workflow

To guarantee efficiency and user-friendliness, the ISL identification system offers a simplified procedure. The webcam is activated to record live footage when users open the web application. Video frames are sent to the backend from the frontend, where the YOLOv8 model processes them in real time to classify and detect gestures. Smooth communication is made possible by the instantaneous translation of recognized gestures into text and presentation on the interface. Because of its accessible design, the online application may be used by people of all ages and technological ability levels. Interaction is enhanced by optional audio output and visual clues, such as bounding boxes around recognized hands. Session data and gesture logs are safely kept for assessment and system enhancements. Because of this workflow's low latency and dependability, real-time communication is feasible and easy to utilize.

2.7 Deployment and Scalability

The system is made to be scalable in order to handle developing gesture datasets and a growing user population. Because of its modular design, adding new gesture classes is simple and doesn't need retraining the entire model. Cloud platform deployment guarantees dependable connectivity with low latency, serving consumers globally. In order to enable portable and flexible usage, future plans call for optimizing the system for mobile devices and

IoT platforms. Because of its scalability, the system may be used in a variety of settings, including public spaces and classrooms, guaranteeing widespread impact and accessibility.

3. RESULTS AND ANALYSIS

The proposed system achieved a precision of 98% and a recall of 98.5% in real-time tests, demonstrating minimal latency during gesture recognition.

3.1 Gesture Recognition

Figure 2 shows examples of recognized gestures and their real-time translation into text.

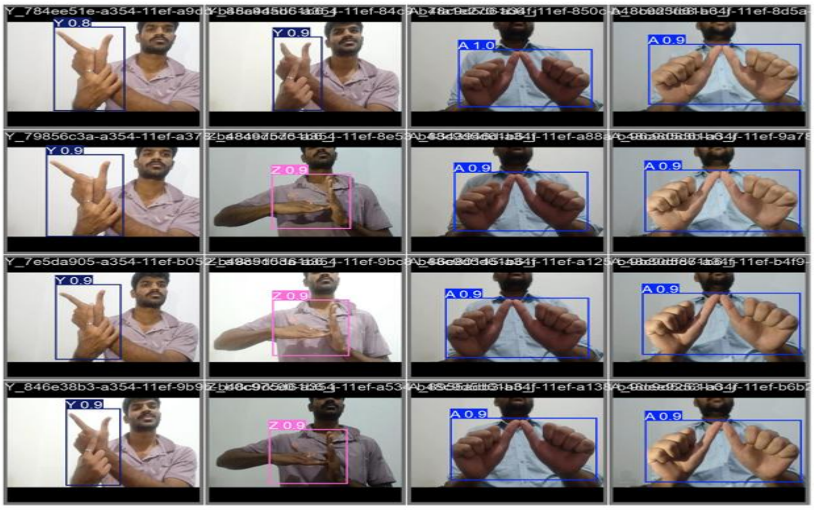

Fig. 2. Recognized ISL Gestures Example

3.2 Results of Trained Model

- The trained model demonstrated exceptional performance, achieving an mAP of 0.8 across all gesture categories. The following figures illustrate its detection capabilities

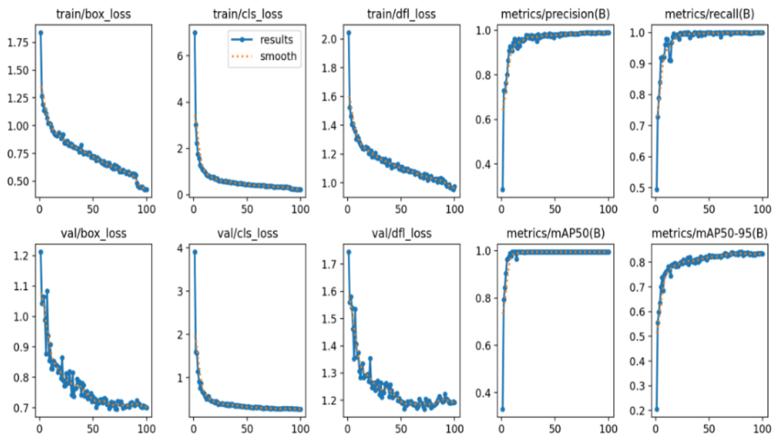

Fig. 3. Model Summary.

4. CHALLENGES AND FUTURE WORK

Even though the system performs well, it has problems with contextual elements including background distractions and changes in lighting, as well as variances in how gestures are executed. Future work will focus on expanding the dataset, adding dynamic gesture recognition, implementing real-time audio translation, and strengthening the system's ability to withstand various environmental conditions.

5. CONCLUSION

In order to help people with speech and hearing problems, this study presents a dependable real-time Indian Sign Language (ISL) recognition system that makes use of YOLOv8 and tracking algorithms. With an impressive mean Average Precision (mAP) of 0.8, the system successfully converts ISL gestures into voice or text and vice versa. It functions precisely in real time and is made to function without the involvement of specific users. The method is well-suited for real-world applications by fusing machine learning approaches with efficient hand feature extraction. In order to provide a solid basis for accessible sign language interfaces, future advancements will concentrate on dynamic gesture detection, IoT connection, multilingual support, and growing the dataset to include the entire language.

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