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SLIngo: An App - Based Sign Language Interpreter using Machine Learning

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ABSTRACT:

In an increasingly interconnected world, effective communication remains a cornerstone of daily interactions. However, individuals who are deaf or hard of hearing often encounter significant barriers that hinder their ability to communicate with the hearing population. This prevalent issue underscores the necessity for equal access to information and services for those who rely on sign language. To address this critical gap, we propose the development of SLIngo, an innovative mobile application that employs sophisticated algorithms and machine learning to accurately translate sign language in real-time. By bridging the communication divide between diverse communities, SLIngo aims to empower individuals who use sign language, facilitating smoother interactions and fostering inclusivity. SLIngo is a platform that not only enhances communication but also promotes greater understanding and awareness of the deaf and hard of hearing community, ultimately contributing to a more equitable and connected society.

Keywords: Machine Learning, SLIngo, TensorFlow,

Introduction:

Deafness is a global condition that affects approximately 466 million people, including around 34 million children. Individuals who are deaf face numerous challenges in their daily lives, particularly in areas such as communication, education, employment, and socialization. A prevalent misconception is that deaf individuals are unable to communicate; however, many rely on sign language as their primary means of interaction. Sign language is a rich and complex language, complete with its own grammar and syntax, which varies across different cultures and regions. Recognizing the diversity within the deaf community is crucial for fostering an inclusive and accessible society for all individuals, regardless of their hearing status.

Despite the importance of sign language, there remains a significant gap in effective communication between deaf individuals and those who do not use sign language. This gap can lead to misunderstandings, social isolation, and limited access to essential services. To address this issue, we introduce SLIngo, an innovative app-based sign language interpreter designed to bridge the communication divide between hearing-impaired individuals and non-sign language users.

SLIngo leverages advanced machine learning techniques and computer vision to detect and interpret sign language gestures in real-time. The system comprises two main components: an Image Capture System and a Machine Learning Model. The Image Capture System utilizes the device's camera to capture the hand movements of the user, while the Machine Learning Model processes these images to accurately interpret the signs and display their meanings on the screen.

The versatility of the SLIngo system allows it to be utilized in various settings, including educational institutions, workplaces, and public spaces, thereby facilitating effective communication between hearing-impaired individuals and those who do not use sign language. By enhancing communication accessibility, SLIngo aims to improve the quality of life for individuals with hearing disabilities and promote greater inclusivity across diverse environments. This paper will explore the development, functionality, and potential applications of SLIngo, highlighting its significance in addressing the communication challenges faced by the deaf community.

Aims and Objectives:

The primary objective of the SLIngo application is to effectively bridge the communication gap between the deaf community and hearing individuals. The application is designed to deliver accurate and reliable interpretations of sign language into spoken language and vice versa. To achieve this overarching goal, the app aims to fulfil the following specific objectives:

1. **User -Friendly Interface:** The app will feature an intuitive and accessible interface that accommodates users of varying hearing abilities, linguistic backgrounds, and sign language dialects.
2. **Gesture Recognition and Interpretation**: The app will be equipped with machine learning technology to recognize and interpret a wide range of sign language gestures, ensuring precise translation into spoken language.

Features of SLIngo:

The features of the SLIngo Application are as follows:

1. **Machine Learning-Based Application**: The application is built using machine learning techniques to accurately recognize and interpret sign language gestures.
2. **User-friendly Interface**: The application has a user-friendly interface that is easy to navigate and allows users to quickly access the features they need.
3. **Offline Functionality**: The application can operate in offline mode, allowing users to use it even without an internet connection.
4. **Accuracy and Performance:** The application is designed to be highly accurate with good performance, providing users with a smooth and reliable experience.

Methodology :

An interactive method/approach is used to build SLIngo Application and it had to go through the following steps:

1. Data Collection: A dataset consisting of 24,000 sign language images were created and labeled with their corresponding sign language alphabets (All 26 letters of alphabets A-Z excluding J and Z).
2. Data Pre-processing: The dataset was split into training (70%), validation (20%), and testing (10%) sets. The images were resized to a standard size of 600 x 600 pixels and normalized to pixel values between 0 and 1.
3. Model Architecture: A Convolutional Neural Network (CNN) model was designed with several convolutional layers, max pooling layers, and dense layers using the TensorFlow library.
4. Model Training: The model was trained on the training set using the Adam Optimizer, sparse categorical cross-entropy loss, and accuracy metric for 10 epochs.
5. Model Evaluation: The trained model was evaluated on the testing set.
6. Model Deployment: The trained TensorFlow model was converted to a TensorFlow Lite model and saved as a .tflite file for deployment in a mobile app.
7. Performance Analysis: The accuracy and loss metrics of the model were analyzed to determine its performance on the test dataset.

Scope and Benefits :

The objective of SLIngo is to develop an Android application that interprets sign language and provides translations to facilitate communication between deaf individuals and hearing individuals. It includes image classification using the trained TensorFlow Lite model, camera integration for capturing images, gallery integration for selecting images, and user authentication for security purposes. The target audience for the application is individuals who want to communicate with people who use sign language as their primary mode of communication and hearing individuals who wish to communicate with them. The deliverables of the project will include the Android app that can be installed on mobile devices, the trained machine learning model that can classify sign language and provide translations, and the documentation that describes the project's architecture, design, and implementation.

The SLIngo application offers a range of benefits that makes it a convenient and effective way to learn sign language. Some of them are:

1. **Improved Communication**: The app can improve communication between sign language users and non-sign language users, facilitating smoother interactions and reducing misunderstandings.
2. **Cost - Effective:** The app can provide a cost-effective solution for communication without the need for expensive interpretation services.
3. **Educational Tool:** The app can serve as an educational tool for individuals who want to learn sign language or improve their skills.
4. **Accuracy and Performance:** The app is designed to be highly accurate with good performance, providing users with a smooth and reliable experience.
5. **Simplicity:** The system allows users to easily capture or upload images and quickly receive accurate predictions.

SLIngo Application System :

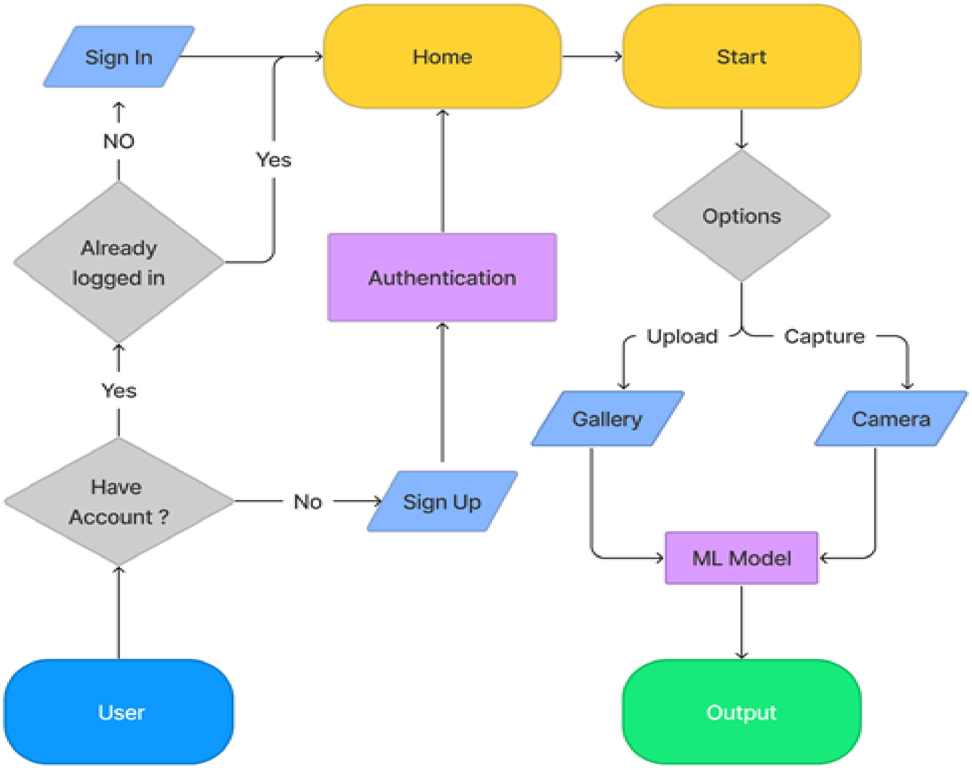

Figure 1: Flow Diagram of SLIngo App

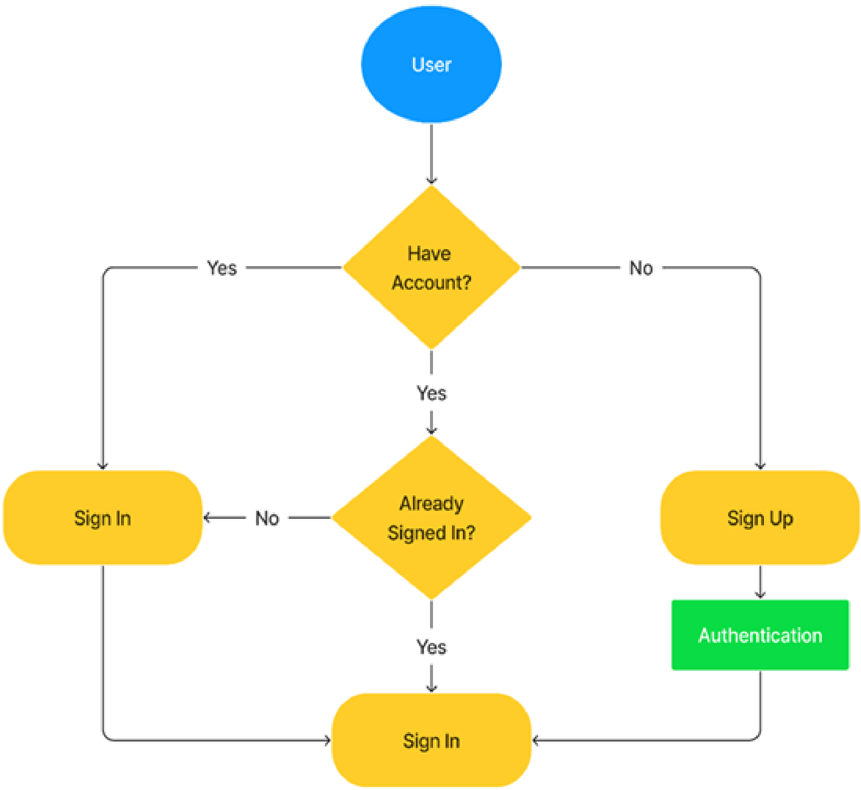

Figure2: User's Registration in SLIngo App

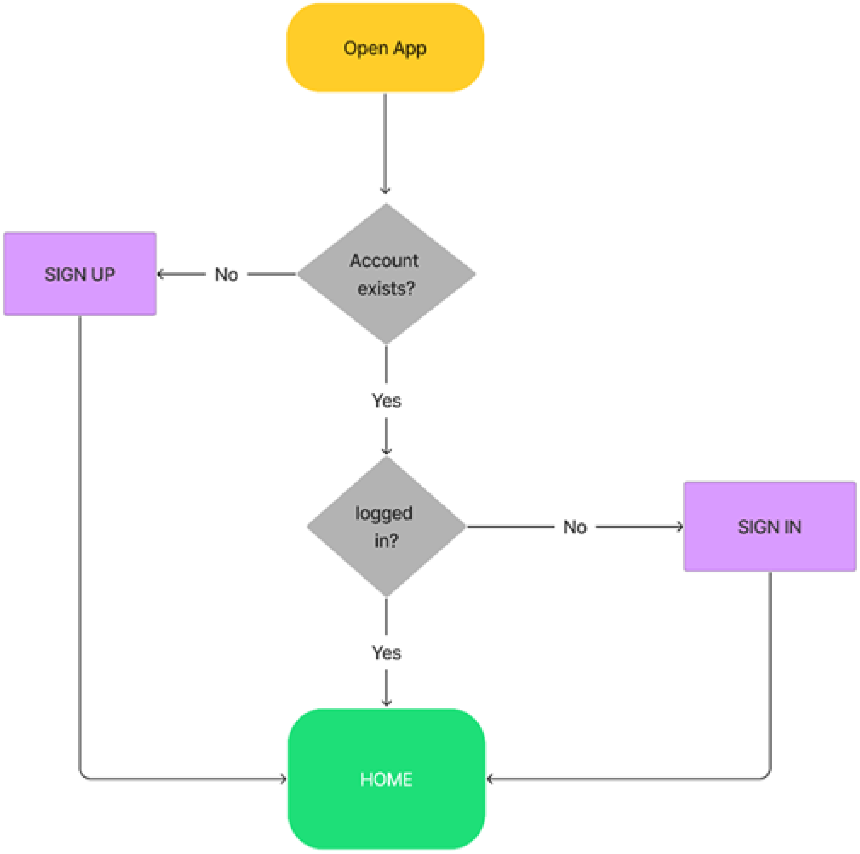

Figure 3: Users' Sign-In/Log-In in SLIngo App

Visual Representation of SLIngo App Features :

Figure 4: Splash Screen

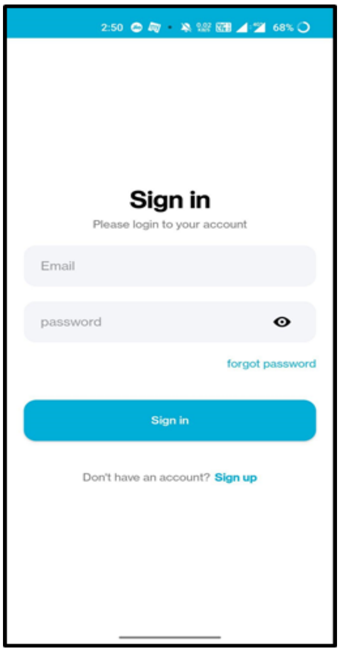

Figure 5: Sign-In Screen

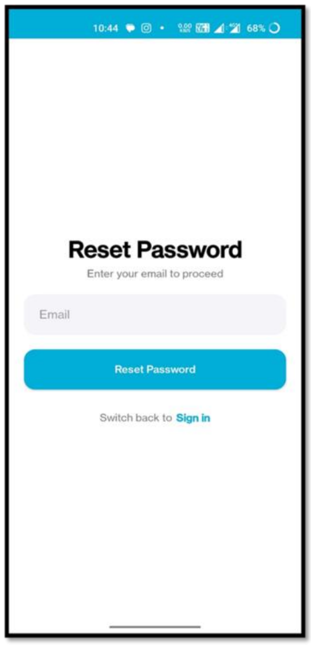

Figure 6: Reset Password Screen

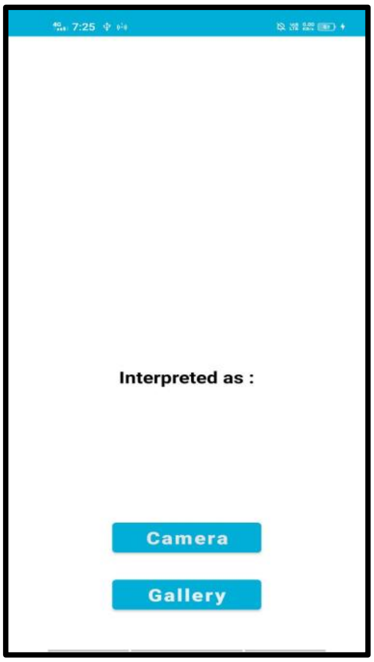

Figure 7: Capturing with Camera and Gallery Options

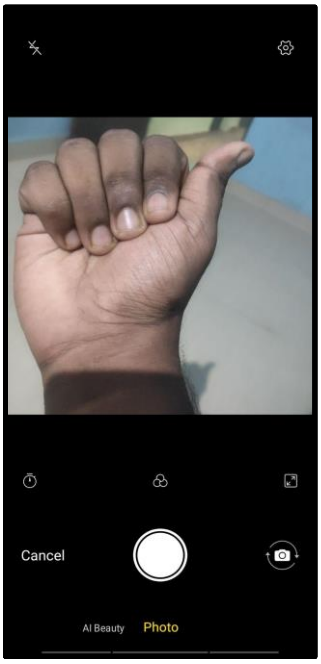

Figure 8: Screen with Camera Option

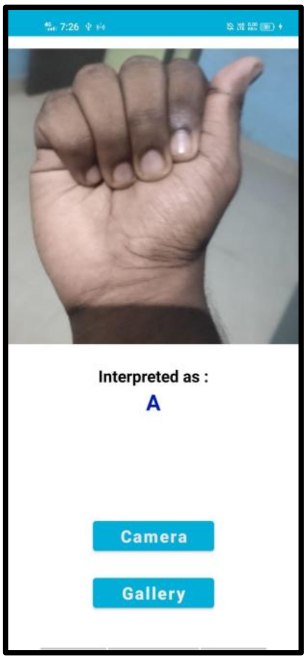

Figure 9: SLIngo Sign Language Interpreter

Figure 10: Screen with Gallery Option

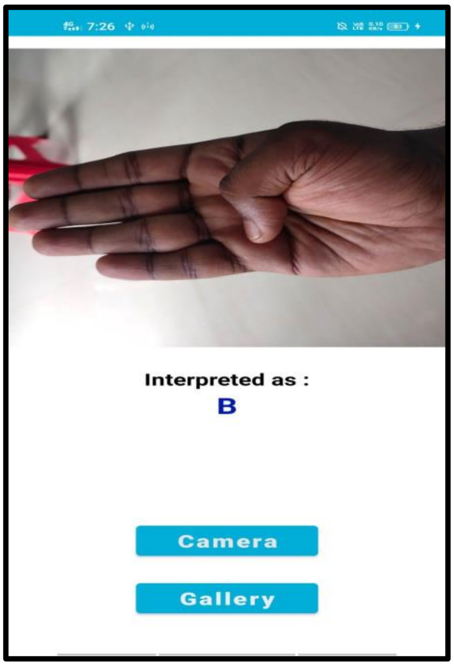

Figure 11: SLIngo Sign Language Interpreter

Machine Learning Evaluation Results :

```
model.fit(
    train_ds,
    validation_data=val_ds,
    epochs=10
)
✓ 753m 50.1s

Epoch 1/10
840/840 [==============================] - 4584s 5s/step - loss: 0.5097 - accuracy: 0.8654 - val_loss: 0.9809 - val_accuracy: 0.8506
Epoch 2/10
840/840 [==============================] - 4391s 5s/step - loss: 0.0266 - accuracy: 0.9936 - val_loss: 0.8900 - val_accuracy: 0.8835
Epoch 3/10
840/840 [==============================] - 4397s 5s/step - loss: 0.0121 - accuracy: 0.9967 - val_loss: 0.9141 - val_accuracy: 0.8994
Epoch 4/10
840/840 [==============================] - 5683s 7s/step - loss: 0.0119 - accuracy: 0.9970 - val_loss: 1.0033 - val_accuracy: 0.8225
Epoch 5/10
840/840 [==============================] - 4402s 5s/step - loss: 0.0246 - accuracy: 0.9952 - val_loss: 1.2612 - val_accuracy: 0.8923
Epoch 6/10
840/840 [==============================] - 4389s 5s/step - loss: 0.0102 - accuracy: 0.9976 - val_loss: 1.1152 - val_accuracy: 0.9171
Epoch 7/10
840/840 [==============================] - 4333s 5s/step - loss: 0.0069 - accuracy: 0.9983 - val_loss: 1.3678 - val_accuracy: 0.8808
Epoch 8/10
840/840 [==============================] - 4336s 5s/step - loss: 0.0182 - accuracy: 0.9963 - val_loss: 1.0671 - val_accuracy: 0.8952
Epoch 9/10
840/840 [==============================] - 4348s 5s/step - loss: 0.0022 - accuracy: 0.9996 - val_loss: 0.8587 - val_accuracy: 0.9175
Epoch 10/10
840/840 [==============================] - 4367s 5s/step - loss: 0.0038 - accuracy: 0.9989 - val_loss: 1.0083 - val_accuracy: 0.9133
```

Figure 12: Convolutional Neural Network (CNN) Model Evaluation

Conclusion :

SLIngo is a powerful tool for helping sign language users to communicate with the world around them. By utilizing machine learning, the app is able to interpret sign language accurately and in a user-friendly way. This technology has the potential to revolutionize the way people with hearing impairments interact with the world and can serve as an invaluable aid for those who rely on sign language. With continued development and support, the SLIngo App could become a critical bridge for effective communication for sign language users everywhere.

Future Enhancement :

The Sign Language Interpreter App is an application that uses machine learning and convolutional neural networks to interpret signs.
To improve the app, there are several future enhancements that can be made.

1. Enhance the accuracy of the app's sign language interpretation by incorporating more advanced machine learning algorithms.
2. Allow users to upload and share their own sign language videos and recordings.
3. Introduce a feature that allows users to practice their sign language skills with a virtual instructor.
4. Incorporate a live sign language translation service, so users can communicate with one another in real time.
5. Develop a library of sign language lessons and tutorials for users to learn.
6. Add support for more sign languages.
7. Implement a feature that allows users to search for specific sign language words or phrases.

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