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Enhancing Stuttering Detection and Therapy with ML

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Abstract: *Stuttering, impacting speech fluency, can significantly hinder communication. This paper proposes a mobile application that leverages machine learning for automated stuttering assessment and delivers personalized speech therapy exercises, empowering both Speech-Language Pathologists (SLPs) and individuals who stutter. An LSTM model, trained on the SEP-12 dataset, analyzes user speech recordings to generate a fluency score. A pre-trained Wav2Vec2 model identifies disfluent phonemes, guiding the selection of practice words for targeted exercises. This program incorporates relaxation techniques, syllable division training, and speech modification techniques, tailored based on the user's fluency score. SLPs can utilize the app's assessment capabilities and progress tracking features to augment their therapy sessions, while individual users benefit from the app's accessibility, allowing them to practice exercises and monitor progress independently. User progress is tracked through exercise completion monitoring and re-assessments. The app, deployed on Firebase and developed with FlutterFlow, offers a promising approach to enhance accessibility and effectiveness of speech therapy for individuals who stutter*

Key Words: *Stuttering, Speech Therapy, Machine Learning, LSTM, Speech Analysis.*

1. INTRODUCTION:

Stuttering, also known as stammering, is a speech disorder characterized by involuntary repetitions, prolongations, and blocks in speech production [1]. It affects individuals of all ages and can significantly impact their communication skills and quality of life [1]. Traditional speech therapy approaches, often involving one-on-one sessions with a qualified SpeechLanguage Pathologist (SLP), offer demonstrably positive outcomes. However, a critical barrier to effective treatment is accessibility. Several factors limit access to traditional speech therapy:
Cost: Therapy sessions can be expensive, creating a financial burden for many individuals. Availability: The number of qualified SLPs may not meet the demand in all regions, leading to long wait times or a lack of services altogether.
Geography: Individuals in remote areas may not have access to a qualified SLP within a reasonable distance. These limitations are highlighted in research, which shows that privately insured children and those with co-occurring conditions are more likely to receive therapy services compared to their uninsured counterparts [2].

The consequences of limited access to therapy can be significant. Stuttering can be associated with substantial psychosocial challenges including social anxiety and a diminished quality of life [1]. Without proper therapy, individuals who stutter may struggle to manage their condition and achieve their full communication potential.

As Sonya Renee Taylor eloquently states, 'We are being given the opportunity to stitch a new garment. One that fits all of humanity and nature.' After the pandemic, this sentiment perfectly captures the need for innovation in speech-language pathology. An inclusive approach that centers on accessibility for all who require communication support is essential [3].

This paper proposes a novel mobile application designed to address the issue of accessibility in stuttering therapy. Leveraging AI, the app aims to provide a more accessible, personalized, and efficient approach to stuttering assessment and therapy.

The app complements, rather than replaces, the valuable role of SLPs. We acknowledge the importance of the desensitization and stabilization phase in stuttering therapy, which often involves addressing emotional factors best handled by a qualified professional. Our focus is on supporting SLPs and empowering users with the tools and confidence to manage their stuttering.

2. **Problem Statement:**

Stuttering, also known as stammering, is a speech disorder characterized by involuntary repetitions, prolongations, and blocks in speech production . It affects individuals of all ages and can significantly impact their communication skills and quality of life [1]. Traditional speech therapy approaches, often involving one-on-one sessions with a qualified Speech-Language Pathologist (SLP), offer demonstrably positive outcomes. However, a critical barrier to effective treatment is accessibility.

- Several factors limit access to traditional speech therapy:
- Cost: Therapy sessions can be expensive, creating a financial burden for many individuals.
- Availability: The number of qualified SLPs may not meet the demand in all regions, leading to long wait times or a lack of services altogether.
- Geography: Individuals in remote areas may not have access to a qualified SLP within a reasonable distance.
- These limitations are highlighted in research, which shows that privately insured children and those with co-occurring conditions are more likely to receive therapy services compared to their uninsured counterparts

3. LITERATURE REVIEW:

A. Stuttering Treatment Techniques:

Stuttering is a speech disorder characterized by disfluencies like repetitions, prolongations, and blocks. Fortunately, various techniques can help individuals who stutter achieve smoother speech. A contemporary approach to stuttering treatment emphasizes exercises that modify the timing and physical tension of speech movements, as explored by Ludo Max and Anthony J. Caruso.[4]

B. Speech Modification Techniques

The effectiveness of techniques like easy onset and pantomiming in reducing blocking frequency is commendable.[5]

C. Relaxation Techniques

Studies suggest that coastal breathing, a deep breathing technique, can be beneficial for people who stutter [7]. This aligns with the general understanding that relaxation techniques can help reduce overall tension, potentially improving fluency.

D. Rate Control Techniques

Slow rate modeling, positions the PWS in a passive learning role and aligns with the demands capacity model-based approach [8].

E. Detection of Stuttering

L. Chee and his team's paper is focused on using Mel Frequency Cepstral Coefficients (MFCC) to recognize repetitions and prolongations in stuttered speech. Machine learning algorithms, specifically k-Nearest Neighbors (k-NN) and Linear Discriminant Analysis (LDA), were applied for this recognition. The goal was to improve the understanding and identification of specific speech patterns related to stuttering.[9]

In the paper, Classification of Healthy and Pathological voices using MFCC and ANN an approach for identifying healthy and pathological voices using an automatic voice disorder detection system is presented. Mel Frequency Cepstral Coefficients (MFCC) are used in the paper to extract features from voice signals. An Artificial Neural Network (ANN) is used to classify the feature vector, which consists of 19 MFCCs. [10]

Unlike previous methods relying on language models, Kourkounakis' proposed model uses acoustic features only, avoiding the need for speech recognition. The approach employs a deep residual network and bidirectional long short term memory (Bi-LSTM) layers to classify various stutter disfluencies.The research demonstrates the effectiveness of the method in identifying different types of stutters directly from audio signals, providing potential applications in therapy and speech analysis tools.[11]

4. Scope:

- Designing and implementing a real-time speech analysis system capable of detecting instances of stuttering during live speech.
- Integrating various speech analysis engines and machine learning algorithms to provide accurate and personalized feedback to users.
- Creating an intuitive and accessible web interface for users to access speech therapy exercises, receive feedback, and track their progress over time.
- Developing a comprehensive curriculum of speech therapy exercises focusing on breath control, relaxation techniques, and speech modification to address the specific needs of individuals who stutter.

5. Proposed system:

This paper proposes a web application designed to provide personalized speech therapy support for individuals who stutter. The application leverages machine learning for speech analysis and incorporates evidence-based techniques to deliver a comprehensive therapy program which aids SLPs.

A. Assessment Module:

The initial user interaction involves an assessment module that gathers data to personalize the therapy program. Users record a standardized paragraph reading through the app's microphone. This audio sample undergoes the following processes:

- Data Collection: The user's speech sample is recorded using the device's microphone. As illustrated in Figure 1, the user interface presents a clear and concise layout for recording speech samples.

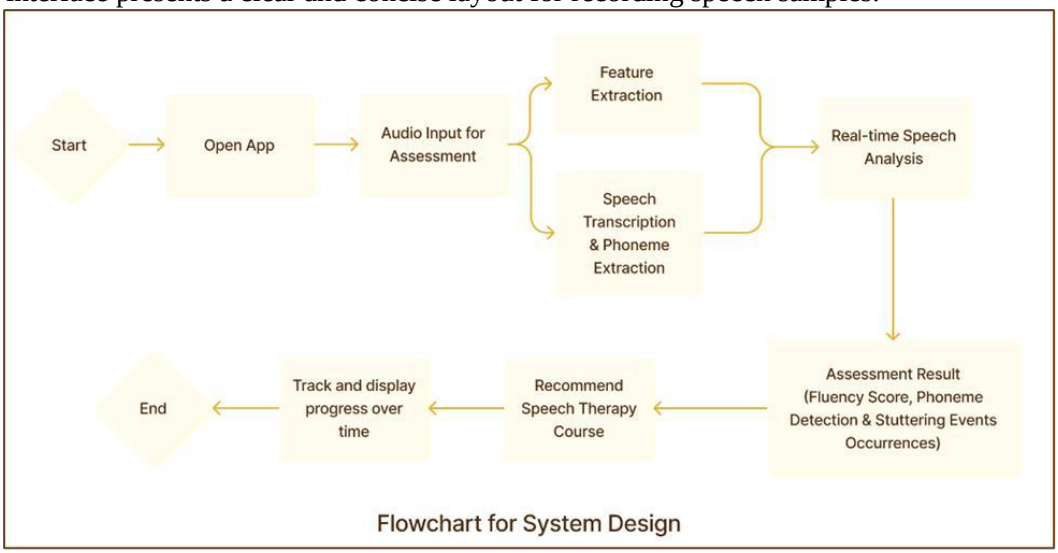

Fig. 1. Flow chart

- Fluency Score Calculation: Based on the analysis results from the LSTM network, the application calculates a fluency score. This score quantifies the user's stuttering severity, providing a baseline for monitoring progress over time.

- Disfluent Phoneme Detection: An additional model is employed to identify specific phonemes where the user exhibits greater disfluency.

B. Speech Therapy Module

Following the assessment, the application generates a personalized speech therapy program based on the user's fluency score and identifies disfluent phonemes. The exercise screen in Figure 2 presents clear instructions alongside visual aids to guide users through each therapy technique. This program incorporates various evidence-based techniques to address stuttering:

• Exercise Types: The therapy program includes a variety of exercises categorized into three main areas:
  – Relaxation Exercises: Techniques like progressive muscle relaxation and diaphragmatic breathing are incorporated to address the link between tension and stuttering.

– Syllable Division Techniques: Exercises targeting syllable division aim to improve speech fluency by breaking down words into manageable units.
– Speech Modification Techniques: Techniques like the ”slide-out,” ”easy onset,” and ”prolonged speech” are included to modify speech production patterns and enhance fluency.
– Specific Phoneme Practice: Words containing the phonemes identified as disfluent are integrated into exercises, allowing users to practice specific sounds that pose challenges. This targeted approach aims to improve fluency at the phoneme level.

• Quizzes: Interactive quizzes are used to assess a user's understanding of concepts of the techniques taught.

C. Progress Monitoring

The application incorporates functionalities to track user progress and monitor their journey towards improved fluency:

• Exercise Tracking: The app tracks user completion of exercises, recording data such as day, and the type of exercise completed. This data provides valuable insights into user adherence to the therapy program.
• Assessment History: The application stores the results of previous assessments, including fluency scores. This allows users to visualize their progress over time by tracking changes in their fluency scores.
• Reassessment: Users are encouraged to take reassessments periodically to gauge their progress and potentially adjust their therapy plans accordingly. Monitoring fluency improvements through reassessments is crucial for maintaining user motivation and optimizing therapy effectiveness.

6. Implementation:

This section delves into the implementation aspects of developing the proposed mobile application for stuttering therapy.

A. Model Development

The application incorporates functionalities to track user progress and monitor their journey towards improved fluency:

• Dataset: The model was trained on the publicly available SEP-12 dataset. The SEP-12 dataset consists of speech recordings from podcasts of individuals who stutter, providing valuable data for identifying stuttering patterns.
• Features: Mel-Frequency Cepstral Coefficients (MFCCs) and spectrograms were extracted from the audio samples in the SEP-12 dataset. MFCCs capture the spectral characteristics of speech, while spectrograms offer a visual representation of the frequency content over time. These features effectively represent speech patterns and disfluencies suitable for machine learning analysis.
• Model Architecture: A Long Short-Term Memory (LSTM) network architecture was chosen for the core model. LSTMs are a type of recurrent neural network capable of learning complex temporal dependencies in sequential data, making them well-suited for analyzing speech, which is inherently sequential.
• Training Process: The LSTM model underwent training on the SEP-12 dataset using MFCCs and spectrograms as input features. The training process aimed to optimize the model's ability to identify stuttering patterns within the speech samples. A loss value of 0.4942 was achieved during training, indicating the model's effectiveness in learning relevant information from the data.

B. Phoneme Detection

An additional pre-trained model, facebook/wav2vec2-lv-60-espeak-cv-ft, is employed for phoneme-level analysis of the user's speech. Phonemes are the basic units of speech sound. This pre-trained model plays a crucial role in identifying specific phonemes where the user exhibits greater disfluency. By pinpointing problematic phonemes, the application can tailor therapy exercises to address these specific challenges.

C. Mobile Application Development

Flutterflow, a low-code development platform, is used to build the entire web application. Flutterflow offers functionalities for:

• User Interface: Designing a user-friendly interface for user interaction, including recording speech samples, displaying assessment results, and providing therapy exercises.
• Data Management: Storing and managing user data, including assessment results, exercise completion records, and progress in history.

D. Development

Firebase, a cloud platform by Google, is chosen for application deployment

7. Result:

Introduction of system to the user this will tell us briefly how it is useful here we have used turtle which we name it as sturtel.

Fig.2: Mascot Introduction

Splash, Login & Home Screens

After the introduction the user is redirected to the login page where the user has to enter login and password for log in. This is for authentication purposes and after logging the user is redirected to the home page screen of the application .

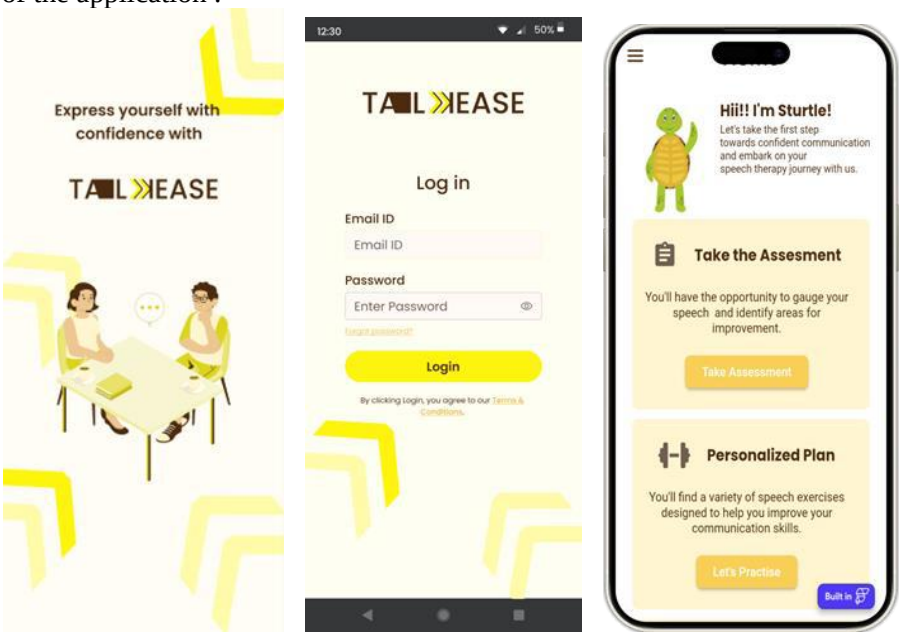

Fig 3: Initial Screens

Assessment Module

Here we take assessment of the user. In the first screen we tell them purpose of this assessment and also we gave them instructions to be followed for assessment after reading this user click on get started button after that in assessment user has to read paragraph given on the screen here we have took the paragraph which consist of almost all the peaches and after it is done application tells use which phonemes he shutter and fluent score and after clicking next summary of assessment is shown.

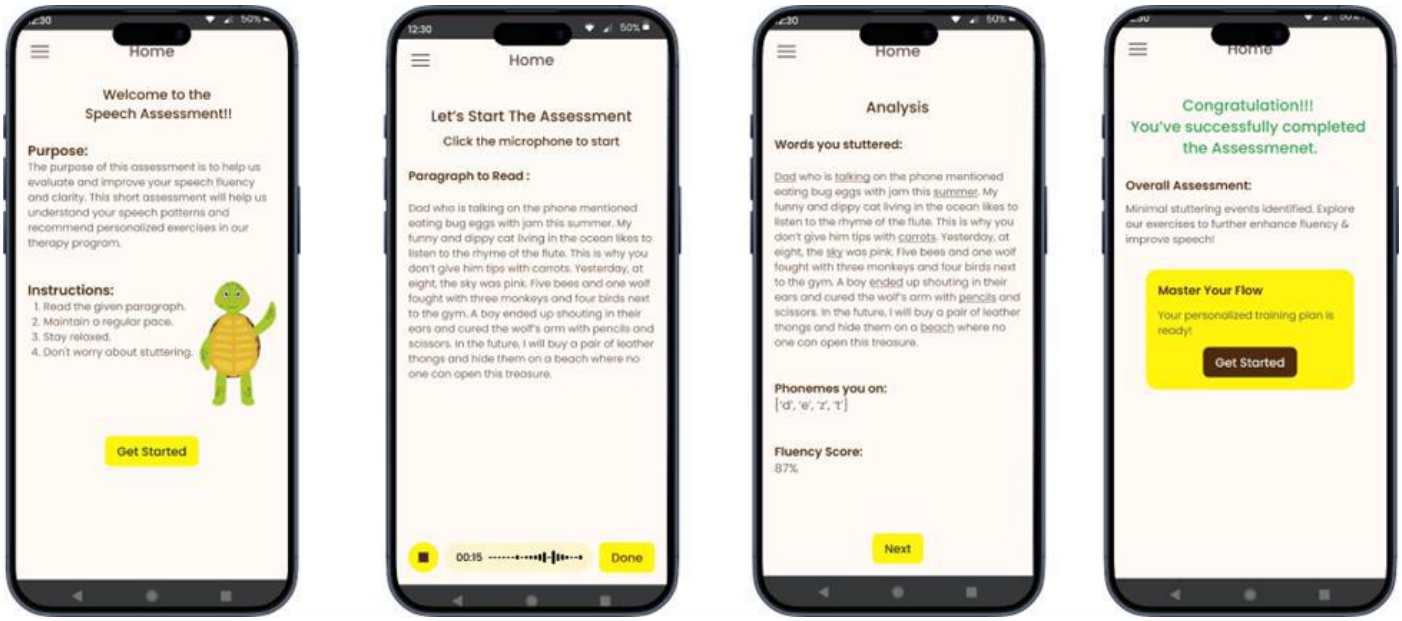

Fig 4: Assessment Screens

Course Module

Here users are served which different courses this consist of 30 days plan and contains whereas courses which will help them in reducing the sluttering as shown in image 5here we also added image of one course how it looks

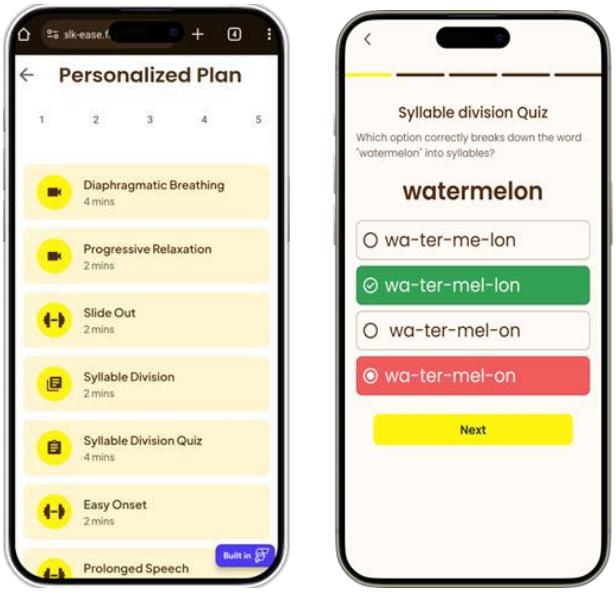

Fig 5: Course & Quiz Screens

In the following image 6 shows how first we do relaxation of the body. As almost every therapist suggest to start with body relaxation this also help user in concentrate in the therapy and fell relax here we used diaphragmatic breathing and progressive relaxation of body relaxation in diaphragmatic breathing we relax inner body like diaphragm and in progressive we relax user's hand, leg, shoulder, etc

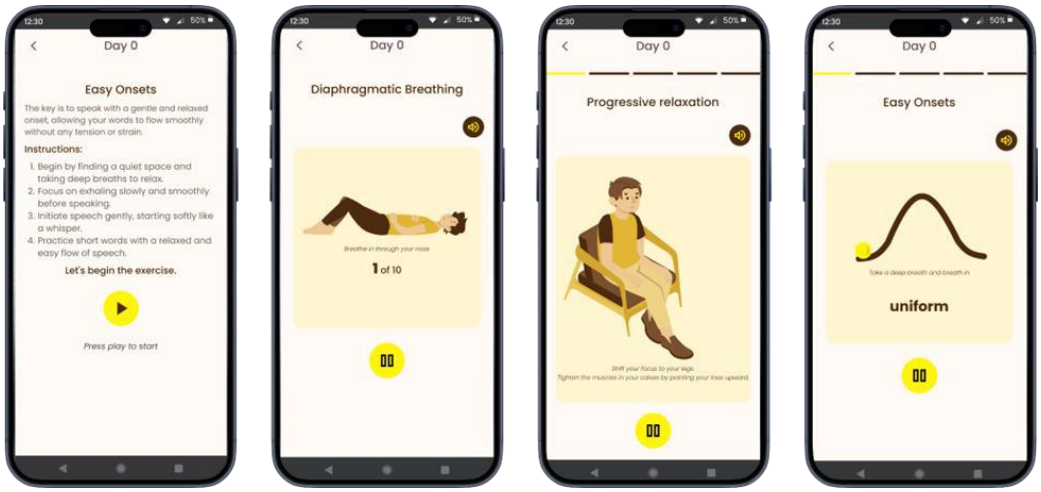

Fig 6: Exercise Screens I

Here in the figure 7 we use tongue exercise by using slide down technique and word breaking technique. here in slide down we slow down the pronunciation where the user slutter and in break down we break the ford so that they can speak it properly

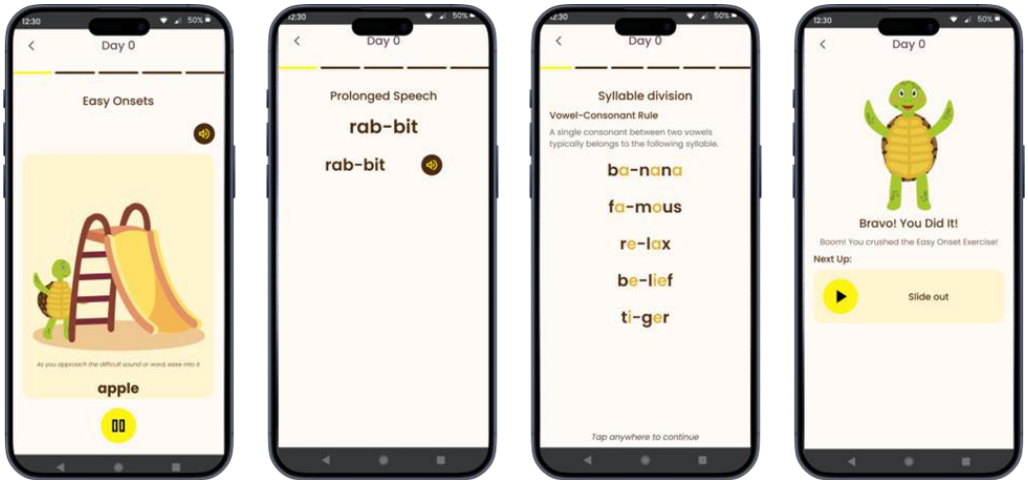

Fig:8: Exercise Screens II

Progress Tracking Module

In the end of the month we also provide the overall summary of the progress of the user and showing their score according to date and conclusion it is basically traced data of 30 days.

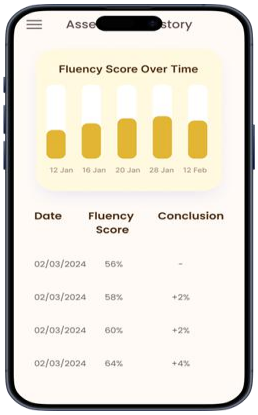

Fig:8: Progress Tracking Screen

8. Future Scope :

- Therapy Customization for Different Age Groups:

Currently, the therapy program is designed to be generalized for all age groups. In the future, the application can be enhanced to tailor therapy techniques and exercises specifically for different age demographics. This customization would consider factors such as developmental stages, cognitive abilities, and speech development milestones unique to each age group, optimizing therapy effectiveness and user engagement.

- Multilingual Support:

To cater to a more diverse user base, future iterations of the application can incorporate multilingual support. This feature would enable users to access therapy content, instructions, and exercises in their preferred language. By offering therapy materials in multiple languages, the application can reach a broader audience and provide inclusive support to individuals from various linguistic backgrounds.

- Integration of Online Speech-Language Pathologist (SLP) Therapy:

While the current application provides self-guided therapy exercises, integrating online sessions with certified speech-language pathologists (SLPs) could enhance the user experience and therapy outcomes. Through live video consultations, users can receive personalized guidance, feedback, and support from trained professionals. This hybrid approach combines the benefits of technology-driven self-paced learning with the expertise and individualized attention of licensed therapists, offering a comprehensive and holistic therapy experience.

- Gamification and Interactive Features:

Introducing gamification elements and interactive features can make therapy sessions more engaging and motivating for users. Future updates could include gamified challenges, progress tracking, virtual rewards, and social interaction features to foster a sense of accomplishment, competition, and community among users. By gamifying the therapy experience, the application can increase user participation, adherence, and long-term engagement, ultimately leading to better therapy outcomes.

- Continuous Research and Development:

As technology and understanding of speech disorders evolve, ongoing research and development efforts are crucial to keep the application up-to-date with the latest advancements. This includes exploring emerging technologies such as natural language processing (NLP), sentiment analysis, and emotion recognition to enhance the application's speech analysis capabilities and therapy interventions. Additionally, collaborating with experts in speech pathology, linguistics, and human-computer interaction can inform the development of innovative features and best practices for speech therapy delivery in the digital age.

9. Conclusion:

This app empowers speech therapy. It uses machine learning to analyze speech and create personalized therapy plans for stuttering. By analyzing speech patterns and pinpointing problem sounds, the app (trained on the SEP-12 dataset) acts as a valuable assistant to Speech-Language Pathologists (SLPs). It also makes therapy more accessible by offering personalized exercises and progress tracking, potentially reaching those who might not have easy access to traditional SLP services.

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REFERENCES:

1. Perez, H. R., and Stoeckle, J. H. (2016). Stuttering: Clinical and research update. In Stuttering (Chapter 4). National Institutes of Health. https://pubmed.ncbi.nlm.nih.gov/27303004/

2. Davidson, M. M., Alonzo, C. N., and Stransky, M. L. (2022). Access to speech and language services and service providers for children with speech and language disorders. Journal of Speech, Language, and Hearing Research, 65(8), 2562-2576.
3. Bea Staley, Marise Fernandes, Ellen Hickey, Helen Barrett, Karen Wylie, Julie Marshall, Mershen Pillay, Harsha Kathard, Ryann Sowden, David Rochus, Carol E. Westby, T. Rosario Roman, and Sally D. Hartley. (2020). Stitching a new garment: Considering the future of the speech–language therapy profession globally. International Journal of Speech-Language Pathology, 22(1), 11–23.
4. Nicole E. Neef, Alexandra Korzeczek, Annika Primaßin, Alexander Wolff von Gudenberg, Peter Dechent, Christian Heiner Riedel, Walter Paulus and Martin Sommer "Contemporary Techniques for Establishing Fluency in the Treatment of Adults Who Stutter",2020
5. Imtiaz, S., Kiyani, M. N., and Ijaz, T. (2022). The comparison of easy onset and pantomiming treatment on blocking in stammering. *The Rehabilitation Journal*, 6(2), 338-341. http://trjournal.org/index.php/TRJ/article/view/119
6. Imtiaz, S., Kiyani, M. N., and Ijaz, T. (2022). The comparison of easy onset and pantomiming treatment on blocking in stammering. *The Rehabilitation Journal*, 6(2), 338-341. http://trjournal.org/index.php/TRJ/article/view/119
7. Reitzes, P., and Quesal, R. W. (2011). The anatomy and physiology of costal breathing and how it relates to stuttering. [Online] StutterTalk. Retrieved from http://stuttertalk.com/2011/02/27/costalbreathing-stuttering-series.asp
8. L. R. Lasalle, "Slow speech rate effects on stuttering preschoolers with disordered phonology," Clinical Linguistics and Phonetics, vol. 29, no. 5, pp. 1–24, 2015. DOI: 10.3109/02699206.2014.1003970
9. L. Chee, O. Ai, M. Hariharun and S. Yaacob "MFCC based Recognition of Repetitions and Prolongation in Stutterd Speech using k-NN and LDA " in Proceeding of 2009 IEEE Student Conference on Research and Development on 16-18 NOV. 2009.
10. Smitha , S. Hegde, S.Shetty and T.Dodderi, "Classification of Healthy and Pathological voices using MFCC and ANN",in 2018 Second International Conference on Advances in Electronics, Computer and Communications,in 2018.
11. T. Kourkounakis, A.Hajavi and A.Etemad "Detecting multiple speech disfluencies using Deep Residual Network with Bidirectional Long Short-Term Memory,"in ICASSP 2020, on June 01,2020.
12. A.Gaodida, H. Koppisetty, K. Potdar, and A. Biwalkar , "Aiding Speech Therapy Using Audio And Video Processing" 2020 IEEE Asia-Pacific Conference on Computer Science and Data Engineering (CSDE), May 20,2021.
13. J. Vuppalapati, S. Kedari, A. a Ilapakurti and S.Kedari , "Artificial Intelligent (AI) Clinical Edge for Voice disorder Detection" on 2019 IEEE Fifth International Conference on Big Data Computing Service and Applications (BigDataService), 2020.
14. L. Chee, O. Ai, M. Hariharun and S. Yaacob ``MFCC based Recognition of Repetitions and Prolongation in Stutterd Speech using k-NN and LDA " in Procceding of 2009 IEEE Student Conference on Research and Development on 16-18 NOV. 2009.
15. Smitha , S. Hegde, S.Shetty and T.Dodderi, "Classification of Healthy and Pathological voices using MFCC and ANN",in 2018 Second International Conference on Advances in Electronics, Computer and Communications, on 2018.
16. T. Kourkounakis, A.Hajavi and A.Etemad "DETECTING MULTIPLE SPEECH DISFLUENCIES USING A DEEP RESIDUAL NETWORK WITH BIDIRECTIONAL LONG SHORT-TERM MEMORY,"in ICASSP 2020, on June 01,2020.
17. G. Milani, M. Ramasfolii and M. Krishani, , "A real-time application to detect human voice disorders," 2020 International Conference on Decision Aid Sciences and Application (DASA),on June 25,2021.
18. Shivangi, A. Johri and A.Johri, "Parkinson Disease Detection Using Deep Neural Networks"in Jaypee Institute of Information Technology, on 2019.
19. J. Wang and C.Jo, "Vocal Folds Disorder Detection using Pattern Recognition Methods"in Proceedings of the 29th Annual International Conference of the IEEE EMBS Cit́e Internationale, Lyon, France, on August 23-26, 2007, .
20. S. Ng, D. Tao, J. Wang, Y. Jiang W. Ng and T.Lee, "An Automated Assessment Tool for Child Speech Disorders"in ISCSLP 2018, on 2018.
21. J. Zhang, B. Dong and Y.Yan, "A Computer-assist Algorithm to Detect Repetitive Stuttering Automatically"in 2013 International Conference on Asian Language Processing, on 2013.

22. M. Jamis, E. Yabut, R.Manuel and A.Catacutan-Bangit, ”Speak App: A Development of Mobile Application Guide for Filipino People with Motor Speech Disorder”in Proceedings of TENCON 2018-2018 IEEE Region 10 Conference at Jeju, Korea,on 28-31 October 2018.
23. N. Nasiri and S.Shirmohammadi, ”Measuring Performance of Children with Speech and Language Disorders Using A Serious Game”in This full text paper was peer-reviewed at the direction of IEEE Instrumentation and Measurement Society prior to the acceptance and publication, on 2017.
24. C.Francis , Dr.V. Nair and S.Radhika, ”A Scale Invariant Technique For Detection Of Voice Disorders Using Modified Mellin Transform”in 2016 International Conference on Emerging Technological Trends [ICETT] , on 2016.
25. T. Ijitona, J. Soraghan, A.Lowit, G. Di-Caterina and H.Yue, ”Automatic Detection of Speech Disorder in Dysarthria using Extended Speech Feature Extraction and Neural Networks Classification ”in Press, on 2013 .
26. O. Asmac, R. Abdelhadi, C.Bouchaib S.Sara and K.Tajeddine, ”Parkinson’s Disease Identification using KNN and ANN Algorithms based on Voice Disorder”in Auckland University of Technolog, on June 04,2020.
27. Z.Ali, M. Alsulaiman, G. Muhammad , I. Elamvazuthi and T.Mesallam, ”Vocal Fold Disorder Detection based on Continuous Speech by using MFCC and GMM”in 2013 IEEE GCC Conference and exhibition, at Doha, Qatar, on November 17-20 2013.
28. C. Vaquero, O. Saz, E. Lleida and W. Rodr´ıguez, ”E-INCLUSION TECHNOLOGIES FOR THE SPEECH HANDICAPPED”in ICASSP, on 2008.
29. V. Vel´asquez-Angamarca, K.Mosquera-Cordero, V.Robles-Bykhoev , A.Lean-Pesintez ,D.Krupke , J.Knox , V.Torres-Segarra , and P.Chicaira-Juela, ”An educational robotic assistant for supporting therapy sessions of children with communication disorders”in 2019 7th International Engineering, Sciences and Technology Conference (IESTEC), on July 27, 2019.
30. M.Ochoa-Guaraca, M. Carpio-Moreta, L.Serpa-Andrade ,V.Robles-Bykbaev, M.Lopez-Nores and J.Duque, ”A robotic assistant to support the development of communication skills of children with disabilities”in IEEE 11CCC , on 2016.
31. Pahwa, G. Aggarwal and A. Sharma, ”A machine learning approach for identification and diagnosing features of Neurodevelopmental disorders using speech and spoken sentences”in International Conference on Computing, Communication and Automation (ICCCA2016), on 2016.
32. V. Berisha, J. Liss,S.Sandoval , R.Utianski and A.Spanias, ”MODELING PATHOLOGICAL SPEECH PERCEPTION FROM DATA WITH SIMILARITY LABELS”in 2014 IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP), on 2014.
33. G. Castellanos, G. Daza, L. S´anchez, O. Castrill´on and J.Su´arez,”Acoustic Speech Analysis for Hypernasality Detection in Children” in Proceedings of the 28th IEEE EMBS Annual International Conference, at New York City, USA, on Aug 30-Sept 3, 2006.
34. W. H. Manning, ”Clinical decision making in fluency disorders,” 2nd ed. San Diego, CA: Singular Thomson, 2001.
35. R. M. Gabel, G. W. Blood, G. Tellis, and M. T. Althouse, ”Measuring role entrapment of people who stutter,” Journal of Fluency Disorders, vol. 29, pp. 27–49, 2004.
36. J. Adrian, M. Gonzalez, and J. Buiza, ”The use of computer-assisted therapy in anomia rehabilitation: A single-case report,” Aphasiology, vol. 17, no. 10, pp. 981–1002, 2003.
37. C. J. Lonigan, K. Driscoll, B. M. Phillips, B. Cantor, J. Anthony, and H. Goldstein, ”A computer-assisted instruction phonological sensitivity program for preschool children at-risk for reading problems,” Journal of Early Intervention, vol. 25, no. 4, pp. 248–262, 2003.
38. D. M. Brennan, A. C. Georgeadis, C. R. Baron, et al., ”The effect of video conference-based telerehabilitation on story retelling performance by brain-injured subjects and its implications for remote speech-language therapy,” Telemed J E Health, vol. 10, no. 2, pp. 147–154,2004