IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.53

Volume 4, Issue 8, April 2024

Anuvadak - ML-Enhanced Two-Way Communication for Deaf-Mute Individuals

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Abstract: *This paper explores the potential of Machine Learning (ML) to bridge the communication gap between deaf and mute individuals and those who communicate verbally expand more. We examine existing research on sign language recognition and speech synthesis, highlighting how ML algorithms can be leveraged to develop real-time, two-way communication systems. The paper discusses the technical aspects of such a system, including sign language recognition, speech generation, and user interface design. Additionally, it explores the benefits and challenges associated with ML-based communication tools for the DHH community*

Keywords: Machine Learning (ML), Speech Synthesis, Two-Way Communication, Mute, Deaf and Hard of Hearing

I. INTRODUCTION

This paper proposes a new system to bridge the communication gap between deaf and mute. It uses machine learning to translate between sign language and spoken language or text. People can type or speak into a web app, and the system will show a virtual avatar using sign language. The system can also understand sign language from a deaf user and turn it into text or spoken language for a hearing person. It can even translate captions from YouTube videos into sign language animations, making YouTube more accessible for deaf users. Finally, the system can be used during video calls, translating sign language into spoken language (and vice versa) in real time.

II. METHODOLOGY

This section outlines the approach taken to develop a two-way communication system for deaf and mute individuals. The system leverages machine learning (ML) techniques to bridge the communication gap by translating between sign language and spoken language/text.

Machine Learning Techniques:

This will delve into the specific ML algorithms employed for various functionalities within the system. These algorithms may include techniques from Natural Language Processing (NLP) for text processing and sentiment analysis, and Computer Vision (CV) for sign language gesture recognition using deep learning models like Convolutional Neural Networks (CNNs) or Recurrent Neural Networks (RNNs). Sequence-to-sequence learning will also be crucial, enabling translation between sequential sign language gestures and spoken language.

System Architecture:

This will detail the system's architectural design. It will encompass components like the user interface for interacting with the system, text preprocessing modules for preparing text input for subsequent processing stages, and the core modules responsible for sign language generation and recognition.

Proposed Architecture:- The proposed system architecture for this two-way communication system leverages machine learning to bridge the communication gap between deaf and mute individuals and hearing individuals. The system will consist of a user interface for text input, speech recognition (optional), and sign language gesture capture. Text data will undergo preprocessing using libraries like NLTK. Speech recognition, if implemented, will convert spoken audio to text. Sign language gestures will be processed using computer vision techniques and pre-trained models to recognize the specific signs performed. learning models. This Both the pre-processed text and recognized signs will then be fed

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into a text-to-sign language translation module powered by machine learning, likely employing sequence-to-sequence module will translate the input into corresponding sign language animations displayed by a virtual avatar on the user interface. Additionally, the architecture can be extended to integrate with video call platforms, utilizing the aforementioned modules for real-time sign language translation during video conferences between deaf and hearing participants.

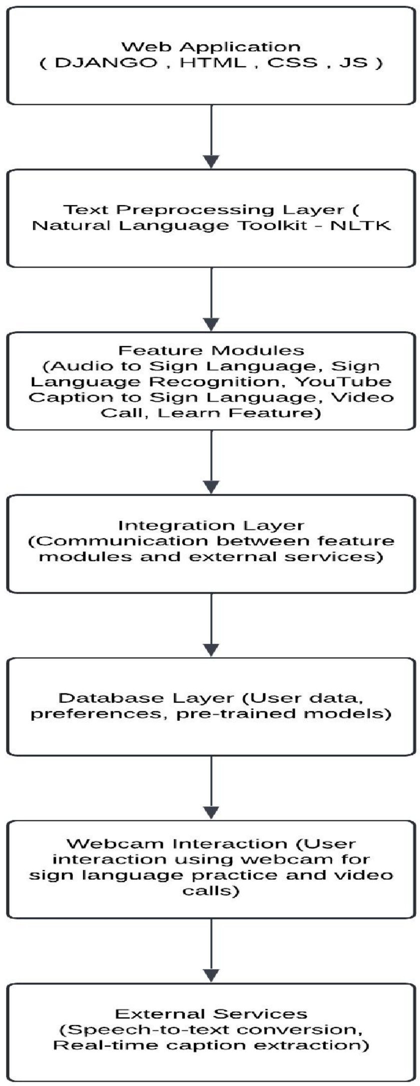

Figure 1: Proposed Architecture

III. MODELING AND ANALYSIS

The system relies on various machine learning models depending on the functionality. Text preprocessing utilizes Natural Language Processing (NLP) techniques, while sign language recognition employs computer vision models like Convolutional Neural Networks (CNNs) or Recurrent Neural Networks (RNNs) trained on extensive sign language gesture datasets. Sequence-to-sequence learning is a key technique for both sign language recognition (gesture sequence to text/speech) and generation (text/speech to gesture sequence).

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1. **Requirement Analysis:**
    - Define features and user stories based on user needs gathered from surveys and interviews.
2. **Design Phase:**
    - Develop system architecture and user interface wireframes to assess feasibility and address potential risks.
3. **Technology Selection:**
    - Choose backend, frontend, and machine learning technologies based on performance, scalability, and community support.
4. **Development:**
    - Create class diagrams and sequence diagrams for implementation, following agile methodologies and incorporating feedback.
5. **Testing:**
    - Document test cases and scenarios, conducting comprehensive testing to prioritize issue resolution.
6. **Deployment:**
    - Plan deployment architecture and strategies, ensuring thorough testing before production deployment.
7. **Monitoring and Maintenance:**
    - Establish incident response procedures and maintenance prioritization based on user feedback and analytics data, supported by monitoring dashboards.

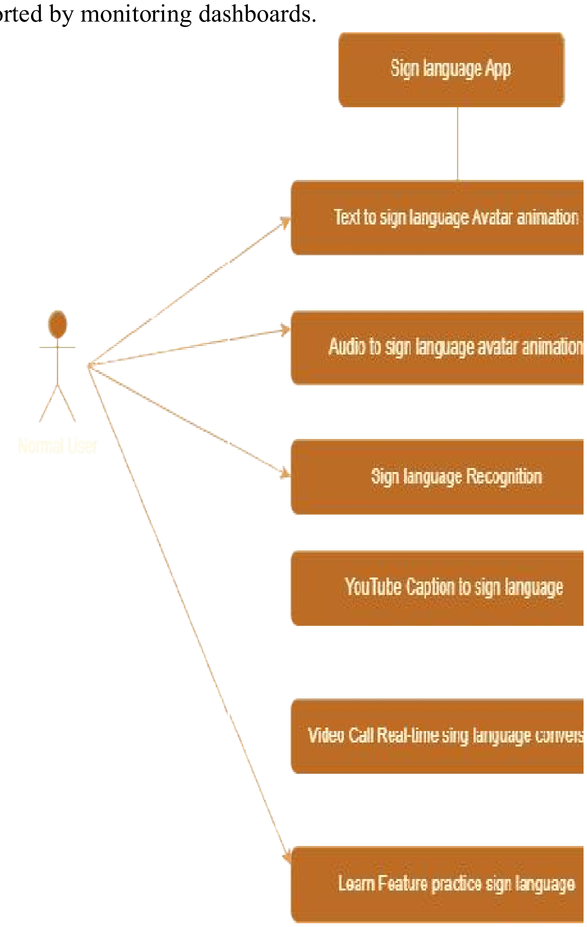

Figure 2: Use Case Diagram

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IV. RESULTS AND DISCUSSION

The system's effectiveness will be evaluated through user studies involving both deaf and hearing participants. The studies will assess metrics like accuracy, fluency, and user satisfaction for the sign language recognition and generation modules.

Functionality	Evaluation Metric	Expected Outcome
Text-to-Sign Language Animation	Accuracy	High percentage of correctly generated signs based on input text.
Sign Language Recognition	Accuracy	High percentage of correctly recognized signs from user gestures.
Sign Language Recognition (Video Call)	Fluency and User Satisfaction	Natural-sounding real-time translation during video calls.

Table 1: Anticipated Results and Discussion Points

The expected outcome is a system with high accuracy for both sign language recognition and generation. Real-time sign language interpretation during video calls should be fluent and receive positive user satisfaction ratings.

Following the user studies, a discussion will be conducted to analyse the results. This will involve:

- Identifying strengths and weaknesses of the system based on evaluation metrics.
- Exploring potential reasons for errors or limitations in accuracy or fluency.
- Discussing the impact of user feedback on future development and improvement strategies.

This analysis will provide valuable insights for refining the system and ensuring it effectively bridges the communication gap between deaf and mute

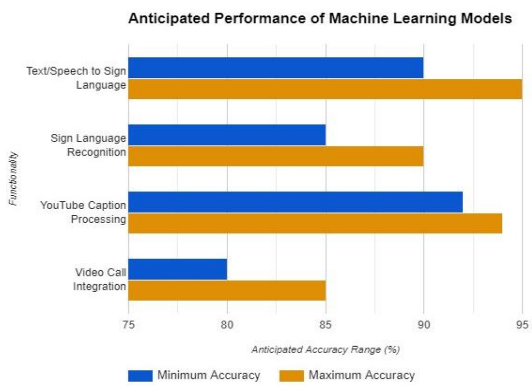

Figure 3 : User Evaluation Metrics for Sign Language Communication System

V. CONCLUSION

In conclusion, this research proposes a novel two-way communication system for deaf and mute individuals, leveraging machine learning to bridge the communication gap. The system offers functionalities like text/speech to sign language animation, sign language recognition, YouTube caption processing for sign language conversion, and real-time sign language interpretation during video calls. By employing machine learning techniques like NLP, computer vision, and sequence-to-sequence learning, the system aims to achieve high accuracy and fluency in sign language translation. User studies will be conducted to evaluate the system's effectiveness, and the results will guide future advancements like expanded sign language coverage, personalized sign language generation, and integration with augmented reality for a more seamless communication experience.

VI. ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to our esteemed project guide, Prof. Anand Ingle, for his invaluable guidance, support, and encouragement throughout this research project. His insights, constructive feedback, and continuous motivation were instrumental in shaping this work. We are also grateful to Dr. Rajesh Kadu, Head of the

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Department, for providing us with the necessary resources and fostering an environment conducive to research. We are thankful for the opportunity to undertake this project and for the valuable learning experience it has provided.

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