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Original Article

AI-Based Stuttering Therapy and Improvement System

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Abstract

Stuttering affects several dimensions of human life, including speech quality, self-perception, academic participation, and social interaction. Typical symptoms include sound repetitions, prolongations, and silent blocks, all of which can increase stress and make everyday communication difficult. Although speech therapy is an effective intervention, it often involves high cost, limited access to trained specialists, and difficulty in sustaining guided self-practice.

To address these limitations, this paper presents an AI-based stuttering therapy and improvement system that uses artificial intelligence and machine learning to analyze speech patterns in real time. The proposed system evaluates pronunciation, fluency, speech rate, pauses, and repetitions using speech recognition and intelligent analysis techniques. It then provides real-time feedback, personalized therapy recommendations, and structured daily practice sessions for both children and adults. By improving accessibility, affordability, and consistency of practice, the system aims to help users communicate more fluently and confidently.

Introduction

Speech is one of the primary means through which human beings express ideas, thoughts, and emotions. When fluency and naturalness in speaking are disrupted, an individual may experience reduced confidence, weaker academic performance, and difficulty in interpersonal communication. Stuttering, also known as dysfluency, is a speech fluency disorder character¬ized by involuntary repetitions, prolongations, and blocks. It affects millions of people worldwide, especially children and adolescents, and may persist into adulthood if not properly managed.

Traditional approaches to stuttering treatment generally in¬volve repeated one-on-one therapy sessions with a speech-language pathologist and regular guided exercises. While these methods can be effective, they demand time, sustained commitment, and frequent access to professional support. Such requirements may limit their availability and long-term practicality for many users.

Recent progress in artificial intelligence (AI) and speech recognition has created new opportunities for automated speech assessment. Modern AI systems can analyze sound patterns with high accuracy and identify features related to fluency, pause behavior, articulation, and repetition. These advances make it possible to design intelligent therapy systems that provide immediate feedback and personalized practice routines.

This paper presents an AI-based stuttering therapy and improvement system designed to analyze speech, detect dys¬fluency patterns, and generate therapy support adapted to the needs of each user. The system aims to improve accessibil¬ity, personalization, and effectiveness in speech therapy by combining speech processing, machine learning, and progress monitoring in a unified platform.

Literature Survey

Stuttering has long been studied in the fields of speech pathology, linguistics, and signal processing because of its significant influence on communication and quality of life. Early research primarily focused on clinical and behavioral approaches in which speech-language pathologists manually analyzed speech and applied therapies such as slow speech training, breathing control, and repetition exercises. Although these methods showed partial success, they were highly de-pendent on professional expertise and subjective evaluation.

With the advancement of digital signal processing, re-searchers began exploring computational methods for the analysis of speech disorders. Initial work concentrated on acoustic parameters such as pause duration, pitch variation, speaking rate, and signal energy

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to distinguish fluent from disfluent speech. These approaches improved objectivity, but they still depended heavily on hand-crafted features and rule-based classification.

Machine learning later improved the field by enabling data-driven detection of stuttering patterns. Classifiers such as Support Vector Machines (SVM), k-Nearest Neighbors (k-NN), and Hidden Markov Models (HMM) were employed to separate fluent and disfluent speech segments. These mod¬els relied on extracted speech features to detect repetitions, prolongations, and other dysfluency events. However, perfor¬mance depended strongly on the size and quality of the training data.

Mel-Frequency Cepstral Coefficients (MFCCs) became es¬pecially important in computational speech analysis because they represent characteristics that align well with human auditory perception. Prior work showed that MFCC-based systems improved stuttering detection accuracy compared with basic acoustic parameters alone. Even so, many such systems were limited to offline analysis and did not provide interactive user feedback.

More recently, deep learning methods such as Deep Neural Networks (DNNs), Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and Long Short-Term Memory (LSTM) networks have been applied to speech dis¬order analysis. CNNs are effective for identifying patterns in spectrograms, while RNNs and LSTMs are better suited to modeling temporal dependencies in speech. These methods have improved classification accuracy but generally require large labeled datasets and substantial computational resources. Researchers have also examined auditory feedback methods such as Delayed Auditory Feedback (DAF) and Frequency Altered Feedback (FAF) for improving speech fluency. Studies suggest that such methods can support therapy when combined with guided speaking exercises. However, many of the available tools are not sufficiently adaptive or personalized.

Mobile and web-based speech therapy applications have expanded accessibility by offering recording, playback, and predefined exercises. While helpful, many of these applica¬tions still lack detailed speech analysis, automated dysfluency detection, real-time feedback, and robust progress tracking. Therefore, there remains a need for an integrated AI-based system that combines detection, personalization, therapy sup¬port, feedback, and long-term monitoring in a single platform.

Proposed Work

The proposed AI-based stuttering therapy and improve-ment system is designed to help individuals who stutter by identifying speech patterns, evaluating fluency, and delivering adaptive therapy guidance. It integrates speech processing, artificial intelligence, machine learning, and conventional ther¬apy principles to create a real-time and user-friendly solution for speech improvement.

User Input and Speech Recording

The process begins with user speech acquisition through a microphone in a web or mobile application. Users can perform guided activities such as reading passages, repetition drills, and spontaneous speaking tasks. The recorded speech serves as the primary input for subsequent processing and provides data for both immediate analysis and long-term progress tracking.

Speech Processing Module

Once speech is captured, it is passed to the speech pro-cessing module. This stage performs essential preprocessing and analysis, including Automatic Speech Recognition (ASR), stuttering detection, and fluency measurement.

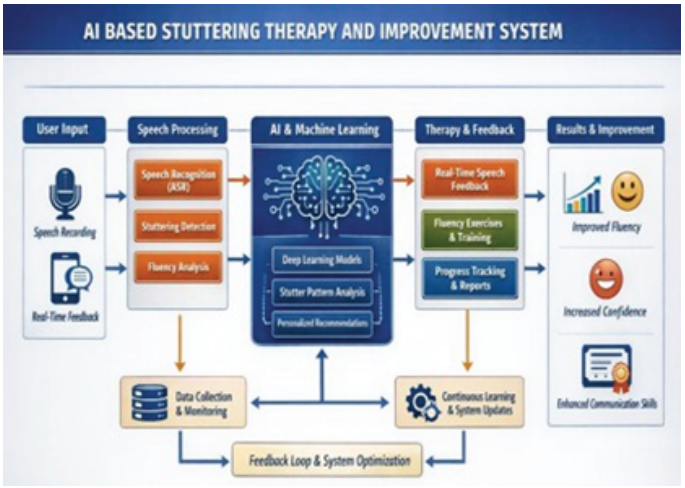

Figure 1. *System architecture.*

ASR converts spoken language into text, enabling additional linguistic analysis. Stuttering detection identifies common dys¬fluency events such as repetitions, prolongations, and abnor¬mal pauses. Fluency analysis evaluates speaking rate, pause duration, and rhythm to compute an overall fluency score. These operations transform raw speech into structured features suitable for AI-driven interpretation.

AI and Machine Learning Module

The core intelligence of the system lies in its AI and machine learning module. Deep learning models trained on labeled speech datasets are used to identify stuttering patterns and separate fluent from disfluent speech segments.

The model analyzes the frequency and type of disfluen-cies present in a user's speech. Based on this analysis, the system generates personalized recommendations and adapts the therapy process according to the user's observed speech behavior. This data-driven approach offers greater flexibility and personalization than conventional rule-based systems.

Therapy and Feedback Module

After analysis, the system activates a therapy and feedback module that provides real-time guidance. Users are given targeted exercises such as controlled breathing, slow speech practice, syllable repetition, and pronunciation drills.

The difficulty and type of exercises are adjusted dynamically based on user performance and detected stuttering severity. The system also provides progress reports so that users can monitor changes in fluency over time. Real-time and person¬alized feedback helps maintain user engagement and supports more consistent practice.

Results and Improvement Analysis

The system evaluates user outcomes using indicators such as fluency improvement, reduction in stuttering frequency, and confidence development. These metrics are presented through graphs and session-level summaries to make progress visible and measurable.

Data Collection and Monitoring

Speech recordings, extracted features, analysis results, and therapy outcomes are stored in a centralized monitoring component. This enables session-wise comparison, long-term performance analysis, and future system refinement.

Continuous Learning and System Updates

To improve robustness, the system supports continuous learning. New speech samples can be used to retrain and opti¬mize the AI models, improving their ability to handle diverse speech patterns, accents, and practical recording conditions.

Feedback Loop and System Optimization

A feedback loop connects user performance, AI predictions, and therapy outcomes. This loop supports ongoing refinement of the speech analysis algorithms and therapy recommenda¬tions, thereby improving both user experience and overall system effectiveness.

Advantages of the Proposed System

The proposed system offers the following advantages:

- Automated stuttering detection and therapy assistance.
- Personalized and adaptive learning support.
- Real-time feedback and progress tracking.
- Reduced dependence on frequent therapist availability.
- Improved accessibility and cost-effectiveness.

Summary of Proposed Work

Overall, the proposed system provides a comprehensive framework that combines speech processing, AI-based anal¬ysis, personalized therapy, and continuous improvement. It addresses important limitations of conventional therapy by offering an intelligent, scalable, and user-friendly solution for speech enhancement.

Results

This section presents the observed outcomes of the AI-based stuttering therapy and improvement system across mul¬tiple practice sessions. The experiments focus on fluency enhancement, stuttering reduction, and the practical value of personalized feedback.

Experimental Setup

Speech samples were collected from several practice ses¬sions involving controlled speech, reading, repetition, and spontaneous speech. These samples were processed by the system and evaluated using the following criteria:

- Fluency improvement
- Reduction in stuttering frequency
- Effectiveness of personalization
- Consistency of user performance

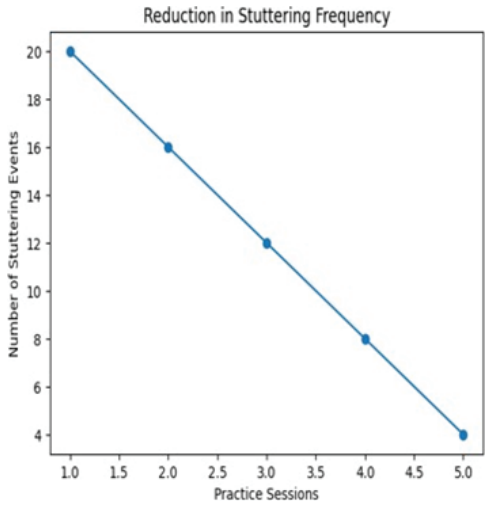

Figure 3. *Reduction in stuttering frequency across practice sessions.*

All tests were assumed to be conducted under comparable conditions to support meaningful session-wise comparison.

Improvement in Fluency Score

The fluency percentage reflects the smoothness and conti¬nuity of speech by combining indicators such as speech rate, pause duration, and repetition behavior. The observed trend shows a gradual increase in fluency across practice sessions, suggesting that repeated AI-guided therapy can improve speak¬ing performance.

Reduction in Stuttering Frequency

Stuttering frequency was evaluated using the number of repetitions, prolongations, and sudden speech blocks. The observed values decrease steadily across sessions, indicating a clear reduction in dysfluency events as the user progresses through therapy.

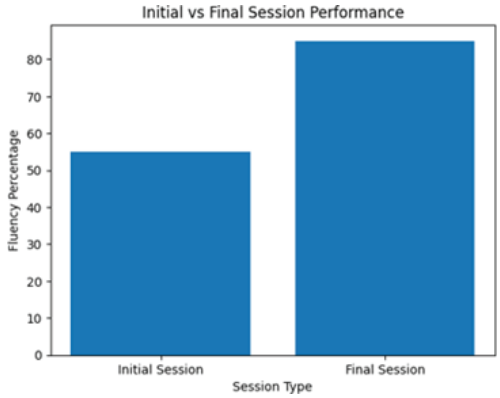

Figure 4. *Comparison of fluency percentage between the initial and final sessions.*

Initial vs. Final Session Comparison

Comparing the initial and final therapy sessions provides a direct indication of overall improvement. The final session shows a substantially higher fluency level than the initial session, reflecting the cumulative effect of repeated therapy practice and adaptive feedback.

Effectiveness of Tailored Therapy

One of the main strengths of the system is personalization. By identifying the specific stuttering characteristics of an individual user, the AI module can recommend exercises that target the user's exact difficulty pattern. This improves the speed and relevance of therapy compared with generic guidance.

Real-Time Feedback

Real-time feedback allows users to identify mistakes im-mediately and adjust their speaking behavior during practice. This immediacy is beneficial for reinforcing correct speaking patterns and increasing user attentiveness during sessions.

Progress Tracking

The system helps users observe long-term speech improve¬ment by displaying fluency scores and stuttering trends over time. Such visibility can improve motivation and encourage sustained practice.

Overall System Performance

Overall, the results suggest that the proposed system is effective as an AI-assisted speech therapy framework. The steady improvement in fluency and the decline in stuttering

Table I. Session-Wise Performance Summary

Session	Fluency Score (%)	Stuttering Events
1	55	20
2	62	16
3	70	12
4	78	8
5	85	4

events indicate the practical value of combining speech anal¬ysis, personalization, and progress monitoring.

Summary of Results

The experimental observations indicate that the AI-supported system improves fluency, reduces stuttering fre¬quency, and can contribute positively to communication con¬fidence over repeated sessions.

Discussion

The obtained results support the main objective of de-veloping an AI-assisted stuttering therapy platform. Fluency improves progressively across sessions, while stuttering fre¬quency decreases in a consistent manner. These trends suggest that the combination of intelligent speech analysis and adap¬tive therapy can produce meaningful gains in communication quality.

A major strength of the system is its ability to provide personalized support. Rather than relying solely on static exer¬cises, the AI module can adapt recommendations according to the user's own speech patterns. This increases the relevance of practice and helps users focus on the most important aspects of their dysfluency.

Another important contribution is the use of real-time feed¬back. Immediate response to speech behavior improves user engagement and allows corrections to occur during the practice process itself. In addition, graphical tracking of fluency and stuttering metrics makes improvement more visible, which can strengthen motivation and consistency.

The feedback loop incorporated into the proposed design also makes the system adaptable. By learning from user data over time, the platform can continue refining its detection accuracy and therapeutic recommendations. This gives it po¬tential value not only as a support tool for individuals but also as a scalable digital therapy solution.

Overall, the findings suggest that AI-based speech therapy systems can complement conventional methods by increasing accessibility, personalization, and continuity of practice.

Conclusion

This paper presented an AI-based stuttering therapy and improvement system aimed at improving clarity, smoothness, and continuity of speech. The framework combines speech recording, speech processing, AI-based dysfluency detection, personalized therapy guidance, and progress monitoring in a single integrated system.

The reported results indicate that the system can improve fluency, reduce stuttering frequency, and support confidence building. Because the platform is adaptive and user-specific,it can provide meaningful long-term support while reducing some of the practical barriers associated with conventional speech therapy, such as cost, availability, and the need for constant supervision.

The proposed model is also scalable and can be extended in future work to include multilingual support, broader speech assessment features, and more advanced personalized learning strategies. Overall, the study highlights the strong potential of accessible and intelligent AI technology in modern speech therapy applications.

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