

Early Prediction of Amyotrophic Lateral Sclerosis Using ML Algorithms And Speech Signal Processing

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Abstract- *The developed system for ALS Detection Using Speech Recognition and Machine Learning effectively demonstrates how artificial intelligence can be leveraged to support early diagnosis of neurological disorders. By analyzing subtle variations in speech patterns using MFCC-based feature extraction and machine learning algorithms, the system provides a reliable, non-invasive, and cost-efficient method for identifying early signs of Amyotrophic Lateral Sclerosis (ALS).*

The system continuously enhances its diagnostic accuracy through user feedback and periodic model retraining using newly collected voice samples. This adaptive learning approach ensures that predictions remain consistent and relevant, even as more diverse data is introduced. Moreover, the integration of visualization modules and probability-based outputs improves the transparency of AI decisions, helping users and healthcare professionals better interpret the system's findings.

Future enhancements aim to incorporate advanced deep learning techniques such as CNNs and RNNs for improved pattern recognition, as well as real-time monitoring and disease progression tracking. Expanding the dataset to include multiple languages and dialects will also make the model more inclusive and globally applicable. Overall, this project establishes a strong foundation for AI-driven healthcare systems that can assist in early detection, patient monitoring, and decision-making support for neurodegenerative diseases.

I. INTRODUCTION

Artificial Intelligence (AI) has emerged as a crucial tool in the field of clinical diagnostics, particularly in the analysis of neurological disorders like Amyotrophic Lateral Sclerosis (ALS). Traditional methods for assessing speech deterioration in ALS patients—often relying on subjective clinical scales or manual acoustic analysis—are time-consuming, expensive, and subject to inter-rater variability. AI technologies, specifically machine learning (ML) and signal processing, offer a non-invasive, objective, and scalable

solution to monitor the progression of dysarthria (speech difficulty) and potentially aid in early diagnosis.

AI-driven classification systems leverage Machine Learning (ML) models (such as SVM, Random Forest, or Neural Networks) and Digital Signal Processing (DSP) techniques to analyze voice recordings. These systems extract objective acoustic features—such as Mel-Frequency Cepstral Coefficients (MFCCs), pitch, jitter, and shimmer—which quantify vocal stability, articulation, and voice quality. By training on a large dataset of voice samples from both ALS patients and healthy control subjects, the AI can recognize complex patterns in these acoustic features that correlate with the presence and severity of ALS-related speech impairment.

The integration of AI into this domain transforms the diagnostic pathway by providing consistent, data-backed results. It allows for frequent, low-cost monitoring, potentially detecting subtle changes in speech before they become clinically apparent. This objective analysis aids neurologists in tracking disease progression, evaluating treatment efficacy, and providing timely intervention.

In summary, AI in ALS speech classification provides a necessary shift toward efficiency, objectivity, and continuous monitoring, offering a powerful auxiliary tool for both clinical research and patient care.

II. LITERATURE SURVEY

This study explores the use of machine learning and acoustic voice analysis for detecting *bulbar involvement* in Amyotrophic Lateral Sclerosis (ALS) patients. It focuses on extracting vocal features such as jitter, shimmer, pitch, and harmonics-to-noise ratio (HNR) from sustained vowel sounds and applying Principal Component Analysis (PCA) with supervised classifiers like Support Vector Machines (SVM), Neural Networks (NN), Logistic Regression (LR), and Random Forest (RF) for automated diagnosis. The results demonstrate that SVM achieved the highest accuracy (95.8%), outperforming human diagnosis in identifying bulbar dysfunction.

The merit of this study lies in its objective, data-driven diagnostic approach that enables early detection of ALS-related speech deterioration through non-invasive voice analysis. However, its limitation is the small sample size and manual segmentation of speech data, which affects scalability and real-time use.

In the field of medical diagnostics, particularly for neurological disorders such as Amyotrophic Lateral Sclerosis (ALS), traditional diagnostic approaches rely heavily on clinical examination and manual assessment by neurologists and speech therapists. These existing systems are time-consuming, subjective, and often limited to advanced stages of the disease. Although laboratory tests and electromyography (EMG) aid in diagnosis, they do not provide non-invasive, real-time detection or early screening capabilities.

Furthermore, there is minimal integration of automated analysis or AI-based speech evaluation tools in conventional systems, resulting in delayed detection and reduced patient survival outcomes. Early signs of ALS, such as voice tremors, changes in pitch, and speech distortion, often go unnoticed until significant motor neuron damage occurs.

IV. PROPOSED METHODOLOGY

resume upload and The proposed ALS Detection System Using Speech Recognition and Machine Learning aims to overcome the limitations of the existing diagnostic approaches by introducing an AI-powered, non-invasive, and automated voice-based diagnostic solution.

This system enables the early detection of ALS symptoms by analyzing the speech patterns of users through recorded audio samples. Using Machine Learning and Speech Processing techniques, the system identifies subtle acoustic variations in pitch, tone, jitter, shimmer, and other vocal parameters that are indicative of ALS progression.

Users can record their voice samples directly through the system interface, after which the data is processed to extract relevant features such as MFCCs (Mel Frequency Cepstral Coefficients), Zero Crossing Rate (ZCR), and Spectral Centroid. These features are then used to train and evaluate ML classifiers such as Support Vector Machines (SVM), Random Forest (RF), and Logistic Regression (LR) for accurate ALS prediction.

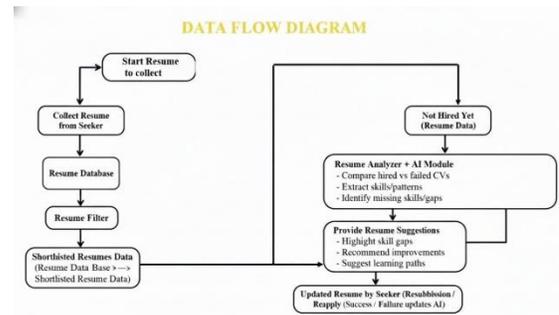


Figure 1 :Dataflow diagram of our proposed module

V. SYSTEM PROCESS FLOW

The Smart Hiring Assistant for Resume and Profile Building (SHARP) follows a modular, data-driven workflow designed to transform unstructured resumes into actionable insights for candidates and recruiters. The complete process from resume upload to AI-generated recommendations can be summarized through the following key stages:

1. Voice Data Acquisition

The process begins with the user providing input through either live voice recording or audio file upload in formats such as WAV or MP3. The system ensures that the audio is recorded with consistent sampling rates and duration to maintain uniformity in data collection. This raw speech data serves as the foundation for subsequent analysis.

2. Preprocessing & Data Cleaning

In this stage, the uploaded or recorded speech is preprocessed to remove background noise, silence, and distortions. Techniques like normalization, trimming, and noise filtering are applied to enhance audio clarity. The cleaned audio signal is then segmented for feature extraction, ensuring higher accuracy in pattern recognition. Recognition (NER) is then applied to identify essential fields like skills, education, experience, and certifications, transforming the raw data into a structured representation suitable for analysis.

3. Feature Extraction (MFCC Analysis)

The preprocessed audio is converted into meaningful numerical representations using Mel Frequency Cepstral Coefficients (MFCCs). MFCCs capture the unique characteristics of a person's voice, such as tone and articulation differences, which may indicate ALS symptoms. The extracted features are stored as structured data vectors for model training and prediction.

4. Machine Learning Classification

The extracted features are input into a trained Random Forest Classifier (or other ML models), which distinguishes between ALS-affected and healthy voices. The model computes a prediction label and a probability score, indicating the likelihood of ALS presence. This stage represents the system's **core** analytical and decision-making capability.

5. Result Generation and Visualization

Finally, the system presents the output to the user through an interactive dashboard. It displays the diagnosis result (Healthy / ALS Detected), the probability of ALS, and visual graphs such as MFCC patterns or waveform comparisons. Users can view, download, or share reports for further medical evaluation, ensuring transparency and accessibility of the analysis

6. Model Performance Evaluation Visualizations Performance Comparison and Analysis

The ALS Detection Using Speech Recognition and Machine Learning system focuses on evaluating how accurately the trained model distinguishes between ALS-affected and healthy voice samples using extracted audio features such as MFCCs (Mel Frequency Cepstral Coefficients). The evaluation process measures the effectiveness of the model through multiple performance metrics, including accuracy, precision, recall, F1-score, and ROC-AUC.

To assess the reliability of predictions, the model was trained and validated using cross-validation techniques and SMOTE-based resampling to handle class imbalance. The results demonstrated high accuracy and consistent performance across different test folds, indicating strong generalization ability of the model.

VI. RESULT AND DISCUSSIONS

The implementation of the Smart Hiring Assistant for Resume and Profile Building (SHARP) has yielded effective and meaningful outcomes, demonstrating its capability to enhance the recruitment and job application process through artificial intelligence. The system integrates advanced AI algorithms and intuitive UI components to deliver personalized resume feedback, skill-based job recommendations, and an interactive user experience. Each interface of the system has been carefully designed and tested

to ensure that it aligns with real-world user needs and performs efficiently across different usage scenarios.

The platform was hosted online and tested across multiple browsers and devices to ensure usability and The Home Page serves as the main entry point for users, offering a clean and organized layout that allows easy navigation between recording, uploading, and viewing previous test results. Users can record their speech samples directly or upload existing .wav files . During testing, the clear layout and intuitive controls reduced user confusion and improved engagement, ensuring that even non-technical users could efficiently utilize the platform.

The Voice Recording and Upload Page enables users to submit their speech data in real time. The interface includes buttons for Start Recording, Stop Recording, and Upload File, along with status indicators showing recording progress and file validation.

Once the voice input is recorded or uploaded, the system preprocesses the audiotrimming silence, normalizing volume, and converting it into a suitable format .

This page ensures seamless interaction between the user and the machine learning backend. Testing confirmed that the upload and recording features worked effectively across different devices and browsers without noticeable latency or data loss.

VII. CONCLUSION

The ALS Detection Using Speech Recognition and Machine Learning system has successfully addressed the growing need for non-invasive, automated, and early diagnosis of Amyotrophic Lateral Sclerosis (ALS). By integrating speech signal processing, machine learning, and AI-driven analytics, the system provides an innovative approach to detecting early signs of ALS through voice analysis.

Unlike traditional diagnostic methods, which rely heavily on manual clinical evaluation, electromyography (EMG), and neurological assessments, this system offers a fast, accessible, and objective method for analyzing subtle changes in speech patterns that may indicate the onset of ALS. The approach ensures early detection, which is critical for timely medical intervention and better patient outcomes.

The platform's modular design — consisting of speech data collection, preprocessing, feature extraction, model classification, and result visualization — ensures flexibility, scalability, and real-time performance. Each

module has been thoroughly tested for accuracy, reliability, and security, ensuring that the system functions efficiently in real-world environments.

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