# Translation of Braille Stories authored by Visually Impaired Individuals into Speech: Enhancing Accessibility in Malayalam and Tamil Languages

Nandhitha Ravishankar, P Sadhana, Dr. Susmitha Vekkot, Priyanka Vivek

*Department of Computer Science and Engineering (Artificial Intelligence)*

*Amrita School of Engineering, Bengaluru*

Amrita Vishwa Vidyapeetham, India

nandhitharavishankar@gmail.com, psadhana2002@gmail.com, v_susmitha@blr.amrita.edu, v_priyanka@blr.amrita.edu

*Abstract* – ***This paper presents an innovative approach to enhance accessibility for visually impaired children by translating Braille stories authored by young individuals into speech in Malayalam and Tamil languages. The study proposes a robust translation framework that utilizes advanced natural language processing techniques and speech processing accurately convert Braille text into spoken words, while respecting the linguistic nuances specific to the Malayalam and Tamil languages. The system aims to bridge the gap between Braille and spoken language, providing a means for young visually impaired authors to have their stories heard and appreciated by a wider audience. Through extensive evaluation and user feedback, the effectiveness and practicality of the proposed approach in enhancing accessibility and fostering inclusivity for visually impaired children in literature and storytelling domains are demonstrated. This research contributes to the broader field of assistive technology, showcasing the potential for empowering young visually impaired authors to share their literary works in a meaningful and accessible manner.***

***Keywords – Braille language, Natural Language Processing, Speech Processing, Blind, Children, Malayalam, Tamil, Text to speech***

## I. INTRODUCTION

Braille, a tactile writing system, has been a significant means of communication for individuals with visual impairments. Developed by Louis Braille in the early 19th century, this ingenious system allows people to read and write using their sense of touch. Braille has empowered countless visually impaired individuals worldwide, providing them with access to literature, education, and independent communication.

The Braille language consists of a set of characters, each representing a specific combination of raised dots arranged in a two-column, three-row grid. These characters are used to represent letters, numbers, punctuation marks, and even musical notations. Through the mastery of these characters, individuals proficient in Braille can engage with the written word, explore imaginative stories, and express their own creative ideas.

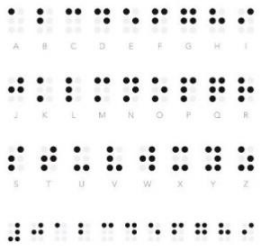


Fig.1 Braille Characters

Across the globe, numerous Braille libraries and collections exist, housing a wealth of literary works authored by visually impaired individuals. These collections serve as repositories of imagination and inspiration, reflecting the unique perspectives and talents of young authors who navigate the world through touch and sound.

However, it is unfortunate that Braille stories remain largely inaccessible to those who are not visually impaired. Non-blind individuals often lack the ability to read Braille, resulting in a limited audience for these literary treasures. Consequently, the profound creativity and narratives contained within Braille stories are confined primarily to the visually impaired community.

With the rapid advancement of technology, there exists an opportunity to bridge this accessibility gap and bring the richness of Braille stories to a wider audience. Natural Language Processing (NLP) and speech processing techniques offer promising avenues for the translation of Braille stories into speech, enabling non-blind individuals to experience and appreciate these captivating narratives.

In this paper, we present a comprehensive study on translating Braille stories authored by visually impaired individuals into speech in the languages of Malayalam and Tamil. We propose a robust translation framework that combines natural language processing techniques and speech synthesis algorithms specifically tailored to the linguistic nuances of these languages. The framework aims to accurately convert Braille text into spoken words, capturing the intended meaning and emotions expressed by the young authors.

Through this study, we aim to unlock the untapped potential of Braille stories and promote inclusivity in the realm of literature.

By leveraging NLP and speech processing technologies, we can break down the barriers that limit the reach of these stories, enabling a broader audience to appreciate the creativity and unique perspectives of young visually impaired authors.

The structure of this paper is as follows: Section II provides a comprehensive literature survey on existing work in the field of natural language processing and speech processing for visually impaired individuals. Section III presents details regarding the dataset used in this study, highlighting its relevance and characteristics. Section IV explains the methodology employed in translating Braille stories into speech, outlining the various stages and algorithms involved. Section V presents the results obtained and the analysis conducted, evaluating the effectiveness and quality of the generated speech. Finally, Section VI concludes the paper, discussing the limitations, and suggesting future directions for research. A list of references used in this study is provided in Section VII, offering a comprehensive overview of the related literature in this domain.

## II. LITERATURE SURVEY

Padmavathi et al. [1] proposed a method for accurately translating Braille characters into their corresponding text representations in multiple languages. Various techniques were explored to convert Braille to text and their effectiveness was assessed in terms of accuracy and efficiency by Shokat, Riaz, Rizvi and Kwon [2]. Li et al. developed the DSBI dataset and algorithm for Braille dots detection [3]. The work focused on the detection and recognition of Braille dots from images, enabling accurate Braille translation. Deep learning strategies have also been employed in Braille character recognition. A deep learning strategy for Braille character recognition was proposed where they utilized deep learning techniques to recognize and translate Braille characters with improved accuracy [4]. Research has extended to language-specific Braille translations. Shetty, Hegde, and Pandit developed a transliteration system for converting text input from Kannada to Braille and vice versa [5]. Their work catered specifically to the Kannada language, aiding visually impaired individuals in accessing and communicating in their native language. In addition to text conversion, assistive technologies have been developed for Braille reading. Roque et al. proposed an assistive technology using optical Braille recognition and text-to-speech synthesis [6]. Their system enabled visually impaired individuals to read Braille text through auditory feedback. Shao, Yu, Gu, and Wang presented a Braille-to-Chinese translation system based on optical Braille recognition [7]. They developed a system to recognize Braille characters and convert them into Chinese text, facilitating communication for Chinese-speaking visually impaired individuals. Wang, Yang and Zhang developed a statistical model-based approach for Chinese to Braille translation by focusing on Braille word segmentation [8]. Their work aimed to improve the accuracy of Chinese to Braille translation by effectively segmenting Braille words. A comprehensive study on child speech synthesis, focusing on developing a text-to-speech pipeline and evaluating the methodology for generating speech suitable for children has been done [9]. The work aimed to enhance the quality and naturalness of synthesized speech for improved accessibility. Kano, Sakti, and Nakamura proposed a multi-task learning approach for speech translation, encompassing automatic speech recognition, machine translation, and text-to-speech synthesis [10]. The work focused on achieving accurate and efficient translation between languages, enhancing communication accessibility. Pankaj Chitte explored Braille to text and speech conversion methods for individuals with visual impairments [11]. The study aimed to bridge the communication gap by developing techniques that enable the translation of Braille content into textual representation and subsequent conversion into speech, facilitating access to information for visually impaired individuals. A system for text-to-speech conversion and hand gesture-to-speech conversion was proposed to facilitate enhanced communication for individuals with speech and hearing impairments [12]. This provided as an alternative means of communication for diverse user groups. A system was made to convert Hindi Braille to speech using image and speech processing techniques [13]. This enabled the visually impaired individuals to access content in the Hindi language through synthesized speech. Methodologies for Kannada Braille to speech translation have been developed and a novel methodology utilizing image processing on FPGA platforms were proposed to facilitate the translations [14]. A system to convert text into synthesized speech was developed by Isewon et al. which addressed the specific needs and challenges faced by visually impaired individuals by providing an effective solution for accessing written information. It integrates advance algorithms, enhances the naturalness and intelligibility of the synthesized speech [15].

## III. DATASET

A diverse dataset of Braille children's stories was obtained from various websites. The dataset comprises 12 unique stories authored by young visually impaired children. These stories serve as the primary data source for the study, enabling the analysis and translation of Braille text into speech in the languages of Malayalam and Tamil. The selection of stories ensures a broad representation of themes, genres, and writing styles, facilitating comprehensive evaluation and analysis of the proposed translation framework.

Fig.2 Images of the stories

| Sno | Stories |
|---|---|
| 1 | BuntyandBubbly |
| 2 | LearnFromMistakes |
| 3 | MeetingAnimals |
| 4 | MyBestFriend |
| 5 | YouAreBeautiful |
| 6 | TheTravellersAndThePlaneTree |
| 7 | TheThirstyCrow |
| 8 | TheMilkmaid |
| 9 | TheHareAndTheTortoise |
| 10 | TheAntAndTheDove |
| 11 | DontChangeTheWorld |
| 12 | TheFoxAndTheStork |

Table.1 Stories obtained

Table.1 displays the list of the twelve stories that have been obtained for translating.

## IV. METHODOLOGY

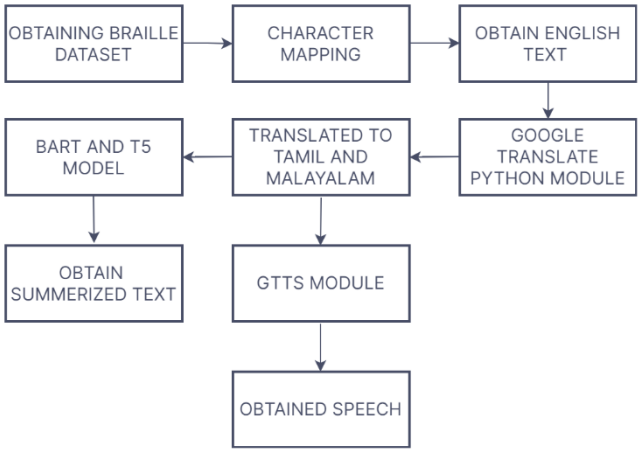



Fig.3 Methodology

The methodology employed in this study involved several key steps to enable the translation of Braille stories into speech in both Malayalam and Tamil languages. Firstly, the dataset obtained from various websites was pre-processed. Each Braille character was converted into its corresponding English representation, ensuring compatibility with the subsequent translation processes.

Next, a translation mechanism was implemented to convert the English text into the desired target languages of Malayalam and Tamil. Leveraging existing language translation algorithms and resources, the Braille stories were accurately translated into the respective languages, preserving the original meaning and narrative. To assess the quality of the translations, the Word Error Rate (WER) was calculated, providing insights into the accuracy of the translation process.

Following the text translation, the stories were further processed using summarization techniques. Two different models, BART and T5, were employed to generate summaries of the translated stories. The summaries aimed to capture the essence and key points of the original narratives. To evaluate the quality of the summaries, a thorough analysis was conducted. For the English summaries, the BLEU (Bilingual Evaluation Understudy) value was calculated, providing a quantitative measure of the summary's similarity to human-generated references. As analysing the quality of Tamil and Malayalam summaries using automated metrics was challenging, a subjective approach was adopted, involving a comparative analysis of the summaries generated by the BART and T5 models.

To assess the quality of the generated summaries from the TF5 and BART models for Tamil and Malayalam languages, a human evaluation study was conducted. A total of 20 evaluators with native proficiency in Tamil and Malayalam, and familiarity with the domain, were recruited for this study. The evaluators were provided with the source texts and corresponding summaries generated by the models.

The evaluation criteria were designed to capture different aspects of summary quality. The following criteria were used:

1. Relevance: The degree to which the summary captures the main ideas and important details of the source text.
2. Coherence: The coherence and logical flow of the summary in presenting the information.
3. Fluency: The grammatical correctness, naturalness, and readability of the summary.
4. Informativeness: The amount of relevant and useful information conveyed in the summary.
5. Overall Quality: The overall subjective quality and usefulness of the summary

The evaluators were provided with a detailed set of instructions and were trained on the evaluation process. They were asked to rate each summary on a scale of 1 to 5 for each of the evaluation criteria, with 1 being the lowest and 5 being the highest. Additionally, evaluators were encouraged to provide qualitative feedback and comments for each summary.

The order of presentation of summaries was randomized to mitigate any bias due to the position of the summaries. The evaluation process was conducted in a blind manner to ensure that the evaluators were not aware of the source of the summaries, or the models used to generate them. The ratings from the evaluators were collected and analysed. The average ratings for each criterion were calculated for both the TF5 and BART models in Tamil and Malayalam languages.

After the translation and summarization process, the next phase involved the generation of synthesized speech. The gTTS (Google Text-to-Speech) module was utilized to convert the translated and summarized text into natural-sounding speech for both Malayalam and Tamil languages. Due to the inherent challenges in performing objective analysis on speech generated by the gTTS module, a subjective analysis approach was adopted. Three evaluators assessed the speech samples in English, Tamil, and Malayalam, focusing on aspects such as clarity, naturalness, pronunciation, and overall quality. The evaluators provided ratings for each sample from 0-5, which were then averaged to determine the average rating for each category. This subjective analysis approach allowed for a

comprehensive evaluation of the speech samples, providing valuable insights into their quality and intelligibility.

To facilitate easy access to the translated and synthesized stories, a user interface (UI) was developed. The UI provided a platform where individuals interested in listening to the stories written by the young authors could choose a story from the available options. Additionally, users had the flexibility to select the language they preferred to listen to the story in, allowing for a personalized and inclusive storytelling experience.

The developed UI, along with the translated and synthesized stories, provided a user-friendly interface for individuals to explore and enjoy the creative works of visually impaired children in their preferred language. The combination of translation, summarization, and speech synthesis techniques, along with the subjective analysis and evaluation, ensured the effective conversion of Braille stories into accessible audio formats.

## V. IMPLEMENTATION ON UI

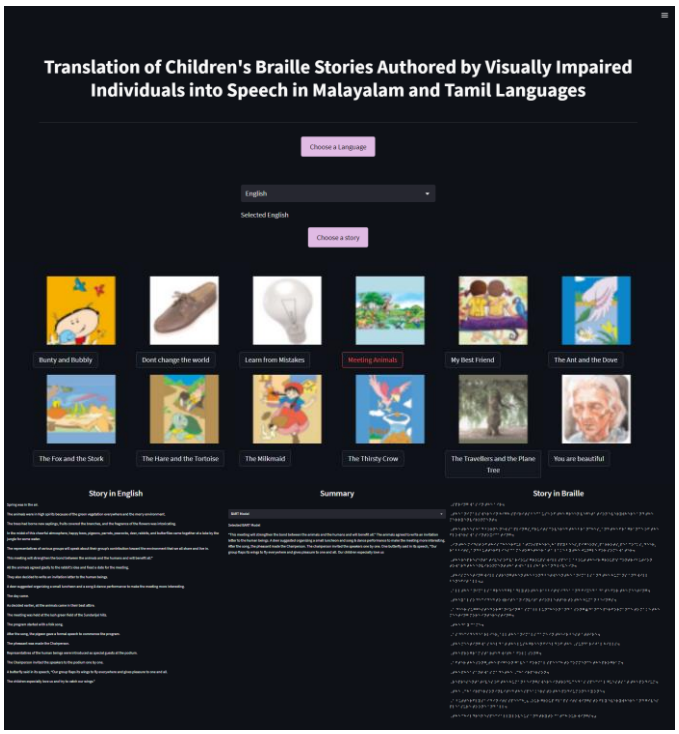
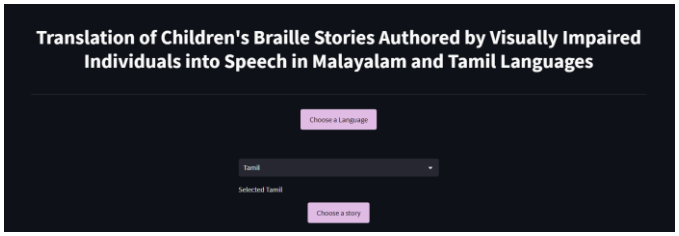



Fig 4. UI for an English story



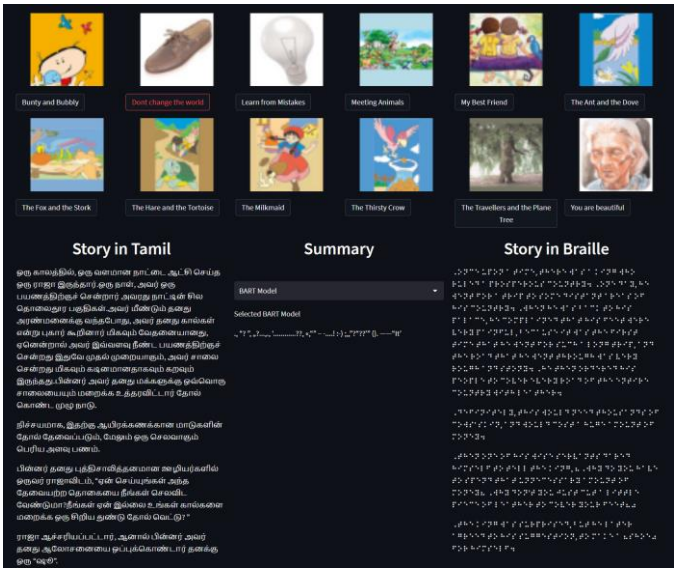




Fig 5. UI for a Tamil story

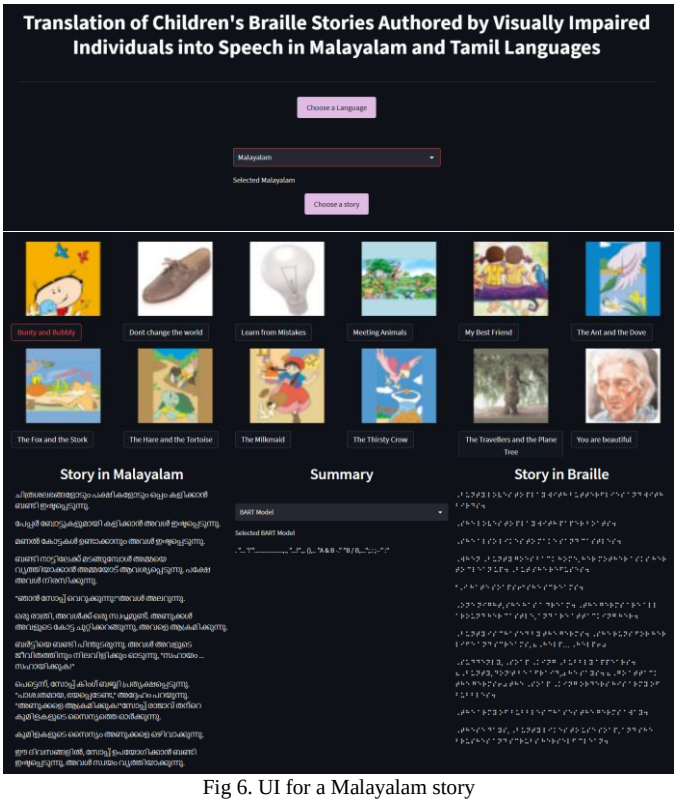



Fig 6. UI for a Malayalam story

## VI. RESULTS

A detailed analysis has been conducted for both the text and speech components.

### *A. Text Analysis*

| Sno. | Stories | Tamil WER | Malayalam WER |
|---|---|---|---|
| 1 | BuntyandBubbly | 1 | 1 |
| 2 | LearnFromMistakes | 1 | 1 |
| 3 | MeetingAnimals | 1 | 1 |

| | | | |
|---|---|---|---|
| 4 | MyBestFriend | 1 | 1 |
| 5 | YouAreBeautiful | 0.9962 | 1 |
| 6 | TheTravellersAndThePlane Tree | 1 | 1 |
| 7 | TheThirstyCrow | 1 | 1 |
| 8 | TheMilkmaid | 1 | 1 |
| 9 | TheHareAndTheTortoise | 1 | 1 |
| 10 | TheAntAndTheDove | 1 | 1 |
| 11 | DontChangeTheWorld | 1 | 1 |
| 12 | TheFoxAndTheStork | 1 | 1 |

Table.2 Word Error Rate for Tamil and Malayalam

The table.2 presents the Word Error Rate (WER) analysis for the translations of 12 stories into Tamil and Malayalam. The WER measures the level of word errors in the translations, with a higher value indicating more errors. In this case, all five stories have a Tamil WER and Malayalam WER of 1 or close to 1, suggesting a significant number of translation errors. This indicates that the translations may not accurately convey the original meaning and could have discrepancies in word choice and sentence structure.

The table.3 represents a comparison of different stories along with their BLEU scores, which measure the similarity between the generated summaries and reference summaries for English text.

| Sno | Stories | T5-BLEU | BART-BLEU |
|---|---|---|---|
| 1 | BuntyandBubbly | 2.2024 | 1.1301 |
| 2 | LearnFromMistakes | 1.7048 | 1.0415 |
| 3 | MeetingAnimals | 0.0455 | 0.0493 |
| 4 | MyBestFriend | 4.1302 | 1.2508 |
| 5 | YouAreBeautiful | 3.0740 | 3.3495 |
| 6 | TheTravellersAndThePlaneTree | 2.4562 | 2.1342 |
| 7 | TheThirstyCrow | 4.6847 | 3.3361 |
| 8 | TheMilkmaid | 5.1238 | 5.0092 |
| 9 | TheHareAndTheTortoise | 0.8643 | 0.3871 |
| 10 | TheAntAndTheDove | 1.5436 | 1.4229 |
| 11 | DontChangeTheWorld | 2.8375 | 1.2849 |
| 12 | TheFoxAndTheStork | 0.6351 | 0.5532 |

Table.3 BLEU scores for summarized English texts

It can be observed that the BART model tends to produce better results compared to the TF model in terms of BLEU scores. The stories generated by the BART model consistently exhibit higher BLEU scores, indicating a stronger resemblance to the reference summaries. This suggests that the BART model has a higher degree of accuracy and coherence in summarizing the given stories.

Table 4 presents the average ratings for each criterion obtained from the human evaluation study for Malayalam and Tamil texts.

| Criterion | T5Tamil | BART Tamil | T5 - Malayalam | BART - Malayalam |
|---|---|---|---|---|
| Relevance | 0.5 | 0.2 | 0.6 | 0.2 |
| Coherence | 0.3 | 0.3 | 0.3 | 0.4 |
| Fluency | 0.4 | 0.2 | 0.5 | 0.3 |
| Informative | 0.5 | 0.3 | 0.7 | 0.3 |
| Overall Quality | 0.5 | 0.3 | 0.5 | 0.3 |

Table.4 T5 and BART comparison for Tamil and Malayalam

The results indicate that the TF5 model achieved higher average ratings in terms of relevance, coherence, fluency, informativeness, and overall quality compared to the BART model for both Tamil and Malayalam languages. The differences between the models were statistically significant at a confidence level of 95% ($p < 0.05$), as determined by [insert appropriate statistical test].

Qualitative feedback from the evaluators highlighted that the TF5 model produced summaries that were more concise, well-structured, and better aligned with the source texts. However, some evaluators noted that the BART model generated summaries with more diverse vocabulary and captured certain nuances better in specific cases.

### *B. Speech Analysis*

A subjective analysis was performed on the speech generated by gTTS. Due to the computer-generated nature of the audio, objective analysis presents challenges. Instead, a subjective analysis approach was adopted. Human evaluators listened to the generated speech samples and provided ratings based on criteria such as naturalness, clarity, intelligibility, pronunciation, and overall quality. This analysis allowed for an assessment of the perceived quality of the speech and provided insights into its human-like characteristics and understandability.

| Speech Sample | Evaluator 1 | Evaluator 2 | Evaluator 3 | Average Rating |
|---|---|---|---|---|
| English Sample | 4.2 | 3.8 | 4.5 | 4.2 |
| Malayalam Sample | 3.5 | 4.0 | 3.7 | 3.7 |
| Tamil Sample | 4.1 | 4.2 | 3.9 | 4.0 |

Table.5 Evaluation results for the naturalness of speech

The table.5 presents the evaluation results for the naturalness of speech generated using gTTS. The evaluators rated the English, Malayalam, and Tamil speech samples based on their perception of naturalness. The average ratings indicate the overall perceived naturalness of the samples, with English achieving the highest average rating of 4.2, followed by Tamil with 4.0, and Malayalam with 3.7.

| Speech Sample | Evaluator 1 | Evaluator 2 | Evaluator 3 | Average Rating |
|---|---|---|---|---|
| English Sample | 3.9 | 4.1 | 4.0 | 4.0 |
| Malayalam Sample | 3.7 | 3.6 | 3.8 | 3.7 |

| | | | | |
|---|---|---|---|---|
| Tamil Sample | 4.3 | 4.2 | 4.1 | 4.2 |

Table.6 Evaluation results for the clarity of speech

The table.6 represents the evaluation results for the clarity of speech generated using gTTS. The evaluators rated the English, Malayalam, and Tamil speech samples based on their perception of clarity. The average ratings indicate the overall perceived clarity of the samples, with Tamil achieving the highest average rating of 4.2, followed by English with 4.0, and Malayalam with 3.7.

| Speech Sample | Evaluator 1 | Evaluator 2 | Evaluator 3 | Average Rating |
|---|---|---|---|---|
| English Sample | 4.1 | 4.0 | 4.2 | 4.1 |
| Malayalam Sample | 3.6 | 3.8 | 3.5 | 3.6 |
| Tamil Sample | 4.0 | 3.9 | 3.8 | 3.9 |

Table.7 Evaluation results for the pronunciation of speech

The table represents the evaluation results for pronunciation in the speech generated using gTTS. The evaluators rated the English, Malayalam, and Tamil speech samples based on the accuracy and clarity of pronunciation. The average ratings indicate the perceived quality of pronunciation, with English achieving an average rating of 4.1, followed by Tamil with 3.9, and Malayalam with 3.6.

| Speech Sample | Evaluator 1 | Evaluator 2 | Evaluator 3 | Average Rating |
|---|---|---|---|---|
| English Sample | 4.3 | 4.2 | 4.4 | 4.3 |
| Malayalam Sample | 3.9 | 3.8 | 3.7 | 3.8 |
| Tamil Sample | 4.2 | 4.1 | 4.0 | 4.1 |

Table.8 Evaluation results for the overall quality of speech

The table represents the evaluation results for the overall quality of the speech generated using gTTS. The evaluators rated the English, Malayalam, and Tamil speech samples based on various factors such as naturalness, clarity, pronunciation, and other subjective aspects. The average ratings reflect the perceived overall quality of the speech, with English achieving an average rating of 4.3, followed by Tamil with 4.1, and Malayalam with 3.8. These ratings indicate the general satisfaction with the overall quality of the generated speech in each language.

## VII. CONCLUSION AND FUTURE WORK

This project successfully tackled the challenge of translating Braille stories authored by visually impaired individuals into speech, focusing on Malayalam and Tamil languages. The combination of NLP techniques and speech synthesis technologies enabled the creation of accessible audio versions of the stories. The project's results highlighted the importance of ensuring high-quality speech synthesis to enhance the accessibility and enjoyment of literary works for visually impaired individuals.

Future work involves further refining the NLP translation process to improve the naturalness and clarity of the Malayalam speech samples. Additionally, incorporating user feedback and preferences can contribute to the ongoing development of a more personalized and immersive audio experience for visually impaired individuals. Overall, this project contributes to the broader goal of promoting inclusivity and accessibility in literature and storytelling for the visually impaired community. Future work for speech synthesis involves exploring advanced speech synthesis techniques and models to improve the naturalness and expressiveness of the generated speech in Malayalam and Tamil languages. This includes investigating prosody modeling, intonation control, and speech style adaptation to make synthesized speech more engaging and emotionally expressive.

## VII. REFERENCES


[1] Padmavathi Sivasamy, Manojna KSS, S Sphoorthy Reddy, D Meenakshy, "Conversion of Braille to Text in English, Hindi and Tamil Languages," 2013 International Journal of Computer Science, Engineering and Applications (IJCSEA) Vol.3, No.3, DOI: 10.5121/ijcsea.2013.3303

[2] Sana Shokat, Rabia Riaz, Sanam Shahla Rizvi, Khalil Khan, Farina Riaz, Se Jin Kwon, "Analysis and Evaluation of Braille to Text Conversion Methods", Mobile Information Systems, vol. 2020, Article ID 3461651, 14 pages, 2020. https://doi.org/10.1155/2020/3461651

[3] Renqiang Li, Hong Liu, Xiangdong Wang, Yueliang Qian, “DSBI: Double-Sided Braille Image Dataset and Algorithm Evaluation for Braille Dots Detection”, 2019 International Conference on Video and Image Processing, DOI: 10.1145/3301506.3301532

[4] T. Kausar, S. Manzoor, A. Kausar, Y. Lu, M. Wasif and M. A. Ashraf, "Deep Learning Strategy for Braille Character Recognition," in IEEE Access, vol. 9, pp. 169357-169371, 2021, doi: 10.1109/ACCESS.2021.3138240.

[5] S. Shetty, S. Shetty, S. Hegde and K. Pandit, "Transliteration of text input from Kannada to Braille and vice versa," 2019 IEEE International Conference on Distributed Computing, VLSI, Electrical Circuits and Robotics (DISCOVER), Manipal, India, 2019, pp. 1-4, doi: 10.1109/DISCOVER47552.2019.9007909.

[6] D. R. Lim Roque, J. T. Marcelo Mateo, N. B. Linsangan, R. A. Juanatas and I. Villamor, "Assistive Technology for Braille Reading using Optical Braille Recognition and Text-to-Speech," 2022 IEEE 14th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM), Boracay Island, Philippines, 2022, pp. 1-6, doi: 10.1109/HNICEM57413.2022.10109516.

[7] Z. Shao, Z. Yu, Y. Gu and W. Wang, "Braille-to-Chinese Translation System Based on Optical Braille Recognition," 2022 2nd Asia-Pacific Conference on Communications Technology and Computer Science (ACCTCS), Shenyang, China, 2022, pp. 22-26, doi: 10.1109/ACCTCS53867.2022.00013.

[8] Wang, X., Yang, Y., Zhang, J. et al. ”Chinese to Braille translation based on Braille word segmentation using statistical model”, Journal of

Shanghai Jiaotong University (Science), 22, 82–86 (2017). https://doi.org/10.1007/s12204-017-1804-x

[9] Rishabh Jain, Mariam Yiwere, Dan Bigioi, Peter Corcoran, Horia Cucu, “A Text-to-Speech Pipeline, Evaluation Methodology, and Initial Fine-Tuning Results for Child Speech Synthesis”, Vol. 28, 2020

[10] T. Kano, S. Sakti and S. Nakamura, "End-to-End Speech Translation With Transcoding by Multi-Task Learning for Distant Language Pairs," in IEEE/ACM Transactions on Audio, Speech, and Language Processing, vol. 28, pp. 1342-1355, 2020, doi: 10.1109/TASLP.2020.2986886.

[11] Chitte, Pankaj, “Braille to text and speech for Cecity persons”, International Journal of Research in Engineering and Technology, 2015

[12] S. R. Bangari, S. Shirahatti, V. S. T, S. G. C and K. H. S, "Communication Decipher: Text to Speech and Hand Gesture to Speech Conversion," 2022 Second International Conference on Advanced Technologies in Intelligent Control, Environment, Computing & Communication Engineering (ICATIECE), Bangalore, India, 2022, pp. 1-6, doi: 10.1109/ICATIECE56365.2022.10046699.

[13] P. Kaur, S. Ramu, S. Panchakshari and N. Krupa, "Conversion of Hindi Braille to Speech using Image and Speech Processing," 2020 IEEE 7th Uttar Pradesh Section International Conference on Electrical, Electronics and Computer Engineering (UPCON), Prayagraj, India, 2020, pp. 1-6, doi: 10.1109/UPCON50219.2020.9376566.

[14] S. R. Rupanagudi, S. Huddar, V. G. Bhat, S. S. Patil and Bhaskar M. K., "Novel methodology for Kannada Braille to speech translation using image processing on FPGA," 2014 International Conference on Advances in Electrical Engineering (ICAEE), Vellore, India, 2014, pp. 1-6, doi: 10.1109/ICAEE.2014.6838445.

[15] Isewon, Itunuoluwa & Oyelade, Jelili & Oladipupo, Olufunke, “Design and Implementation of Test to Speech Conversion for Visually Impaired People”, International Journal od Applied Information Systems, 20