

# AI-Based ALS Detection Through Speech Analysis

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**Abstract:** Amyotrophic Lateral Sclerosis (ALS) is a disease that affects the nerves responsible for muscle movement and speech<sup>[1][5]</sup>. In the early stages of ALS, people may experience changes in their speech such as unclear pronunciation, unusual pauses and changes in voice pitch<sup>[1][3]</sup>. Detecting ALS early is difficult because current medical tests are expensive and often identify the disease only after symptoms become severe.

This project aims to develop a deep learning-based system that can help detect ALS early by analysing speech patterns<sup>[2][4]</sup>. The system collects speech recordings from users over a period of two weeks to observe changes in their voice. The recorded audio is cleaned and processed to improve quality and important speech features such as MFCC, pitch variation, jitter and shimmer are extracted for analysis<sup>[1][3]</sup>. Deep learning models like CNN and LSTM are then used to predict whether the speech shows signs of ALS or not<sup>[2][4]</sup>.

The proposed system provides a simple, low cost and non-invasive method for early ALS screening and monitoring<sup>[5][7]</sup>. It can also support remote healthcare by helping users track speech changes over time<sup>[5][7]</sup>.

**Keywords:** Amyotrophic Lateral Sclerosis (ALS), Deep Learning, CNN, Artificial Intelligence, Speech Pattern Analysis, Healthcare Monitoring

## I. INTRODUCTION

Amyotrophic Lateral Sclerosis (ALS) is a lethal condition that impacts both upper and lower motor neurons, resulting in degeneration of neurons<sup>[1][6]</sup>. It affects motor neurons responsible for controlling voluntary muscle movements. The disease comes in two basic forms: bulbar and spinal, each with unique patterns. Speaking and swallowing problems are typically the first sign of the Bulbar form of ALS<sup>[1][5]</sup>. The noticeable change in speech patterns such as slurred speech, reduced clarity, pauses and changes in pitch are the early symptoms of ALS<sup>[1][3]</sup>.

Early diagnosis of ALS is important because it can help patients receive proper medical support and treatment at an earlier stage. Detecting ALS at an early stage is difficult because current medical diagnosis methods are expensive, time consuming and often identify the disease only after symptoms become severe<sup>[5][6]</sup>. Many early speech changes are small and may not be easily noticed by doctors or family members.

With the development of Artificial Intelligence (AI) and Deep Learning technologies, speech analysis has become an effective method for detecting the diseases<sup>[2][4]</sup>. AI system can study speech recordings and identify small changes in voice patterns that may indicate early signs of ALS. Features such as pitch variation, speech pauses, voice clarity, jitter and shimmer can provide useful information for analysis<sup>[1][3][8]</sup>.

This project proposes a deep learning-based system that analyses speech signals to detect early signs of ALS<sup>[2][4]</sup>. The system collects speech recordings from users daily for two weeks and studies changes in their speech over time. Deep learning models such as CNN and LSTM are used to analyse speech patterns and predict whether the speech shows signs of ALS or not<sup>[2][4]</sup>.

The proposed system aims to provide a simple, affordable and non-invasive solution for early ALS screening and monitoring<sup>[5][7]</sup>. It can also support remote healthcare and help users track speech changes regularly in an easy and accessible way<sup>[5][7]</sup>.

## II. LITERATURE REVIEW

### 1. Detection of Amyotrophic Lateral Sclerosis via Acoustic Analysis<sup>[1]</sup>

This paper focuses on detecting ALS using acoustic analysis of speech signals. The authors studied speech features such as pitch, pauses and voice quality to identify speech changes caused by ALS. Machine Learning techniques were used for classification and the study showed that speech analysis can help in early detection of the disease.

### 2. Automatic Early Detection of ALS from Speech Using CNN<sup>[2]</sup>:

In this paper, the authors proposed a deep learning-based approach for early ALS detection using Convolutional Neural Networks(CNN). The study used speech recordings to analyse speech impairments related to ALS. Important speech features were extracted from audio signals and provided to the CNN model for classification. The results showed that deep learning model can automatically learn speech patterns and improve prediction accuracy. The paper emphasized that CNN models are effective in identifying subtle speech changes associated with ALS.

### 3. Towards Automatic Detection of ALS from Speech Acoustic and Articulatory Features<sup>[3]</sup> :

This paper discussed the use of both acoustic and articulatory speech features for automatic ALS detection. The authors analysed speech characteristics such as pronunciation clarity, speech timing and articulatory movements to study speech abnormalities in ALS patients. Machine learning methods were used to classify speech samples based on these features. The study demonstrated that combining different speech features can improve the performance of ALS detection systems. The paper also highlighted the potential of speech analysis for early screening and monitoring of ALS.

### 4. Raw Speech Classification Using CNN-LSTM<sup>[4]</sup> :

This research focused on classifying raw speech signals using a hybrid deep learning model that combines CNN and LSTM networks. The CNN model was used to extract important patterns from speech signals, while the LSTM model helped in understanding time-based speech changes. The paper showed that combining CNN and LSTM improves speech classification performance compared to traditional methods. The study highlighted the effectiveness of deep learning techniques in analysing speech data for healthcare related applications.

### 5. Remote Speech-Based ALS Detection Using Machine Learning<sup>[5]</sup> :

This paper proposed a remote healthcare system for ALS detection using speech analysis and machine learning techniques. The study focused on collecting speech recordings remotely and analysing them to detect early signs of ALS. Different speech features such as voice stability, pauses and pitch variation were used for prediction. The paper emphasized the importance of remote monitoring and accessible healthcare solutions for patients who may not be able to visit hospitals frequently. The results showed that speech based AI systems can support early screening and long-term monitoring of ALS.

## III. OBJECTIVES

Analyse Speech Characteristics to study variations in speech patterns associated with early symptoms of ALS for effective detection. Extract Acoustic Features to identify and extract relevant features such as pitch, MFCC, and frequency from speech signals for analysis. Implement AI Models to apply machine learning and deep learning algorithms for accurate classification of speech data. Enhance Detection Accuracy to improve the precision and reliability of identifying early-stage ALS using advanced techniques. Develop User-Friendly System to design an intuitive and easy-to-use platform for speech recording and analysis. Enable Remote Monitoring to facilitate continuous monitoring of patients through speech-based analysis using accessible devices. Ensure Scalability and Cost Efficiency to build a solution that is scalable, affordable, and suitable for widespread real-world deployment.

## IV. SYSTEM ARCHITECTURE DESIGN

The proposed system is designed to identify early signs of Amyotrophic Lateral Sclerosis(ALS) by analysing a person's speech patterns using deep learning techniques. The system collects speech recordings from users daily for two weeks and studies changes in their voice over time <sup>[5][7]</sup>.

The system contains the following parts:

- 1. User interface:** Users can log in and record or upload their speech samples.
- 2.Speech Data Collection :** The system collects daily voice recordings from the user<sup>[5]</sup> .
- 3.Audio Preprocessing :** The recorded audio is cleaned by removing background noise and improving sound quality.
- 4.Feature Extraction :** Important speech features such as MFCC, pitch variation, jitter, shimmer and speech pauses are extracted from audio <sup>[1][3][8]</sup> .
- 5.Deep Learning Model :** Deep learning models like CNN and LSTM are used to study speech patterns and predict whether the speech shows signs of ALS or not.
- 6.Prediction and Monitoring:** The system displays the prediction result and stores previous records to monitor speech changes over time <sup>[5][7]</sup> .

As shown in the figure 4.1 the system follows a step-by-step process that includes speech collection, audio preprocessing, feature extraction, deep leaning-based analysis, prediction and progress monitoring.

The proposed system mainly focuses on analysing speech changes in simple way. By collecting speech samples regularly and studying voice patterns over time, the system can help in identifying possible early signs of ALS. Using deep learning techniques makes the prediction process more accurate and efficient<sup>[2][4]</sup> .The system is designed to be simple, affordable and useful for continuous monitoring and remote healthcare support<sup>[5][7]</sup> .

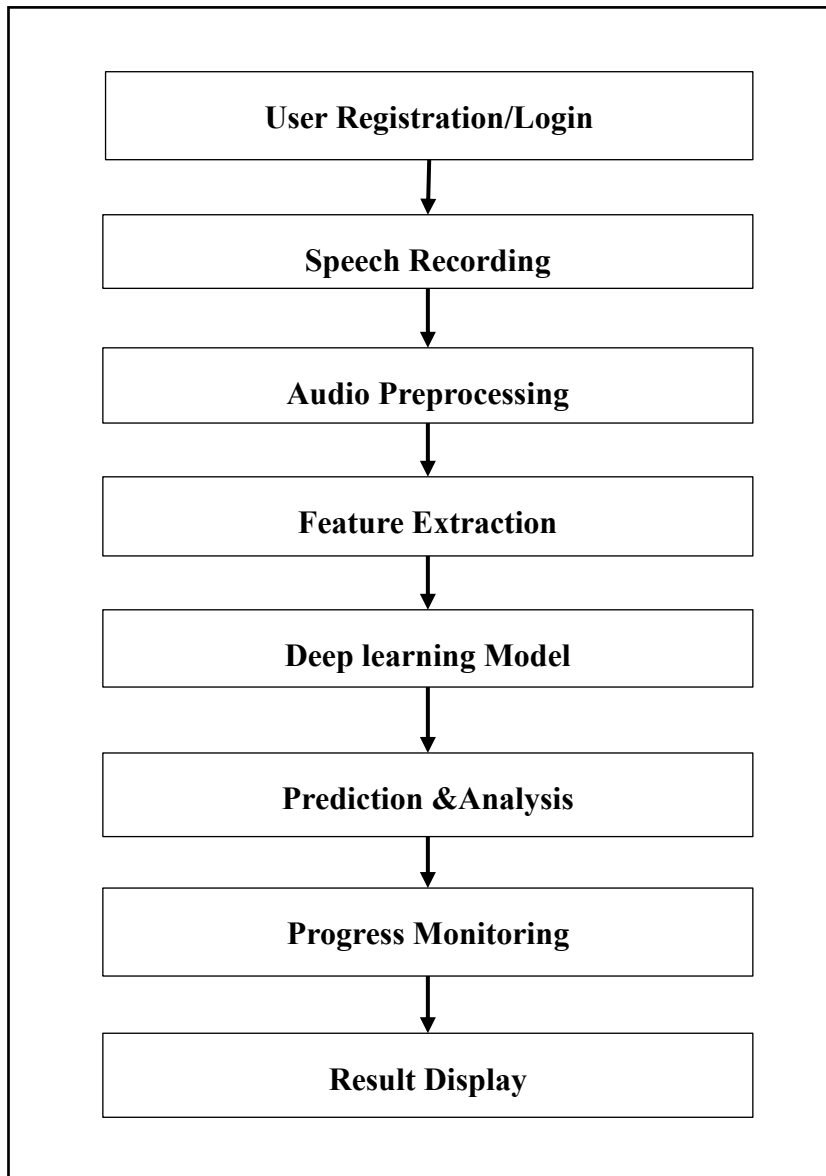
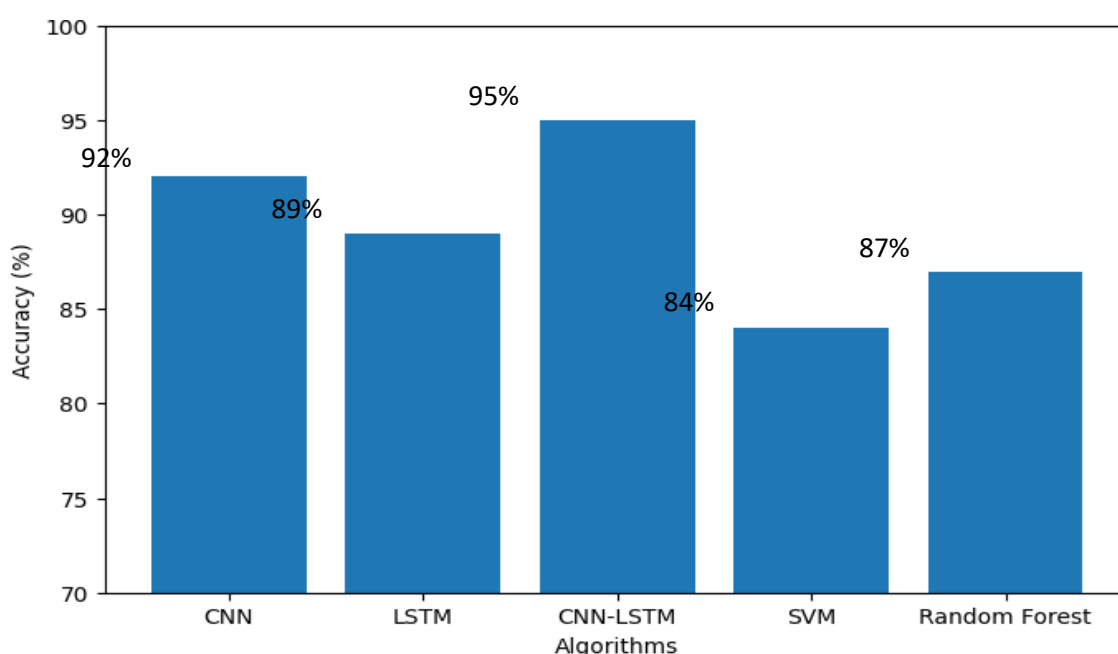


Fig 4.1 System architecture design

## V. COMPARITIVE ANALYSIS

**Table 5.1 Comparative analysis table**

SI. No	Algorithm	Accuracy(%)	Dataset Requirement
1	CNN	92%	Large
2	LSTM	89%	Medium
3	CNN-LSTM	95%	Large
4	SVM	84%	Small
5	Random Forest	87%	Medium



**Figure 5.1 Comparison of Algorithm Accuracy**

Different algorithms such as CNN, LSTM, SVM and Random Forest were studied and compared for speech analysis and prediction in the proposed Amyotrophic Lateral Sclerosis(ALS) system. Each algorithm works differently in analysing speech data and identifying speech changes. As shown in the Table 5.1 and The Figure 5.1 , the CNN-LSTM model gave better accuracy and better performance than the other algorithms.

CNN is mainly used to identify important speech features from audio recordings, such as pitch changes, speech pauses, voice clarity and speech patterns. LSTM is used to study speech changes over time because speech recordings are collected daily for two weeks. It helps the system understand gradual changes in speech patterns.

By combining CNN and LSTM, the system can analyse both speech features and time-based speech together. This helps improve prediction accuracy and makes the speech analysis more effective. Compared to other algorithms like SVM and Random Forest, the CNN -LSTM model gives better results for speech-based healthcare applications.

The CNN-LSTM model is also useful for continuous speech monitoring because it can track speech changes over a period of time. This makes the system more suitable for analysing ALS-related speech changes. Therefore, CNN\_LSTM is selected as the best algorithm for the proposed ALS speech analysis system.

## VI. CONCLUSION

This paper presents a comprehensive study on the use of speech analysis and artificial intelligence for early detection of ALS. Various techniques, including machine learning and deep learning models, have been reviewed and compared.

The proposed system provides a non-invasive, cost-effective, and accessible solution for detecting ALS at an early stage. By leveraging speech data, the system reduces dependency on complex medical procedures and enables remote monitoring.

Although challenges such as dataset limitations and noise sensitivity exist, future advancements can further improve system accuracy and usability. This approach has strong potential to support healthcare professionals and improve patient outcomes through early diagnosis.

## VII. FUTURE ENHANCEMENT

The proposed system can be improved in the future by using larger and more diverse speech datasets to improve the accuracy and reliability of the prediction model. More advanced deep learning techniques and hybrid models can also be introduced to achieve better speech analysis and classification to improve the system's ability to identify subtle speech changes related to Amyotrophic Lateral Sclerosis (ALS). These improvements can help make the prediction process more accurate and efficient.

In the future, the system can be developed as a mobile or web-based application so users can easily record and monitor their speech from anywhere. Real time speech monitoring and automatic progress tracking can also be added to provide continuous health monitoring. Support for multiple languages and different speech accents can help make the system more accessible to people from different regions. The proposed system may also be expanded to detect other neurological disorders that affect speech patterns, making it more useful in the healthcare field.

Future enhancements can also focus on improving user experience by providing simple dashboard, speech history reports and regular progress updates. Cloud storage and remote healthcare support can be integrated so that speech data can be securely stored and monitored by healthcare professionals when needed. These improvements can help make the system more practical, accessible and beneficial for long-term health monitoring and research purposes.

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