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Sign Language based Web Search Application using OpenCV

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ABSTRACT: This research paper introduces a singular approach to decorate net accessibility for individuals with speech impairments by way of making use of sign language recognition generation. We developed a system that allows users to perform web searches using sign language gestures captured through a camera. Our method involved creating a dataset comprising hand sign images for each letter from A to Z. We then trained a machine learning model, specifically the Random Forest algorithm, to recognize these gestures and interpret them as search queries. Further for developing the technology, we also created a user-friendly application using Python, which guides users through the search process with voice prompts and recognizes their hand gestures. This application aims to make net browsing more feasible for individuals with speech impairments. Furthermore, we examine the overall performance of other machine learning algorithms, such as Decision Tree, Support Vector Machine (SVM), Stochastic Gradient Descent (SGD), and K-Nearest Neighbors (KNN). However, our results depicted that the Random Forest algorithm performed out in getting the best in areas of accuracy and efficiency.

KEYWORDS: Sign Language, Web Search, Machine Learning

I. INTRODUCTION

In today's digital world, accessing information online is vital, from learning to communication. However, people with speech impairments often face obstacles when trying to find in the web because traditional methods rely on speaking. This research aims to solve this problem by developing a system that lets users find in the web using sign language. Our motivation comes from the need to make the internet more inclusive for everyone. By creating a system that understands sign language, we hope to give people with speech impairments a way to access online resources more easily. In this paper, we discovered existing research on sign language recognition and the way it is able to be implemented to web search. We then explain how we built our system, including collecting data, training a computer model, and creating a user-friendly interface. Next, we share our findings and discuss what they mean for improving web accessibility. Finally, we look ahead to future developments possible for this technology and its impact on people's lives. Through this research, we aim to contribute to making the digital world more inclusive for everyone.

II. RELATED WORK

The 'Hausar Kurma' mobile app, developed by Ahmed Lawal and his team, is an innovative educational tool designed for Hausa-speaking hearing impairment students in Nigeria. This app is a notable example of leveraging mobile technology to enhance educational access and to provide quality for students with different needs. It employs Hausa Sign Language to facilitate English language learning, ensuring that individuals who are hearing impaired can receive quality education in a manner that's accessible to them [1]. In the broader context, the literature indicates a surge in the growth of mobile applications aimed at translating sign language into verbal

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languages. This trend is evident in the creation of apps for the Android platform that cater to various languages, including Indian, Indonesian, Hindi, and Filipino. The 'Hausar Kurma' app aligns with these developments, yet stands out for to its targeted approach for the Hausa-speaking community [1]. From a technical standpoint, the app utilizes TensorFlow Lite, a framework that allows for the deployment of machine learning models on mobile devices. This choice reflects a commitment to leveraging cutting-edge technology to enhance educational outcomes. The app's interface, crafted using Java and XML, is moulded to be user-friendly, catering to the specific needs of its users. The usage of SQLite for data management further underscores the app's robustness and reliability [1].

The educational influence of the 'Hausar Kurma' app is significant. Through statistical analysis, including the binomial test and Wilcoxon signed-rank test, the app has demonstrated a marked improvement in students' English language skills. The strong effect size of $r=0.633$ is indicative of the app's efficacy. These results are a testament to the app's role in not just enhancing language skills but also in contributing to the academic and social integ ration of hearing impairment students [1]. However, the journey of 'Hausar Kurma' is not without its challenges. The literature points to a scarcity of comprehensive resources on Hausa Sign Language, which poses a hurdle for developers and educators alike. Additionally, the need for better training facilities and resources is evident. The app's development team has navigated these challenges, setting a precedent for future initiatives in this space [1].

The 'Hausar Kurma' mobile app is a beacon of innovation in the field of special education technology. It exemplifies the transformative power of mobile technology when tailored to meet the needs of marginalized communities. The app not only facilitates language learning but also embodies the broader objective of inclusive education. As the literature suggests, while there are challenges to be addressed, the positive impact of such technological interventions is undeniable, paving the way for further research and development in this vital area of education. The statistical validation of the app's effectiveness, with a binomial test yielding a probability of 0.0098 and a Wilcoxon signed-rank test showing a Z-score of 2.82 ($p < 0.05$), reinforces the practical significance of the intervention in the educational landscape for hearing impairment students [1].

Sign language recognition is a field witnessing significant advancements, driven by the imperative of facilitating communication for the deaf and difficulty of hearing community. Recent literature delves into vari ous approaches tailored to different sign languages, highlighting the nuances of American Sign Language (ASL), Chinese Sign Language (CSL), and Italian Sign Language (LIS), among others. Notably, some languages exhibit minimal dynamic signs, enabling recognition solely through spatial positioning analysis, which streamlines the process by eliminating the requirement for temporal analysis [2] [10].

Virtual avatars have emerged as an innovative solution in sign language communication, serving as digital representations capable of conveying both static and motion-based signs. This development aims to bridge communication gaps between signers and non-signers, offering more accessible and intuitive communication channels, both online and offline. The use of virtual avatars enhances interpretative capabilities, facilitating smoother interactions for sign language users [2].

Research endeavors in sign language recognition span a wide range of methodologies and frameworks. These include the usage of technologies like Kinect, exploration of hidden Markov models tailored for this purpose, comprehensive surveys to comprehend the landscape of sign language recognition, and the enforcement of convolutional neural networks for recognizing diverse sign languages. Such diverse approaches reflect the interdisciplinary nature of the field and underline efforts to betterment the accuracy and efficiency of recognition systems [2]. Sign language recognition heavily relies on advanced techniques and models to achieve precise and accurate results. Kalman filtering aids in motion tracking, automatic skin segmentation isolates relevant features, and visual sign language recognition strategies are optimized for different languages. Additionally, hidden Markov models are deployed for real-time recognition, contributing to the robustness and adaptability of sign language recognition systems across varied contexts and languages [2].

Acknowledging the significant contributions of researchers and their affiliations is essential. Active participat ion in conferences and events focusing on robotics and experimental methodologies underscores the interdisciplinary nature of sign language technology research. Collaboration with sign language interpreters further refines systems,

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ensuring cultural sensitivity and accuracy in recognition technologies [2] [11]. Ethical considerations are paramount in sign language research to safeguard participants' rights. Studies emphasize the absence of competing interests and the non-involvement of human or animal subjects. Collaborating with sign language interpreters ensures cultural appropriateness and accuracy in recognition technologies, reflecting the commitment to inclusive and responsible research practices. The paper authored by W. Aly et al. presents a significant contribution to the field of Sign Language Recognition (SLR), emphasizing the importance of automatic SLR systems in facilitating communication for the hearing impaired. It traces the trajectory of SLR research, noting a shift from sensor -based methods to vision-based approaches utilizing camera images for recognition, reflecting advancements in technology and methodology [3].

Acknowledging the progress in sensor technologies like Microsoft Kinect and Leap Motion controller, the literature review highlights key works in SLR research, including the application of Randomized Decision Forests for hand pose estimation and classification. This diversity of methods illustrates the evolving landscape of SLR research and the continual quest for improved recognition accuracy and efficiency [3]. The paper a user-independent American Sign Language alphabet recognition system, leveraging depth images and PCANet features to address common challenges in SLR, such as hand segmentation and appearance variations. By exploiting the depth images advantage and the discriminative feature extraction capabilities of PCANet, the system aims to achieve enhanced accuracy and robustness in recognizing sign language alphabets [3].

Through thorough experimental evaluation using benchmark datasets, the research demonstrates promising results in user-independent recognition. The fusion of depth images and PCANet features significantly enhances the system's performance, showcasing its potential in applications that is practical in real -world scenarios involving sign language communication. It emphasizes the critical role of user-independent recognition systems in practical SLR applications. It proposes future research directions, advocating for the adoption of advanced deep learning techniques and the integrating multimodal data sources to extend the system's capabilities beyond alphabet recognition to encompass full sentences and complex gestures in sign language. The directions keep promise for further advancing the field of SLR and enhancing communication accessibility for the hard hearing community [3].

III. METHODOLOGY

The methodology is meticulously designed to deliver the robustness of the sign language-based web search system. It comprises the following stages:

I. Dataset Creation:

1. Image Acquisition: The model utilizes the `cv2.VideoCapture()` function from the OpenCV library to capture real-time images of gestures in sign language for each one letter part of alphabet from the camera. This function is capable of interfacing with the camera hardware and capturing frames, which then processed extracts sign language gestures.
2. Dataset Assembly: A dataset is created has 100 images for each letter, culminating in a total of 2600 images.

II. Data Preprocessing:

Dataset Division: Use of the training-test split function from the sklearn module, the dataset is partitioned into two subsets:

1. Training Set: 80% data (2080 images) is used for training the model. This subset helps the model learn the patterns associated with each sign language gesture.
2. Testing Set: 20% data (520 images) is reserved for testing the model. This subset is crucial for evaluating the model's performance on data not seen during the training phase.

III. Model Training and Evaluation:

1. Classifier Training: The Random Forest classifier technique has been applied to the training dataset. Random Forest is a learning method that operates by constructing many decision trees in phase of training and giving the class that is the mode of the classes (classification) of the individual trees.
2. Model Testing: After training, the model is tested using the testing dataset. The accuracy is calculated by comparing the model's predictions against the actual labels of the test images.

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3. Accuracy Achievement: An accuracy of 99.8214\% indicates that the model is highly effective at correctly classifying the sign language gestures.

Fig. 1. sign language recognition images from dataset

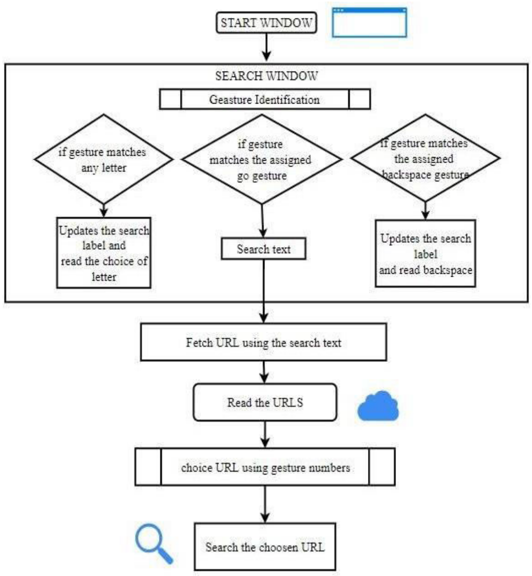

Fig. 2. System flow

IV. Application Development:

I. The application is developed with a focus on user interaction and accessibility:

a) UI Construction: The Python tkinter module is utilized for crafting the user interface.

b) Speech Synthesis: The pyttsx3 module is integrated to facilitate text-to-speech conversion.

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V. Application Walkthrough:

a) Initial Prompt: Upon launch, the application vocalizes a welcome message and instructions for search initiation using sign language.

b) Gesture-Based Navigation: Users interact with the application through sign language gestures, with specific gestures assigned to functions like backspace and search initiation. The camera captures the user's hand gestures, translating each gesture of sign language into the corresponding letter in alphabet.

c) Search Interface: A dedicated search window captures letter inputs via sign language, and thumb gestures navigate through displayed URLs. Users can see the letters they have signed appear in a text box within the search window while there is an auditory feedback to the letter input. This feature ensures that users who are visually impaired can also use the application effectively.

IV. EXPERIMENTAL RESULTS

Performance: The language recognition model using random forest reaches 99.8214 %The sign language recognition model using the random forest achieved an accuracy of 99.8214%

Comparative analysis: The model implementation of other machine learning algorithms. the decision tree algorithm gave an accuracy of 99.6428% while support Vector Machine (SVM) gave an accuracy of 99.81% and stochastic Gradient Descent gave 76.7857% accuracy and K-Nearest Neighbours (KNN) gave a similar 99.821% of accuracy.

Random Forest classifier outperformed most other algorithms, with the exception of KNN, which showed comparable performance.

Limitations and Assumptions: Though the study uses various light conditions in image capture, yet it may not be suitable for scenarios where there are multiple people standing, as the model may try to capture the palm as input which is not intended. Additionally, the dataset could be expanded to include more gestures depiction words etc.

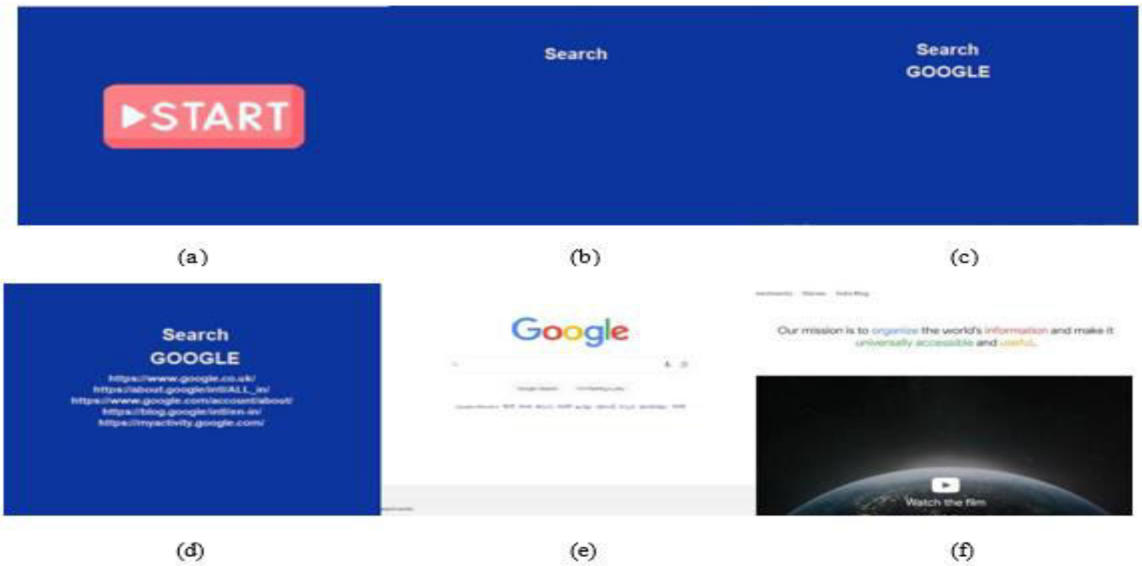

Fig. 3. Application flow (a) Start window of application (b) search window of application (c) search keyword entered (d) Url results given by search platform [4][5][6][7][8] (e) first selected url page [4](f) second selected url page [5]

Image (a) shows the start window of the application, providing options to begin a new project, load existing work, or access settings and help resources, all accessible through sign language commands. Image (b) displays the search window where users can input keywords or phrases to locate specific text within documents or images using sign

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language, featuring a search bar and options for refining search parameters. Image (c) presents the URL results generated by the search platform, listing relevant sources based on the user's query interpreted through sign language. Image (d) depicts the first selected URL page, which is displayed in a viewer within the application, allowing users to view and interact with the content directly through sign language commands. Finally, image (e) shows the second selected URL page, similarly presented in a viewer for users to examine and utilize the information provided using sign language.

V. CONCLUSION AND FUTURE SCOPE

In conclusion, the research project on sign language recognition has successfully demonstrated the feasibility and machine learning techniques effectiveness, particularly the Random Forest classifier, to interpret sign language gestures with a high Accuracy. The results, showcasing an accuracy rate of 99.8214%, underscore the potential of this technology as a valuable communication aid for individuals with speech and hearing impairments while the intuitive UI and gesture-based navigation facilitate a seamless user experience. This highlights the application of machine learning algorithms in creating more accessible communication tools.

Future directions for this sign language recognition project encompass a multi-faceted approach aimed at augmenting the system's accuracy, inclusivity, and user accessibility. Advancements in machine learning, deep learning majorly, are anticipated to significantly enhance gesture recognition capabilities. The incorporation of 3D modeling and motion capture technologies is expected to provide a richer interpretation of complex gestures. Expanding the dataset to include a broader spectrum of sign languages and non-manual signals will cater to a more diverse user base, promoting global inclusivity and dynamic gesture with movement. The implementation of user feedback loops will be crucial for continuous model refinement, ensuring the system evolves in alignment with user needs. The mobile application will extend the system's reach, providing users with the convenience of accessing the technology on handheld devices. Prioritizing data privacy and security will be essential, necessitating the adoption of advanced encryption and secure data handling practices. Lastly, the API creation may offer easy integration with platforms existing, thereby enhancing the system's utility and facilitating wider adoption.

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