

Chapter 7

Discussion and Conclusion

7. Summary of the work

Our research efforts throughout this thesis have been focused on a thorough examination of stammering in Hindi language, delving into its intricate linguistic nuances and looking for creative solutions to the problems faced by those who stammer. To achieve our goals, we used a multifaceted strategy that included linguistic analysis, dataset creation, annotation schema design, and ASR model experimentation. We consider the accomplishments, revelations, and contributions that resulted from our research as we come to the end of this academic journey.

Our path was directed by the goals established at the beginning of the study, which led us to a deeper comprehension of Hindi stammering and its effects on language processing and communication. Our main goal was to identify and understand the linguistic features of Hindi stammering. As a result of our investigation, we were able to identify speech patterns and nuances, which helped us gain a deeper understanding of this complicated communication disorder within the Hindi linguistic context.

We set out to build a comprehensive dataset of Hindi stammered speech to make future analysis and experimentation easier. This carefully curated and annotated dataset now serves as a priceless

tool for ongoing research projects in the field of stammering and related areas, fostering an environment for inquiry and development.

The key contribution of this study was the creation of a novel annotation schema that made it possible to record minute details in stammering patterns. This schema not only aided in our analysis but also has the potential to direct subsequent research, offering a solid framework for linguistic study of stammering.

The study of Hindi stammering turned out to be an interesting intellectual journey. We developed a comprehensive understanding of the effects of stammering on language and communication by examining sound characteristics, syntactic structures, semantic content, pragmatic usage, and social implications. This information is ready to guide targeted interventions, support networks, and therapeutic strategies catered to the unique linguistic difficulties faced by Hindi-speaking individuals who stammer.

Our investigation also included Automatic Speech Recognition (ASR), where we investigated the possibility of using stammering information to improve ASR models and promote inclusivity and accessibility for people who stammer. We made considerable progress by creating and evaluating a binary stammering classifier, which can differentiate stammered speech from the non-stammered speech and paves the way for the incorporation of stammering-specific ASR models into current speech recognition pipelines.

Our research adds to the growing body of knowledge on stammering and encourages empathy, awareness, and fact-based assistance for those who stammer. We acknowledge that our work is a first step in a prolonged process to promote inclusiveness, understanding, and effective communication for those affected by stammering in the Hindi-speaking community and beyond.

7.1 Linguistic Aspect

This study explored the linguistic aspect of stammering by examining the linguistic patterns of native Hindi PWS at various levels such as sound, word, sentence, meaning and social contexts. The findings of this study have the potential to shed new light on the linguistic aspect of stammering and contribute to a better understanding of this complex speech disorder. Furthermore, the results of this study may have implications for the development of more effective speech therapy interventions for Hindi PWS. This research work is based on data collected from male Hindi speaking PWS. One of the limitations of the study is that the linguistic insights from this may not give right representation for female Hindi speaking PWS. Though, we tried to include female data, but it was not easy to get that. Our future work will try to collect more inclusive data from both female and male stutterers.

7.2 Computational Aspect

Our research primarily aimed to assess the viability of developing a Hindi stammering detection model. Our results highlighted the application of image classification techniques for constructing a stammering classifier, emphasizing the need to contextualize these findings within the broader context of stammering studies in languages other than Hindi. Despite dataset limitations, we strategically employed non-invasive data augmentation methods and opted for image classification over traditional Mel-frequency cepstral coefficients (MFCC) extraction, allowing a convolutional neural network (CNN) to autonomously capture stammering-specific traits.

Comparing the outcomes of our study with other research poses a challenge due to our distinct focus on binary stammering versus non-stammering classification. Our approach and architectural framework diverge significantly from established methodologies, introducing a unique perspective. Despite these differences, our findings align with conclusions from prior

contributions, affirming the feasibility of using machine learning for stammering identification. While strategies may differ, our results maintain a consistent trajectory with existing knowledge in the field.

In terms of results, an analysis of metrics within the confusion matrix, including accuracy and classification effectiveness, places our experiment prominently among distinguished research efforts discussed in literature review. Notably, our study achieved accuracy levels exceeding the significant threshold of 95%, reinforcing the proficiency of our methodology in discerning intricate patterns inherent in Hindi stammering. This observation highlights the stature of our approach among high-accuracy classification studies, affirming its ability to identify complex patterns within the domain of Hindi stammering.

7.3 Forensic Science Aspect

This research, while primarily focused on stammering and speech recognition in Hindi, has significant implications for forensic science through its methodological advancements and potential applications.

- **Speaker Identification and Verification** One of the key applications of speech analysis in forensic science is speaker identification and verification. The detailed linguistic and computational analysis of stammering can provide forensic experts with enhanced tools to distinguish between individuals based on their unique speech patterns, including stammering. By understanding the specific markers of stammering in Hindi speakers, forensic scientists can improve the accuracy of speaker identification in cases where the suspect or witness has a speech disorder.
- **Enhanced ASR Systems for Forensic Analysis** The development of stammering-specific ASR models can be integrated into forensic audio analysis. These models can assist in

transcribing and interpreting audio evidence more accurately, even when the speech is disfluent or includes stammering. This can be particularly valuable in legal contexts where precise transcription of spoken evidence is crucial. The comprehensive dataset and novel annotation schema developed in this research provide a rich resource for linguistic profiling. Forensic linguists can use these tools to analyze speech patterns, including stammering, to derive sociolinguistic and psycholinguistic profiles of individuals. This can aid in criminal investigations by providing insights into the speaker's linguistic background and psychological state. The inclusive technology developed through this research can be applied to forensic interviews and interrogations. By ensuring that ASR systems accurately recognize and transcribe stammered speech, law enforcement agencies can improve the quality of interviews with individuals who stammer, ensuring that their statements are recorded accurately and fairly. The interdisciplinary nature of this research, which bridges Linguistics, Computer Science, and Speech Language Pathology, sets a precedent for cross-disciplinary collaboration. Forensic science often requires the integration of multiple fields to solve complex cases. The methodologies and findings from this research can inspire similar collaborative efforts in forensic science, leading to innovative approaches and solutions.

7.4 Use cases and Applications

In a world marked by linguistic diversity and the persistent challenges faced by individuals with speech disorders, a pioneering piece of research emerged in this work, offering innovative solutions to improve communication and accessibility. As a resolute research scholar specializing in Linguistics, and Natural Language Processing, my focus has been on addressing a crucial aspect

of speech disorders – stammering – within the context of Hindi, one of India's prominent languages.

One remarkable application of this research lies in speech therapy, where targeted interventions can be devised based on linguistic analysis, transforming the way individuals who stammer in Hindi receive support and guidance. Moreover, the expansion of this research to encompass other Indian languages, reflecting the nation's remarkable linguistic diversity, promises a more inclusive and culturally sensitive approach to stammering detection and intervention. In this section, we explore applications and implications of this research, spanning from the realms of speech therapy and transcription services to language learning apps and digital platforms' accessibility features. By delving into each of these domains with academic rigor and technical precision, we unveil the transformative potential of this research, illuminating the path toward enhanced communication, inclusivity, and empowerment for individuals who stammer in Hindi and beyond.

7.4.1 Speech therapy for Hindi Speakers

This research categorizing stammering in Hindi audio samples holds promise for speech therapy, particularly for individuals who speak Hindi. Let us delve into a detailed description of how this research can be exceptionally useful in the context of Hindi-speaking people undergoing speech therapy:

- **Targeted Therapy Programs**

One of the primary benefits of this research is the ability to develop highly targeted speech therapy programs for individuals who stammer in Hindi. Speech therapists can utilize findings to create personalized interventions that address the specific linguistic characteristics of stammering in this language. By tailoring therapy in this manner, therapists can significantly enhance the effectiveness of their treatments.

- **Linguistic Insights**

This research provides invaluable linguistic insights into the nature of stammering in Hindi. Therapists can use this information to analyze the speech patterns of their clients in a more precise and nuanced way. They can identify which phonemes, syllable structures, or grammatical constructions are particularly challenging for the individual and design exercises to target these specific linguistic features.

- **Early Intervention**

For children who stammer in Hindi, early intervention is crucial. This research can assist in early identification and intervention, allowing therapists to work with young learners to improve fluency at an early age. This can have a profound impact on the child's confidence and communication skills as they grow.

- **Progress Monitoring**

This research can be integrated into speech therapy software, or tools used by therapists to monitor the progress of their clients. By continuously analyzing speech samples, therapists can objectively track improvements in fluency and adjust therapy plans accordingly. This data-driven approach can lead to more efficient and effective therapy sessions.

- **Customized Exercises**

Therapists can develop speech exercises and practice materials specifically tailored to address the linguistic challenges posed by stammering in Hindi. These exercises can be designed to gradually increase in complexity as the individual progresses, providing a structured path towards improved fluency.

- **Speech Analytics**

Advanced speech analytics tools can be built based on the findings and methods used in this research. These tools can automatically transcribe and analyze spoken content in real-time, flagging instances of stammering. Therapists can then review these flagged segments to provide targeted feedback to their clients during therapy sessions.

- **Remote Therapy**

In today's digital age, remote speech therapy has become increasingly common. This research has the potential to enhance the quality of remote therapy sessions by providing therapists with a deeper understanding of the client's speech patterns, even when they are not physically present. This can make therapy more accessible and convenient for individuals in remote or underserved areas.

- **Training for Speech Therapists**

This research can be incorporated into the training curriculum for future speech therapists. It can serve as a valuable resource for educating aspiring therapists on the linguistic nuances of stammering in Hindi, ensuring that they are well-prepared to provide effective therapy to their future clients.

- **Support for Multilingual Therapists**

For speech therapists who work with clients from diverse linguistic backgrounds, this research can offer specific guidance on addressing stammering in Hindi-speaking clients. This can be especially beneficial for therapists who are proficient in multiple languages but require language-specific insights.

- **Empowering Clients**

By using research findings to explain the linguistic aspects of their stammering, clients can gain a deeper understanding of their condition. This knowledge can empower them to actively

participate in their therapy and practice exercises more effectively, leading to improved outcomes.

The research on categorizing stammering in Hindi audio samples has the potential to revolutionize speech therapy for Hindi-speaking individuals. It offers a scientific foundation for targeted interventions, progress monitoring, and the development of specialized tools and materials. This, in turn, can enhance the quality of life for those who stammer in Hindi, improving their communication skills and self-confidence. It represents a significant step forward in the field of speech therapy, with the potential to benefit countless individuals in need of support and assistance.

7.4.2 Content Filtering

Integrating stammering detection model into content filtering systems, especially within customer service or call center environments, offers numerous advantages. Below is a detailed explanation of how this integration can work and its potential benefits:

- **Real-time Stammering Detection**

The stammering detection model would operate in real-time, analyzing spoken interactions as they occur during customer service calls. The model would continuously process the audio stream, identifying instances of stammering based on linguistic and speech patterns specific to Hindi, as per this research.

- **Alerting Customer Service Representatives**

When the stammering detection model identifies stammering in a caller's speech, it can trigger an alert to notify the customer service representative (CSR) overseeing the call. This alert could manifest as a visual notification on the CSR's computer screen, an audio cue, or both, ensuring that the CSR is aware of the situation without causing any disruption to the conversation.

- **Providing Additional Support**

Armed with the knowledge that the caller is experiencing stammering, the CSR can take proactive steps to provide additional support and assistance. CSRs can adapt their communication style by speaking more slowly, using simpler language, and displaying patience to create a more comfortable and less stressful environment for the caller.

- **Improved Customer Experience**

By offering tailored support to callers who stammer, customer service interactions become more inclusive and empathetic. This can significantly enhance the overall customer experience. The caller is more likely to feel valued and understood, which can lead to higher customer satisfaction and loyalty.

- **Enhanced Communication Effectiveness**

Recognizing stammering allows CSRs to adjust their responses, ensuring that their messages are conveyed clearly, and that the caller fully comprehends the information being provided. This can be especially crucial in scenarios where callers are seeking critical information or assistance, such as troubleshooting technical issues or in emergency situations.

- **Training and Development**

The integration of the stammering detection model can be used as a training tool for customer service teams. It can help in sensitizing CSRs to the challenges faced by individuals with speech disorders and equip them with the skills to manage such situations effectively. This can lead to a more empathetic and skilled customer service workforce, which benefits both stammering callers and those with other communication needs.

- **Compliance and Quality Assurance**

In industries where regulatory compliance is essential, such as healthcare or finance, models generated in this research work can also aid in quality assurance and compliance monitoring. By ensuring that CSRs are responding appropriately to stammering callers, the organization can demonstrate its commitment to inclusive and ethical customer service practices.

- **Data Collection and Analysis**

Over time, the data collected through the stammering detection system can be analyzed to gain insights into the frequency and nature of stammering calls. This data can inform ongoing training and development efforts and help identify trends or issues that may require organizational attention.

- **Multilingual Adaptability**

Given that this research focuses on Hindi, the model can be adapted to other Indian languages, making it even more versatile and applicable in multilingual customer service settings.

Integrating stammering detection model into content filtering systems for customer service and call centers is a significant step toward creating more inclusive and empathetic customer service interactions. It benefits both callers with speech disorders and the organizations providing customer support by improving communication effectiveness and enhancing the overall customer experience. This approach aligns with the principles of inclusivity and empathy in customer service, which are increasingly recognized as essential for building positive customer relationships and brand reputation.

7.4.3 Transcription services

The application of this research in enhancing transcription services for audio containing stammering in Hindi holds substantial potential for various sectors, including media, legal, and

healthcare. Here are some points on how this research can significantly improve transcription accuracy and its far-reaching implications:

- **Transcription Challenges in the Presence of Stammering**

Transcription services play a pivotal role in converting spoken language into written text, catering to a wide array of industries. However, these services face substantial challenges when dealing with audio recordings that include stammering. Stammering, characterized by repetitions, prolongations, and blocks in speech, can pose significant hurdles to accurate transcription.

- **The Role of Current Research**

The research in stammering detection in Hindi audio samples offers a compelling solution to these challenges. By integrating stammering detection model into transcription services, several key benefits can be realized:

- **Enhanced Accuracy**

The stammering detection model can identify segments of audio where stammering occurs, allowing transcriptionists to focus their attention on these specific portions. With this guidance, transcriptionists can allocate additional time and care to transcribe stammered speech accurately, reducing the likelihood of errors or misinterpretations.

- **Time Efficiency**

While transcriptionists may need to slow down their transcription pace during stammered segments, the overall efficiency of the transcription process can still be maintained. This ensures that deadlines are met without compromising the quality of the transcription.

- **Cost Savings**

Enhanced accuracy reduces the need for extensive revisions and corrections, leading to cost savings for clients who require transcription services. This cost-effectiveness can make transcription services more competitive in the market.

- **Legal and Healthcare Applications**

In the legal sector, accurate transcription is essential for court proceedings, depositions, and legal documentation. This research can significantly improve the precision of legal transcripts, ensuring that legal professionals have reliable records of spoken testimony, including any stammered speech. In healthcare, accurate transcription is crucial for medical records, patient histories, and clinical notes. The resultant model can aid in creating precise and complete medical transcripts, which are essential for patient care, research, and compliance with healthcare regulations.

- **Media and Content Creation**

Media companies often require transcription services for interviews, podcasts, and video content. This research can help maintain the integrity of these transcriptions, ensuring that content creators have accurate written records of their spoken content. This accuracy is particularly vital for closed captions in multimedia content, making it more accessible to a wider audience, including those with hearing impairments.

- **Multilingual Adaptability**

While the research initially focuses on Hindi, its principles can be extended to other Indian languages, expanding the applicability of improved transcription services across diverse linguistic contexts.

- **Training and Quality Assurance**

Transcription companies can use the stammering detection model as a training tool for their transcriptionists, helping them become more adept at transcribing stammered speech accurately. The model can also serve as a quality assurance tool, allowing companies to assess and ensure the accuracy of their transcription services.

The research has the potential to help the transcription industry, enhancing accuracy and efficiency across various sectors. Accurate transcripts are indispensable in legal, healthcare, media, and content creation domains, and the model can significantly contribute to meeting these industries' transcription needs. This application aligns with the pursuit of precision, compliance, and accessibility, underscoring the transformative impact of this research in real-world scenarios.

7.4.4 Language learning apps

This research on stammering detection in Hindi audio samples can be a game-changer for language learning applications, particularly those focused on teaching Hindi pronunciation and fluency. Here is a note on how this research can be harnessed to enhance language learning apps and provide personalized feedback to learners. Language learners often face difficulties in mastering pronunciation, especially in languages with unique phonetic features like Hindi. Stammering, which involves speech disruptions, can compound these challenges, making it essential to provide learners with effective tools to correct their speech patterns. This research offers a valuable opportunity to integrate stammering detection and correction features into language learning apps, benefiting learners in the following ways:

- **Real-time Stammering Detection**

Language learning apps can incorporate stammering detection model to analyze learners' speech in real-time as they practice Hindi pronunciation exercises. This enables the app to

identify instances of stammering and pinpoint specific areas where the learner encounters speech disruptions.

- **Personalized Feedback**

Based on stammering detection, the app can provide personalized, context-aware feedback to learners. For instance, it can highlight words or sounds where stammering occurs and offer suggestions for improvement. This feedback is highly tailored to the individual learner's needs, helping them address their specific pronunciation challenges effectively.

- **Targeted Practice Exercises**

Research findings from this research work can inform the development of specialized practice exercises within the app. These exercises can focus on the phonemes, syllable structures, or grammatical patterns that tend to trigger stammering in Hindi. Learners can engage in targeted practice to improve fluency in these challenging areas.

- **Adaptive Learning Pathways**

Building on this research, language learning apps can implement adaptive learning pathways that adjust the difficulty level based on the learner's stammering patterns and progress. Learners who struggle with stammering may receive additional exercises and support to address this specific challenge.

- **Increased Self-confidence**

As learners receive personalized feedback and see improvements in their speech, their self-confidence in speaking Hindi will likely increase. This boost in confidence can lead to more effective communication in real-life situations.

- **Multilingual Expansion**

While the initial focus of this thesis work is on Hindi, the principles of stammering detection can be extended to other languages, broadening the applicability of language learning apps for learners of different languages.

- **Supporting Diverse Learners**

Language learners come from diverse backgrounds and may have different linguistic challenges. Research findings can contribute to making language learning apps more inclusive and adaptable to learners with various speech patterns and needs.

- **Educational Institutions and Tutoring Services**

This research can also benefit educational institutions and tutoring services that use language learning apps as part of their curriculum. These institutions can leverage stammering detection tech to provide more effective pronunciation training to their students.

Integrating stammering detection model into language learning apps is a transformative step towards personalized and effective language acquisition. It addresses the specific challenges learners face when mastering Hindi pronunciation, fostering confidence and fluency. This application aligns with the principles of adaptive learning and individualized support, making language learning more accessible and enjoyable for a wide range of learners. It represents a significant advancement in language education technology and has the potential to empower learners to achieve greater proficiency in Hindi and other languages.

7.4.5 Accessibility features

This research on stammering detection in Hindi audio samples has the potential to make substantial contributions to enhancing accessibility features in digital platforms, including video conferencing tools and voice assistants. Here is a detailed note on how this research can play a pivotal role in improving the user experience for individuals who stammer:

- **Addressing Communication Barriers**

People with speech disorders, such as stammering, often encounter communication barriers when using digital platforms. These barriers can lead to frustration and hinder their ability to effectively engage with technology and communicate with others. This research offers a unique opportunity to address these challenges by integrating stammering detection and adaptation features into digital platforms, resulting in the following benefits:

- **Real-time Stammering Detection**

Digital platforms, such as video conferencing tools and voice assistants, can utilize stammering detection models to analyze spoken interactions in real-time. This detection mechanism identifies instances of stammering in the user's speech during interactions.

- **Adaptive Responses**

Once stammering is detected, these platforms can adapt their responses and interactions accordingly. For instance, in a video conferencing tool, if a user stammers during a call, the platform can display patience by not interrupting or rushing the user to speak. In the case of voice assistants, if a user stammers while giving a command or asking a question, the assistant can respond with understanding and allow for more extended response times.

- **Speech Enhancement**

The research findings can also be applied to enhance the clarity and intelligibility of a user's speech in real-time. Digital platforms can apply algorithms to smoothen out stammered speech, making it more coherent and easier to understand for both human and machine recipients.

- **Reduced Communication Anxiety**

Knowing that digital platforms can accommodate their speech patterns, individuals who stammer may experience reduced anxiety and increased confidence when using technology for communication.

- **Inclusivity in Education and Work**

In educational settings and workplaces that rely on video conferencing tools for remote learning and work, individuals with stammering can actively participate in discussions and presentations without fear of being misunderstood or judged.

- **Support for Virtual Assistants**

Voice assistants, which are increasingly integrated into various devices, can be more helpful and patient when responding to users who stammer. They can adapt their responses, rephrase queries, and provide clarifications as needed.

Integrating this stammering detection model into digital platforms represents a significant step toward greater accessibility and inclusivity. It empowers individuals who stammer to communicate more effectively, reduces anxiety, and enhances their overall digital experience. This application aligns with the principles of universal design and user-centered technology, making digital platforms more welcoming and accommodating for diverse users, including those with speech disorders. It represents a significant stride toward a more inclusive digital world where everyone can participate and communicate with confidence.

7.4.6 Multilingual expansion

Expanding this research on stammering detection from Hindi to other Indian languages is not only a commendable endeavor but also holds immense potential for addressing the needs of individuals who stammer in different linguistic contexts. Here is a comprehensive note on the importance and nuances of this multilingual expansion:

- **The Diversity of Indian Languages:** India is a linguistically diverse nation with a rich tapestry of languages belonging to different language families. The two major language families in India are Indo-Aryan (including Hindi, Bengali, Marathi, and more) and Dravidian (including Tamil, Telugu, Kannada, etc.), with several other languages and dialects spoken across the country.
- **Challenges in Multilingual Stammering Research:** The linguistic diversity of India presents unique challenges when expanding this research to multiple languages. While Indo-Aryan languages may share certain phonetic features due to their common ancestry, there can still be significant variations in phonemic inventories, grammatical structures, and speech patterns. Dravidian languages, on the other hand, have distinct phonological and grammatical characteristics that differ greatly from Indo-Aryan languages.
- **Benefits of Multilingual Expansion:** Below are the possible benefits that we may get after the model's multilingual expansion.
 - **Addressing a Wider Audience:** Expanding this research to include multiple Indian languages allows us to cater to a broader audience. This inclusivity is crucial because individuals who stammer come from diverse linguistic backgrounds.
 - **Cultural Sensitivity:** Different languages and cultures have unique perspectives and attitudes toward stammering. Conducting research across various Indian languages enables us to understand the cultural nuances associated with speech disorders and tailor interventions accordingly.
 - **Comparative Analysis:** By conducting research in multiple languages, we can perform comparative analyses to identify commonalities and differences in stammering patterns.

This can lead to a deeper understanding of the linguistic and phonological factors contributing to stammering.

- **Adapting Strategies:** Insights gained from this research can be used to develop stammering intervention strategies that are sensitive to the linguistic characteristics of each language family. This tailored approach can yield more effective results for individuals seeking therapy in their native language.

- **Importance of Indo-Aryan Language Expansion:** Given that Hindi is an Indo-Aryan language, the insights derived from this research in Hindi can serve as a valuable foundation for expanding into other Indo-Aryan languages. While there are variations among Indo-Aryan languages, they share certain phonemes and phonological features due to their linguistic heritage. Therefore, the findings in Hindi can provide essential insights into stammering patterns in languages like Bengali, Marathi, Gujarati, and more.
 - **Comparative Advantage over Foreign Languages:** In comparison to foreign languages, Hindi specific research in Indian languages offers distinct advantages. Here is why:
 - **Phonemic Similarities:** Indian languages, including those from both the Indo-Aryan and Dravidian families, share commonalities in their phonemic inventories. This means that insights and detection models developed in Indian languages can be more directly applicable to a range of Indian languages compared to foreign languages, which may have entirely different phonetic structures.

- **Cultural Relevance:** The research conducted within the Indian context is culturally relevant and sensitive to the specific challenges faced by individuals in this region. This relevance enhances the effectiveness of interventions and support systems.
- **Scalability:** The multilingual expansion within the Indian context is highly scalable, given the vast population and linguistic diversity in India. The impact of this research can be far-reaching, positively affecting the lives of millions of individuals who stammer across different Indian languages.

Expanding this stammering detection research to include other Indian languages is not only essential for addressing the diverse linguistic needs of the Indian population but also holds promise for shedding light on the broader linguistic factors influencing stammering. While Indo-Aryan languages may share certain linguistic traits, the diversity of Indian languages requires a nuanced approach, and this research can contribute significantly to this endeavor. Furthermore, the insights gained from Indian languages can serve as a valuable reference point for speech disorder research globally, given the distinct linguistic landscape of India.

7.5 Limitations

The difficulties in gathering data, particularly with regard to female volunteers, are one of the major topics of discussion that resulted from this study. While our research aimed to include a diverse range of speakers, we had trouble locating female participants who were willing to provide data on their stammering. It can be difficult to persuade female speakers to come forward and share their experiences because of the social stigma frequently connected to communication disorders. As a result, the majority of the data in our dataset come from male speakers, which restricts the applicability of our computational experiments to settings where men predominate. It is important to note, however, that despite the sparse data, we were able to learn a great deal about linguistics

from the speech of the one female participant. Future research projects should concentrate on reversing this gender disparity by adopting measures to lessen social stigmas and boosting female participation in these types of studies.

7.6 Challenges

Data collection for this study was difficult, especially when trying to convince people who stammer to contribute their speech samples. Stammering is an extremely sensitive and personal issue, and many people may be reluctant to share their speech data out of embarrassment or out of concern for criticism. Since obtaining a representative and diverse sample is necessary for reliable analysis and results, this reluctance poses a significant obstacle to developing a comprehensive dataset for stammering research. Despite our best efforts, the process of gathering information from volunteers presented time and resource limitations because we needed to build rapport and trust with potential participants. Researchers must use proactive and considerate methods in their future work to interact with people who stammer, creating a supportive, empathetic, and inclusive environment.

7.7 Future Plan

For our upcoming research, we intend to develop machine learning models tailored for predicting the severity of stammering by analyzing distinct stammering features present in speech samples. The models will be fine-tuned using multi-class classification data encompassing various severity levels, namely mild, moderate, and severe. Our objective includes identifying specific stammering types such as phoneme repetition, syllable repetition, and prolongation (Dwivedi et al., 2021). This

approach aims to automate and streamline the identification process, eliminating manual tasks like syllable calculation currently performed by speech language pathologists. By leveraging these automated models, we aim to ensure that individuals receive appropriate therapy tailored to their identified patterns. Additionally, we plan to create stammering exercises specifically designed for Hindi speakers, facilitating speech language pathologists in delivering targeted linguistic interventions for effective treatment.

In our future research endeavors, we are contemplating the utilization of pre-trained image classifiers, fine-tuning them with our constrained dataset. It is crucial to highlight that our existing study primarily centered around training models from the ground up, whereas our forthcoming work will involve exploring the use of pre-trained models. It is noteworthy that our current study extensively utilized spectrograms obtained from audio for generating training data, underscoring the effectiveness of imagery in our methodology. This approach exhibits potential for the subsequent stages of our research.

Future research projects on stammering should consider the creation of a language-independent stammering model. The difficulties and linguistic complexities of stammering may differ across different languages and linguistic communities, but our current study concentrated on stammering in the context of the Hindi language. A model that is independent of language would make it possible to understand stammering on a more global scale, enabling cross-linguistic comparisons and having a greater influence on the research community. Such a model would necessitate the gathering of stammered speech data from speakers of different languages, thereby amplifying the significance of addressing data collection issues and enticing participation from different linguistic backgrounds.

Future research should also investigate novel methods to improve data collection, considering the moral ramifications and privacy issues related to speech data. More people who stammer can participate in research projects because of the use of anonymization techniques and strict data protection regulations, which can boost participant confidence and allay potential privacy concerns.

Furthermore, by utilizing developments in machine learning and natural language processing, future research could focus on creating more complex and context-aware stammering models. This may open the door to enhanced speech recognition and language processing tools that better meet the requirements of people who stammer, enabling more inclusive and accessible communication technologies.

In conclusion, our research journey has given us invaluable insights into the linguistic aspects of stammering in the Hindi language, despite the difficulties encountered in data collection and the restrictions imposed by gender representation. Looking ahead, we envision a steadfast dedication to advancing stammering research, tackling obstacles, and seizing chances to improve understanding and support for people who stammer in a variety of linguistic contexts. We can pave the way for a more accepting and empowered environment for those affected by stammering through interdisciplinary collaboration and concerted efforts.

