Chapter 5
Natural Language Speech Processing Integrating Assistive Technologies for Human-Computer Interaction

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ABSTRACT

Natural Language Speech Processing (NLSP) is a fundamental space of consider that centers on the interaction between people and machines through talked dialect. The integration of assistive innovations in this field points to bridge communication holes and upgrade availability for people with inabilities. This chapter investigates the advancing scene of NLSP, emphasizing its part in progressing Human-Computer Interaction (HCI) by empowering consistent communication between clients and computers through voice acknowledgment, blend, and common dialect understanding. Assistive innovations such as speech-to-text, text-to-speech, and voice-controlled frameworks are changing every day intelligent for people with hearing, discourse, and engine impedances, giving them with upgraded independence and interaction conceivable outcomes. The integration of machine learning and profound learning calculations has quickened progressions in discourse acknowledgment precision, enthusiastic tone examination, and context-driven dialect preparing.

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I. INTRODUCTION

The evolution of Human-Computer Interaction (HCI) has consistently aimed to create more seamless and intuitive communication between users and technology. From early punch cards to modern touchscreens, the goal has always been to bridge the gap between human intent and machine comprehension (Averbukh, 2020; Grudin, 2017). In this pursuit, Natural Language Speech Processing (NLSP) has emerged as a transformative force, particularly when integrated with assistive technologies. This synergy promises to revolutionize how individuals, especially those with disabilities, interact with the digital world (Emara, 2018; Emara et al., 2025b).

At its core, NLSP is the interdisciplinary field that enables computers to understand, interpret, and generate human speech (Rao et al., 2020; Tan et al., 2021). It encompasses a wide range of tasks, including automatic speech recognition (ASR), natural language understanding (NLU), and text-to-speech (TTS) synthesis. ASR converts spoken language into text, NLU extracts meaning from that text, and TTS transforms text back into spoken words (Tan et al., 2021; Peng et al., 2025). The development and deployment of these systems depend heavily on scalable data pipelines and distributed processing frameworks, which have been explored in recent work on geographically distributed data management and data processing algorithms (Emara et al., 2023; Emara et al., 2025c). Furthermore, methods for feature selection and hybrid paradigms for high-dimensional data provide useful tools for handling rich speech representations (NguyenDuc et al., 2025; VuThi et al., 2024).

For individuals with visual disabilities, NLSP provides a powerful gateway to information and control. Screen readers and voice interfaces, when combined with richer NLU, can support non-linear navigation and context-aware summarization; such capabilities rely on robust data handling and model adaptation techniques that are discussed in the literature on distributed data systems and adaptive algorithms (Emara & Huang, 2019a; Emara & Huang, 2019b). These approaches help ensure that assistive systems can scale to large vocabularies and diverse content sources. Recent systems that generate context-aware visual descriptions and richer screen-reader experiences demonstrate how adaptive summarization and structured navigation improve access to complex content for blind and low-vision users (Chang et al., 2024; Zong et al., 2022; Bakeer, 2024).

Similarly, people with motor disabilities can benefit substantially from NLSP-enabled assistive technologies. Traditional input methods like keyboards and mice can be challenging or impossible for these users; voice control systems and speech-driven workflows enable dictation, device control, and environment interaction (Mulfari et al., 2023; Qian et al., 2023). Practical deployment of such systems — including on constrained or edge devices and in real-time scenarios — is informed by research on power-saving mechanisms, stratified block processing, and lightweight processing