Chapter 8
Deep Learning–Based Pakistan Sign Language Interpretation for Enhancing Communication for Individuals With Hearing Disabilities

Mehwish Raza
https://orcid.org/0000-0003-1778-6196
NED University of Engineering and Technology, Pakistan

Majida Kazmi
https://orcid.org/0000-0002-2767-3139
NED University of Engineering and Technology, Pakistan

Fauzia Yasir
https://orcid.org/0009-0004-2921-9046
NED University of Engineering and Technology, Pakistan

ABSTRACT

Sign language recognition is a critical area within computer vision and assistive technology, promoting inclusive communication for individuals with hearing impairments. While various international sign languages have been widely studied, Pakistan Sign Language (PSL) remains underexplored. This chapter, per the authors, presents

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a real-time PSL recognition system using the YOLOv5 object detection framework. A custom dataset of 3,963 images, augmented to 9,522 using rotation, noise addition, and exposure adjustment, was developed using hand signs from students at the Ida Rieu School for the Blind and Deaf. The model achieved an accuracy of 94.67%, outperforming previous PSL systems in static sign classification. Comparative analysis shows improved generalization in real world conditions, particularly with complex backgrounds and partial occlusions. Unlike earlier approaches limited to controlled environments, this system demonstrates practical applicability in educational contexts. Future work includes optimizing for low-power edge deployment and dynamic sign recognition.

1. INTRODUCTION

Effective communication is central to human interaction, yet individuals with hearing impairments often face significant barriers in accessing this fundamental right. Sign languages serve as the primary mode of expression for the deaf community, employing visual-manual modalities to convey complex linguistic constructs. However, the lack of widespread knowledge of sign languages among the general population significantly limits the social inclusion and mobility of hearing-impaired individuals (ADCET, 2025). Globally, over 466 million individuals live with disabling hearing loss (a figure projected to rise to 900 million by 2050) (Mirza et al., 2022).

In Pakistan, where over 1.25 million people experience varying degrees of hearing loss (Pakistan Bureau of Statistics, 2021), Pakistan Sign Language (PSL) remains the principal form of communication within the deaf community. While PSL serves as the primary communication medium for this community, the general population's limited familiarity with PSL creates an isolation that extends far beyond simple conversation, affecting education, employment opportunities, healthcare access, and civic participation (Bae, 2023).

The emergence of artificial intelligence and deep learning technologies offers unprecedented opportunities to bridge this communication divide. Computer vision systems, particularly those employing Convolutional Neural Networks (CNNs) and object detection frameworks like YOLO (You Only Look Once) (Redmon & Farhadi, 2018) (Tyagi et al., 2023) have demonstrated remarkable success in visual recognition tasks. However, the majority of research in sign language recognition has focused on American Sign Language (ASL) and British Sign Language (BSL), very few studies have addressed PSL. Furthermore, the limited existing research on PSL often lacks real-world validation, which is crucial for practical deployment and long-term usability.