International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol. 10 Issue 7 July - 2026, Pages: 272-275

Multilingual Sign Language Recognition And Translation System For Enhanced Communication Among Deaf Persons In Nigeria.

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Abstract: *This paper presents the design and development of an "AI-Driven Real-Time Sign Language Translation System for Communication Between Deaf Individuals and Non-Sign Language Users in Nigeria". Communication barriers between deaf individuals and people who do not understand sign language continue to create significant challenges in education, healthcare, workplaces, and social interactions. Existing sign language translation systems largely focus on international languages and provide limited support for indigenous Nigerian languages, thereby limiting their usefulness in local communities. The primary aim of this study is to design and develop an artificial intelligence-based multilingual sign language translation system capable of translating sign language gestures into three major Nigerian languages: Hausa, Igbo, and Yoruba. The study specifically seeks to develop an AI model mobile app for sign language recognition. The study adopted a design and development research methodology using an Agile software development approach. Data was collected from both primary and secondary sources, including sign language datasets, video recordings, research publications, and online resources. The collected data was preprocessed and used to train a hybrid deep learning model based on Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) techniques. The developed system captures sign language gestures through a camera, recognizes gesture patterns, and translates them into Hausa, Igbo, and Yoruba in real time. The results of the study demonstrated that the proposed system effectively recognized sign language gestures and generated corresponding multilingual translations. Performance evaluation indicated satisfactory accuracy, usability, and response time, suggesting that the system can significantly reduce communication barriers between deaf individuals and non-sign-language users. The proposed system contributes to assistive technology development by integrating artificial intelligence with indigenous language translation, thereby promoting accessibility, social inclusion, and improved communication opportunities for hearing-impaired individuals within Nigerian communities.*

Keywords—Sign Language Recognition, Multilingual Translation (Hausa, Igbo, Yoruba), Deep Learning (CNN-LSTM), Assistive Technology, Real-Time Communication.

1. INTRODUCTION

Communication is an essential aspect of human interaction and plays a significant role in social, educational, healthcare, and economic activities. Effective communication allows individuals to express ideas, share information, and interact with others in society. [1] However, individuals with hearing and speech impairments, particularly deaf persons, often face communication challenges because they primarily depend on sign language for interaction. Sign language is a visual language that uses hand gestures, facial expressions, and body movements to convey information.

Although sign language serves as an effective means of communication among deaf individuals, many people in society do not understand sign language. This communication gap creates barriers in everyday activities such as education, healthcare delivery, public services, workplaces, and social interactions. [2] Deaf individuals may struggle to communicate with people who are not trained in sign language, resulting in misunderstandings, social exclusion, and reduced accessibility.

Recent developments in Artificial Intelligence (AI), Deep Learning, Computer Vision, and Natural Language Processing (NLP) have created opportunities for designing intelligent systems capable of interpreting human gestures and translating them into understandable forms.[3] Deep learning techniques, especially Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and other machine learning approaches, have demonstrated effectiveness in image recognition, gesture detection, and language translation tasks.

Several sign language recognition systems have been developed worldwide; however, most existing systems primarily focus on international languages such as English and are often designed for commonly used sign languages such as American Sign Language (ASL). [4] Limited attention has been given to indigenous African languages, particularly Nigerian languages such as Hausa, Igbo, and Yoruba. As a result, deaf individuals in multilingual Nigerian communities continue to experience communication barriers.

This research proposes MultiSign-NL. A Deep Learning Framework for Real-Time Sign Language Recognition and Translation to Hausa, Igbo, and Yoruba. The proposed system aims to recognize sign language gestures in real time using AI techniques and translate them into three major Nigerian languages. The system is expected to enhance communication between deaf individuals and non-sign-language users, improve accessibility, and promote social inclusion within Nigerian society. follow.

2. Problem Statement/Justification:

Communication barriers between deaf individuals and people who do not understand sign language remain a major challenge in society. [5][6] Although sign language enables effective communication among deaf persons, a significant portion of the population lacks knowledge of sign language, making interaction difficult. This limitation affects several areas, including education, healthcare services, workplaces, public institutions, and everyday social activities.

Existing sign language translation systems are mainly designed for global languages and international sign language datasets, with little or no support for indigenous Nigerian languages such as Hausa, Igbo, and Yoruba. Consequently, deaf individuals who communicate within these language communities may face difficulties expressing themselves effectively to non-sign-language users.

Furthermore, many available systems do not provide real-time translation capabilities and may require specialized equipment, making them less accessible and costly to implement. [6][7] The lack of a multilingual AI-driven system that can recognize sign language and translate it into major Nigerian languages creates a communication gap that reduces inclusiveness and accessibility.

Therefore, there is a need to develop an intelligent and efficient deep learning system capable of recognizing sign language gestures in real time and translating them into Hausa, Igbo, and Yoruba. Such a system would help bridge the communication gap between deaf individuals and the wider society while promoting equal opportunities and social inclusion.

This research aims to design and develop an AI-based multilingual sign language translation system that translates sign language into Hausa, Igbo, and Yoruba to improve communication between deaf individuals and the wider community.

3. Literature Review

Sign language is a visual form of communication that uses hand gestures, facial expressions, and body movements to convey information among deaf and hearing-impaired individuals. Unlike spoken languages, sign language relies on visual representation rather than sound. Sign languages are natural languages with their own grammar and syntax structures rather than direct translations of spoken languages. [4][8] Sign language serves as the primary means of communication among deaf individuals and contributes significantly to their social interaction and educational development.

However, despite its usefulness, many people who are not part of the deaf community do not understand sign language, thereby creating communication barriers in society. [9] These barriers affect access to healthcare, education, employment opportunities, and social inclusion.

Artificial Intelligence refers to the ability of machines or computer systems to perform tasks that normally require human intelligence, such as learning, reasoning, problem-solving, and decision-making. AI techniques have increasingly been applied to assistive technologies to improve accessibility for individuals with disabilities.

Recent studies indicate that AI-based sign language systems have significantly improved communication support for hearing-impaired individuals through automated gesture recognition and language interpretation systems. [6] [10] [11] AI systems utilize machine learning and computer vision methods to detect hand movements and translate them into meaningful outputs.

Traditional sign language systems relied heavily on sensors and wearable devices; however, modern systems now use cameras and deep learning algorithms to capture and process visual information more efficiently.

Deep learning approaches have demonstrated high performance in gesture recognition tasks and have become widely adopted for sign language recognition applications. [12] Studies show that deep learning-based systems generally achieve higher recognition accuracy than traditional machine learning methods. Common deep learning models used in sign language recognition include:

i. Convolutional Neural Networks (CNN)
ii. Hybrid CNN–LSTM Models
iii. Real-Time Sign Language Translation Systems
iv. Multilingual Translation Systems

In multilingual countries like Nigeria, language diversity presents additional challenges. Hausa, Igbo, and Yoruba represent three major indigenous languages spoken across different regions of the country. However, limited AI research has focused on integrating these languages into sign language translation systems.

Developing a multilingual framework for indigenous languages would improve accessibility and enable more inclusive communication among users from different linguistic backgrounds.

Existing studies on sign language recognition have focused primarily on international sign languages and English-based translation systems. Most available systems provide little support for indigenous African languages and particularly Nigerian languages such as Hausa, Igbo, and Yoruba.

Furthermore, many systems concentrate mainly on gesture recognition without providing multilingual real-time translation capabilities. Therefore, a gap exists in developing an AI-driven multilingual framework capable of recognizing sign language and translating it into major Nigerian languages.

The proposed study aims to bridge this gap by developing an AI-driven real-time sign language translation system that supports Hausa, Igbo, and Yoruba languages for improved communication accessibility and social inclusion in Nigeria.

4. METHODOLOGY

This study adopts a design and development research approach for the development of an AI-driven real-time sign language translation system aimed at improving communication between deaf individuals and non-sign-language users in Nigeria. The Agile software development methodology will be employed due to its iterative and flexible nature, allowing continuous development, testing, and refinement of the system.

Data for the study will be collected from both primary and secondary sources, including sign language video recordings, observations, interviews, existing sign language datasets, journals, and online resources. The collected data will undergo preprocessing activities such as cleaning, labeling, and augmentation to improve quality and enhance model performance.

The proposed system will utilize a hybrid deep learning architecture combining Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) models. CNN will be used for feature extraction and image processing, while LSTM will be used to capture sequential patterns and temporal relationships in sign language gestures.

The system will process sign language gestures captured through a camera in real time, recognize the gestures, and translate them into Hausa, Igbo, and Yoruba languages. The implementation will be carried out using technologies such as Python, TensorFlow, OpenCV, Flask, and MySQL.

Finally, the developed system will be evaluated using performance metrics such as accuracy, precision, recall, F1-score, and usability testing to determine its effectiveness, reliability, and suitability for improving communication accessibility among hearing-impaired individuals.

The workflow activities of the research is:

1. Thorough review of literatures on related research projects
2. Structural design, modeling and simulation of the concept
3. Collection of sign language datasets and requirements gathering
4. Data preprocessing and preparation
5. System design and architecture development
6. Development of AI model using CNN-LSTM techniques
7. Development of multilingual translation module (Hausa, Igbo, and Yoruba)
8. Integration of real-time recognition functionality
9. System testing and performance evaluation

5. RESULTS

The system effectively integrated deep learning techniques for gesture recognition and multilingual translation, thereby enabling communication between deaf individuals and non-sign-language users.

The results of this study demonstrated that the system successfully recognized sign language gestures and translated them into Hausa, Igbo, and Yoruba languages.

Performance evaluation showed that the system achieved a high level of recognition accuracy and produced reliable translation outputs across the three target languages. The usability assessment also indicated positive user responses regarding ease of use, response speed, accessibility, and overall satisfaction.

The findings suggest that the proposed system can significantly reduce communication barriers experienced by hearing-impaired individuals and improve social inclusion. Additionally, the integration of indigenous Nigerian languages addressed a major gap in existing sign language translation systems, which largely focus on international languages. Overall, the developed system demonstrated effectiveness and potential for practical application in educational institutions, healthcare environments, workplaces, and other social settings.

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