Volume 10, Issue 3, March– 2025 International Journal of Innovative Science and Research Technology
ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

Bridging Communication Gaps: The Development of Speech Interpretation and Gesture Notation for the Hearing and Mute Students of South East Asian Institute of Technology, Inc

Ledon Jay B. Jordan[1]; Javidec D. Monsion[2]; Kane Joy O. Urbayo[3];
Hernan Jr. E. Trillano[4]

[1;2;3]BSIT Students, South East Asian Institute of Technology, Inc., Philippines
[4]Faculty, South East Asian Institute of Technology, Inc., Philippines
College of Information and Communication Technology
Tupi, South Cotabato, Philippines 9505

Publication Date: 2025/03/29

Abstract: Communication is fundamental to human interaction, enabling individuals to express thoughts, emotions, and ideas. However, deaf individuals face unique challenges that require alternative methods to bridge the gap between the hearing and non-hearing communities. Despite technological advancements, communication barriers persist within the deaf community. This study aimed to address these challenges by developing the Speech Interpretation and Gesture Notation (S.I.G.N.) application, a communication tool designed to assist both deaf and hearing individuals in understanding each other. The application provides real-time speech and gesture translation, facilitating more accessible interactions in various situations. The development process followed the Incremental Agile Model, allowing each feature of the S.I.G.N. application to be built, tested, and refined iteratively based on ongoing feedback. The application integrates OpenCV and MediaPipe for sign language recognition, ensuring accurate translations. Results indicated that the S.I.G.N. application is both practical and feasible in enhancing interactions between deaf or mute and hearing individuals. It successfully offers a modern and inclusive solution to communication challenges. Therefore, implementing this system is essential to improving accessibility and inclusivity for all users.

The System Usability Scale (SUS) evaluation showed an average score of 85.75, indicating that the system was highly usable and effective. Both deaf and mute individuals and hearing users provided positive feedback, confirming that the system functioned as intended. The application successfully facilitated smooth communication by converting gestures to text and speech to gestures. While the system was generally easy to use, some respondents suggested that enhancing real-time translation and expanding the sign language database could further improve the user experience. Overall, the SIGN app met its goal of bridging communication gaps and promoting better interaction between deaf and hearing individuals.

Keywords: *Sign Language, Gesture-to-Text, Speech-to-Gesture, Accessibility, Communication System.*

How to Cite: Ledon Jay B. Jordan; Javidec D. Monsion; Kane Joy O. Urbayo; Hernan Jr. E. Trillano (2025). Bridging Communication Gaps: The Development of Speech Interpretation and Gesture Notation for the Hearing and Mute Students of South East Asian Institute of Technology, Inc. *International Journal of Innovative Science and Research Technology,* 10(3), 1489-1498. https://doi.org/10.38124/ijisrt/25mar1295

I. INTRODUCTION

Effective communication is essential for promoting inclusivity, particularly between deaf and hearing individuals. At the South East Asian Institute of Technology, Inc. (SEAIT), deaf students encountered challenges in interacting with peers and teachers due to the lack of effective communication tools. Traditional methods such as note-taking and basic gestures often led to misunderstandings and limited participation in school activities. Additionally, assessing deaf students required adaptations, making it difficult to accurately evaluate their understanding.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

To address these challenges, the researchers developed the Speech Interpretation and Gesture Notation (S.I.G.N.) application. The system translated speech into sign language and gestures into text, allowing real-time interaction between deaf and hearing users. It included a gesture learning module that enabled users to improve their sign language skills, an emergency alert button to notify authorities in critical situations and pre-set assistive buttons to help deaf individuals express essential needs without formal sign language knowledge. Additionally, the system stored a gesture history to allow users to review past conversations, enhancing future interactions.

By automating these processes, the S.I.G.N. application aimed to reduce communication barriers, improve inclusivity, and facilitate more meaningful exchanges between hearing and deaf individuals. The system ensured that interactions became more efficient, accurate, and accessible, ultimately enhancing the communication experience for both communities.

II. REVIEW OF RELATED LITERATURE AND STUDIES

➤ *Vision-Based Continuous Sign Language Recognition*

Sign language translation systems play an essential role in bridging the communication gap between the deaf and hearing communities. Vision-based systems, which use cameras to detect sign language, provide a more practical and affordable solution than sensor-based systems. However, current systems still face challenges, such as limited adaptability for users with additional disabilities and untested effectiveness in real-world settings [1]. Research highlights the need for improving user interaction and assessing long-term retention of sign language skills.

Sign language recognition has gained attention due to the potential of machine learning and image detection technologies to provide real-time captioning during virtual interactions. Models using Keras image analysis can translate gestures into text with high accuracy by detecting pauses and transitions between signs, allowing the translation of full sentences [2].

Similarly, [3] emphasized the importance of gesture recognition and motion tracking in translating sign language into speech and text, making communication smoother for the deaf community.

➤ *Local Efforts in Sign Language Recognition*

In the Philippines, several systems have been developed to address the communication challenges faced by the deaf community. Mendoza and Ramirez introduced a Filipino Sign Language (FSL) recognition system that translates basic hand gestures into text using Convolutional Neural Networks (CNN). However, most systems only focus on static gestures, limiting the recognition of complex and dynamic sign language [4]. Similarly, Alberto et al. proposed a real-time SLR system that translates FSL into spoken language, although the system's real-world effectiveness remains underexplored [5].

Montefalcon et al. highlighted the need for improving cultural context and idiomatic expressions in sign language recognition models. Their research pointed out the limited adaptability of current models to accurately translate complex FSL interactions, emphasizing the need for continuous testing and validation [6].

➤ *Interactive Mobile Applications for Sign Language*

Several mobile applications have been designed to promote inclusive communication between hearing and deaf individuals. "Kinect to Connect," developed by Gezza and Hanani, features a two-way gesture sensor that translates between text and sign language. However, its adaptability across different educational settings and long-term impact remains untested [7]. Similarly, Biswasa et al. explored the use of deep convolutional neural networks (CNNs) for real-time ASL interpretation, but gaps in model adaptability and performance with more complex sign languages were identified [8].

Locally, Banag developed a Filipino Sign Language tutorial mobile application that teaches FSL through animated equivalents of English words and sentences. Despite its success, the study lacked testing beyond the initial group and did not explore its long-term effectiveness [9]. Presto et al. introduced "Senyas," a web-based application featuring a 3D avatar and speech recognition technologies to translate spoken inputs into FSL. However, challenges in fully capturing the complexity of emotions and ensuring usability across different user groups remain unresolved [10].

"Simbo Wika," developed by Empe et al., provided an accessible platform for elementary students to learn FSL. The application effectively supported FSL education but highlighted gaps in its scalability and adaptability to a broader population [11].

III. METHODOLOGY

➤ *Research Methodology*

This section explains the methodology used in developing the Speech Interpretation and Gesture Notation (S.I.G.N.) Application and analysis of its key phases. The Incremental Model was used because it delivered functional components in smaller, manageable increments. Each feature—speech-to-sign translation, assistive buttons, gesture learning, emergency buttons, and gesture history—was developed, tested, and reviewed separately. This approach allowed continuous feedback and improvements, ensuring the application’s functionality and quality.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

➢ *Incremental Model Under the Agile Software Development Methodology.*

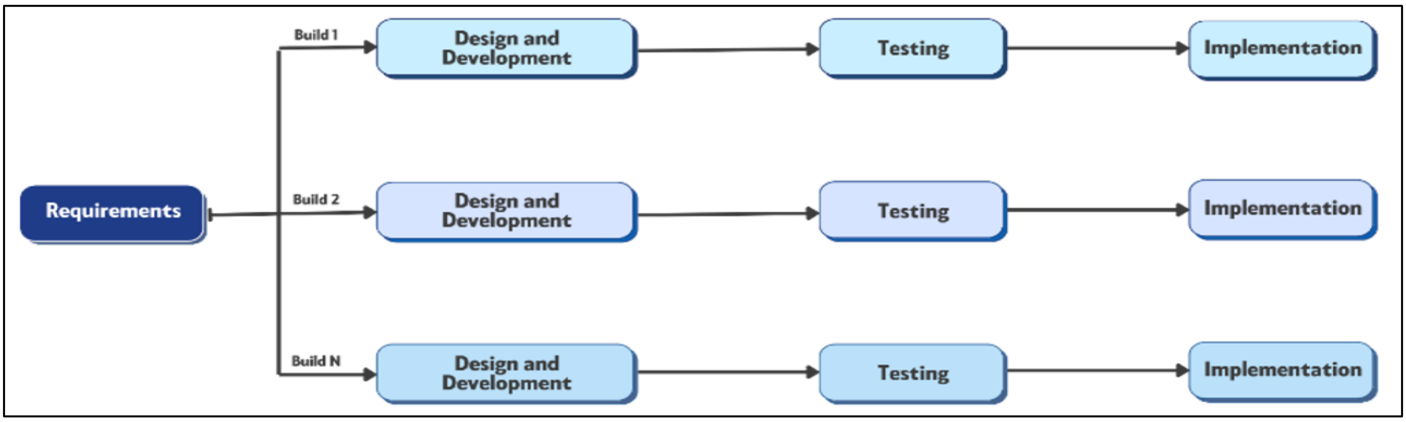

Fig 1 Incremental Model

The Incremental Model was used to develop the Speech Interpretation and Gesture Notation (S.I.G.N.) Application due to its ability to deliver continuous improvements through iterative development. Each stage focused on building and refining specific features such as speech-to-sign translation, assistive buttons, gesture learning, emergency buttons, and gesture history.

In the planning phase, requirements were gathered through observations and consultations at the South East Asian Institute of Technology, Inc. (SEAIT) to identify key features. The design phase involved creating wireframes and workflows to ensure a user-friendly interface aligned with stakeholder needs. During development, core functionalities were incrementally coded and integrated to enhance real-time translation and communication.

Testing was conducted in simulated environments to validate functionality, while feedback collected in the review phase helped refine features and address issues. The system was then deployed in a controlled environment for final validation. This iterative approach ensured that the application evolved effectively, meeting operational and user requirements while promoting continuous communication between deaf and hearing individuals.

➢ *Research Instrument*

Please enter your participant number: ________

1. **Hearing User (Non-Deaf/Mute)**
2. **Deaf/Mute User**
3. **Parent/Guardian of Deaf/Mute Individual**

System Usability Scale (SUS)

This is a standard questionnaire that measures the overall usability of a system. Please select the answer that best expresses how you feel about each statement after using the SIGN application.

	Strongly Disagree	Disagree	Moderately Agree	Agree	Strongly Disagree
1. I think I would like to use this tool frequently.	☐	☐	☐	☐	☐
2. I found the tool unnecessarily complex.	☐	☐	☐	☐	☐
3. I thought the tool was easy to use.	☐	☐	☐	☐	☐
4. I think that I would need the support of a technical person to be able to use this system.	☐	☐	☐	☐	☐
5. I found the various functions in this tool were well integrated.	☐	☐	☐	☐	☐
6. I thought there was too much inconsistency in this tool.	☐	☐	☐	☐	☐
7. I would imagine that most people would learn to use this tool very quickly.	☐	☐	☐	☐	☐
8. I found the tool very cumbersome to use.	☐	☐	☐	☐	☐
9. I felt very confident using the tool	☐	☐	☐	☐	☐
10. I needed to learn a lot of things before I could get going with this tool.	☐	☐	☐	☐	☐

How likely are you to recommend this application to others? (Please circle your answer)

1 - Not at all likely | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 - Extremely likely

Fig 2 SUS Evaluation Form

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

Figure 2 shows the System Usability Scale (SUS) Evaluation Form used to assess the usability and functionality of the Speech Interpretation and Gesture Notation (S.I.G.N.) Application. This form consists of a 30-item questionnaire designed to capture user feedback on their experience with the application, using a 5-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree.

IV. CONCEPTUAL FRAMEWORK OF THE STUDY

➢ *System Design*

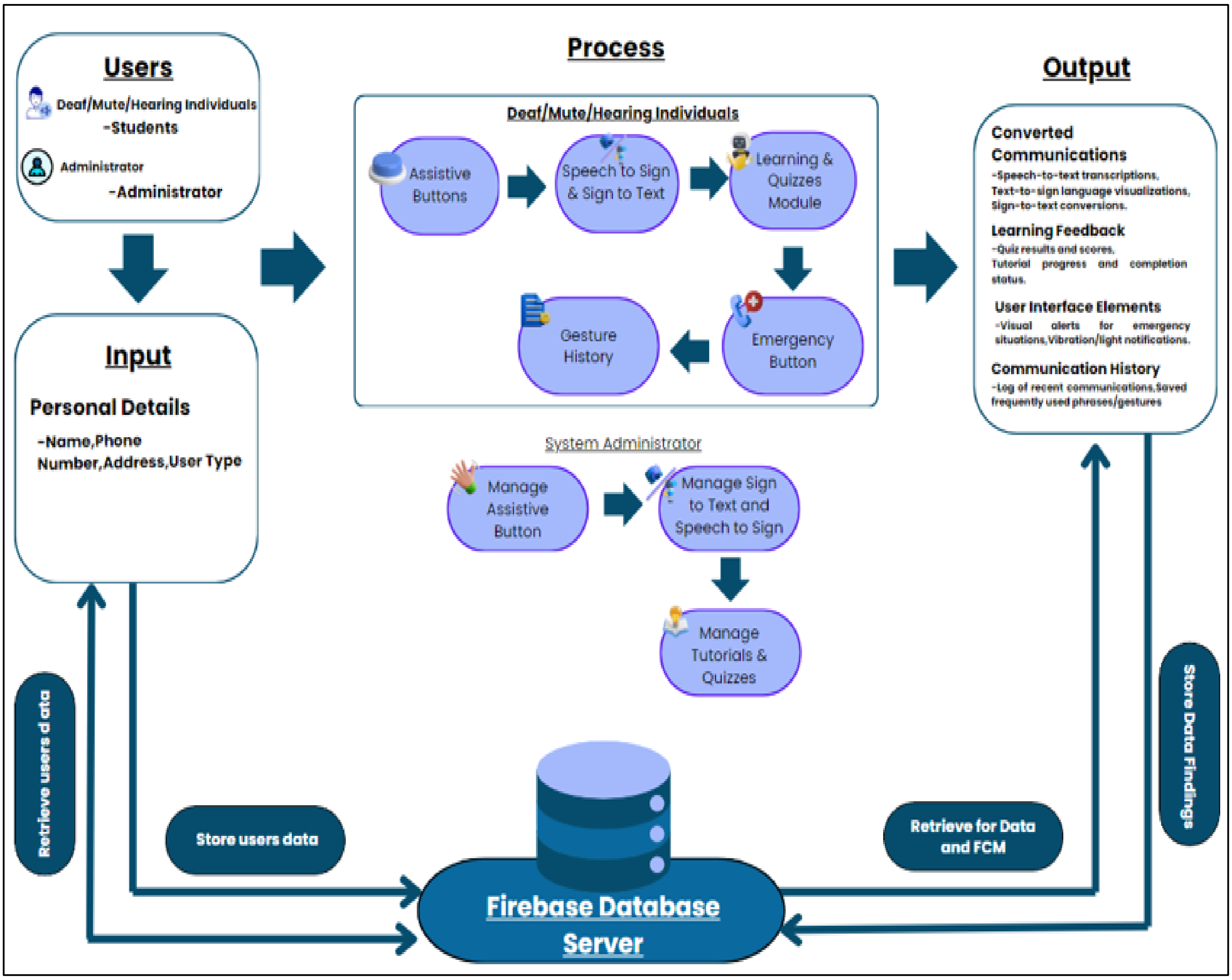

Fig 3 Conceptual Framework of the Study

Figure 3 illustrates the conceptual framework of the Speech Interpretation and Gesture Notation (S.I.G.N.) Application, highlighting the interaction between users, input, processes, and outputs to facilitate effective communication. The framework identifies two primary user groups: Deaf/Mute Users, who utilize features such as sign-to-text translation, assistive buttons, and emergency alerts; and Hearing Users, who use the application to convert speech to sign language and access gesture history. The input includes gesture data captured through the camera and speech data from hearing users. The processes are divided based on user roles: Deaf/Mute processes involve performing sign language gestures and accessing assistive tools while Hearing User processes focus on providing speech input and receiving translated gestures. System processes include translation, gesture recognition, emergency handling, and gesture history storage. The outputs include real-time text, sign language translations, and accessible communication options to ensure seamless interaction.

The framework reflects the study's objectives: to create an inclusive system that improves communication efficiency, enhances accessibility, and bridges the gap between Deaf/Mute and hearing individuals. The S.I.G.N. application provides an intuitive, reliable, and real-time communication solution that addresses the needs of its target users.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

➢ *System Design*

Fig 4 Assistive Buttons Module

Figure 4 shows the Assistive Buttons feature of the S.I.G.N. Application, enabling users to select, customize, and play commonly used phrases for easier communication.

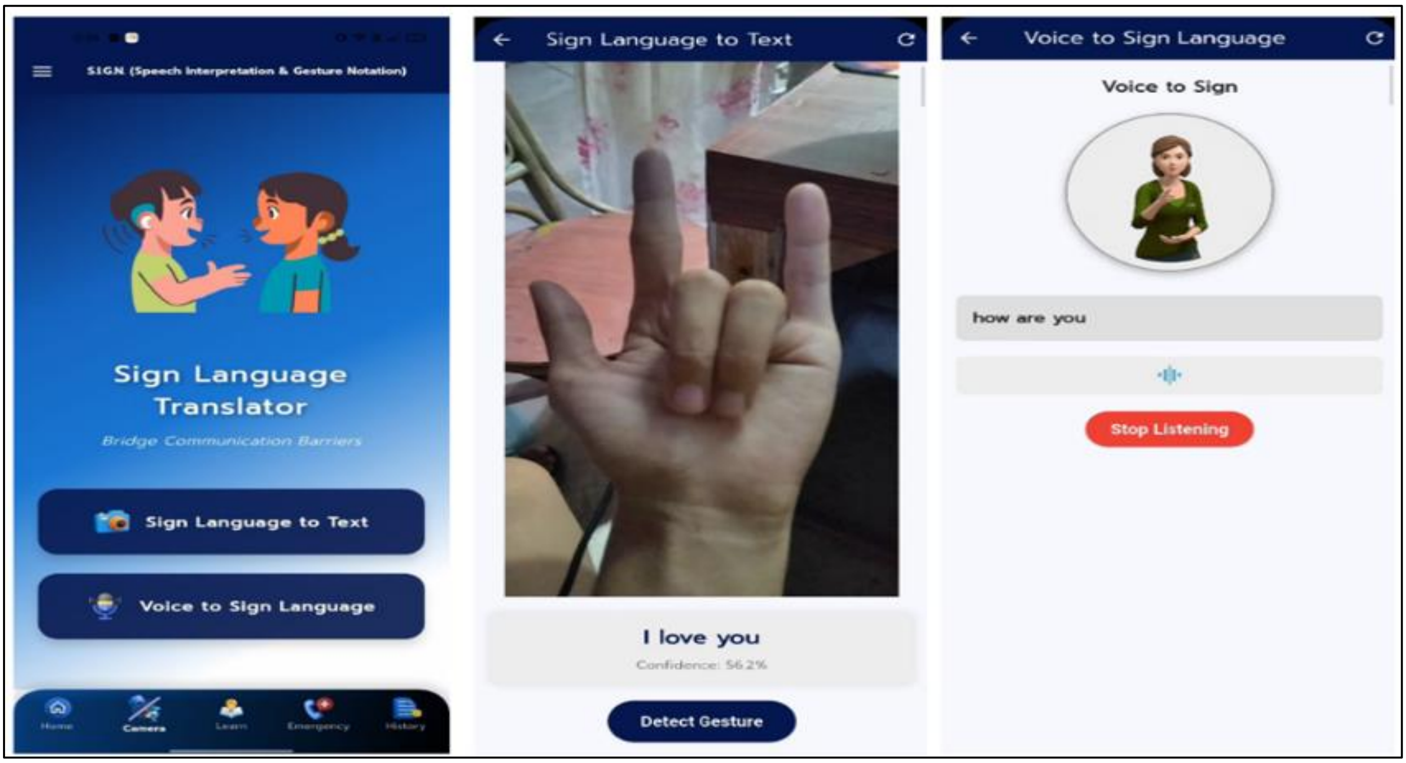

Fig 5 Gesture-to-Text and Speech-to-Text Module

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

Figure 5 shows the Sign Language Translator feature of the S.I.G.N. Application, enabling real-time translation between sign language and text or voice.

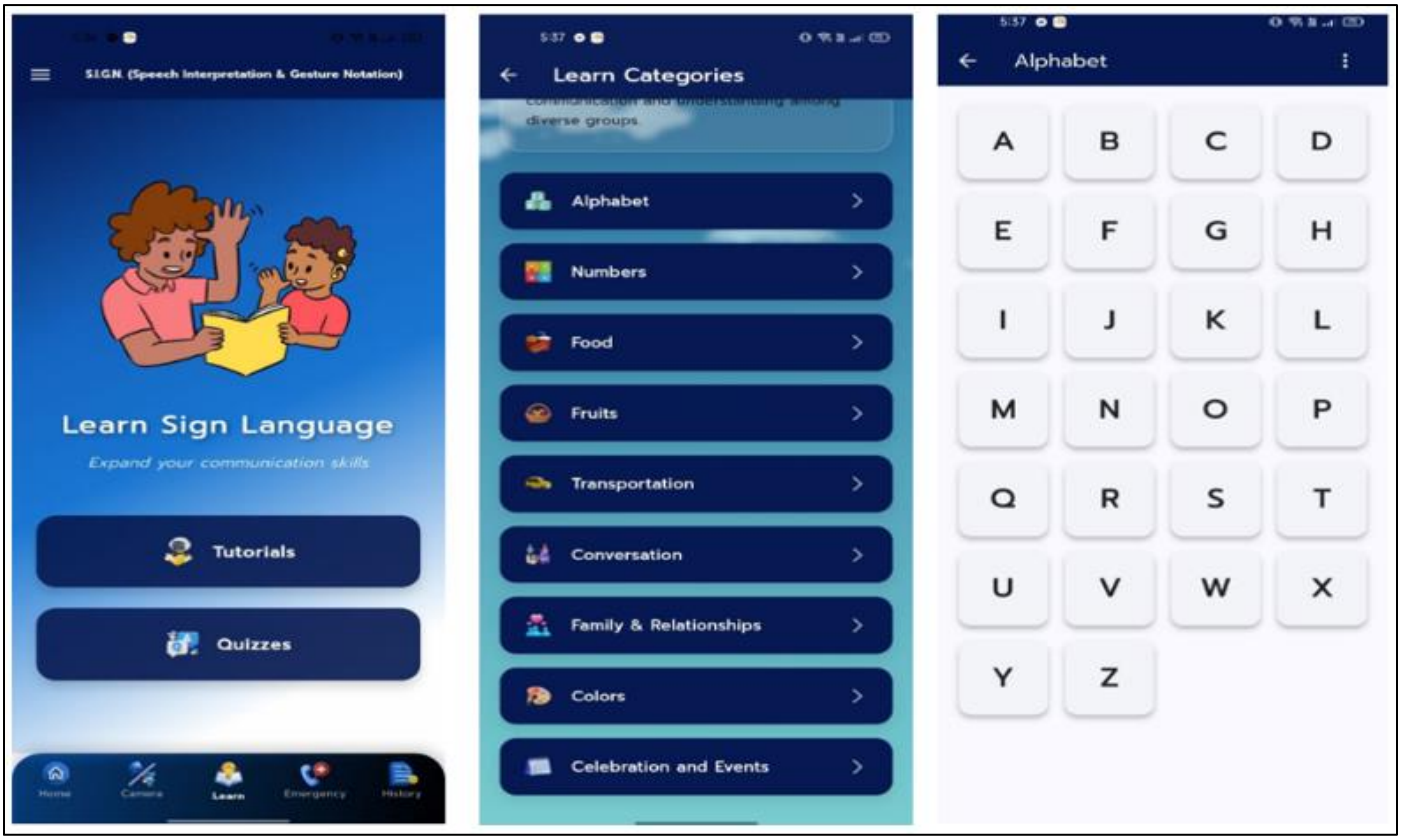

Fig 6 Tutorials Modules

Figure 6 shows the Learn Sign Language module of the S.I.G.N. Application**,** which offers tutorials and quizzes across multiple categories to enhance communication skills.

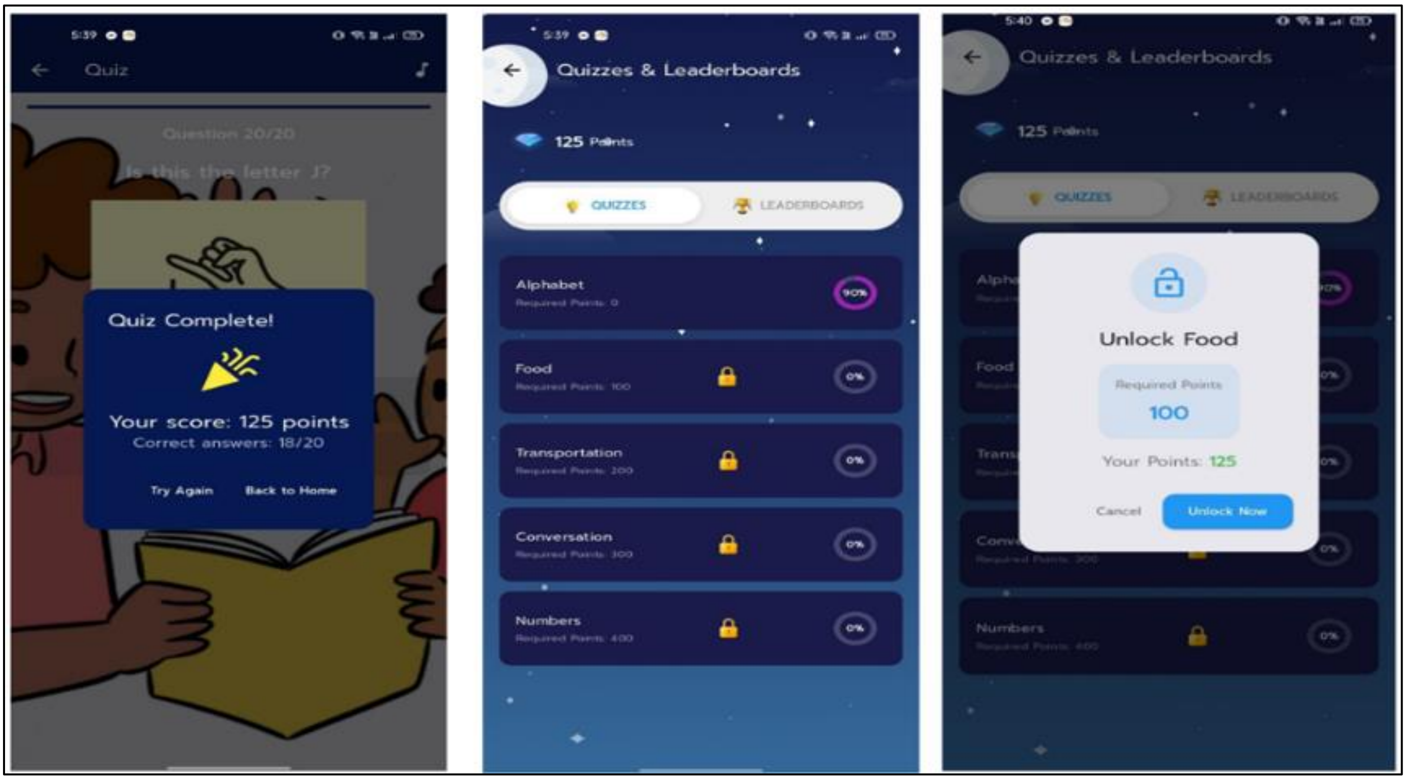

Fig 7 Quiz Modules

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

Figure 7 shows the Quizzes and Leaderboards module of the S.I.G.N. Application, where users can complete quizzes, earn points, and unlock new categories to enhance their learning experience.

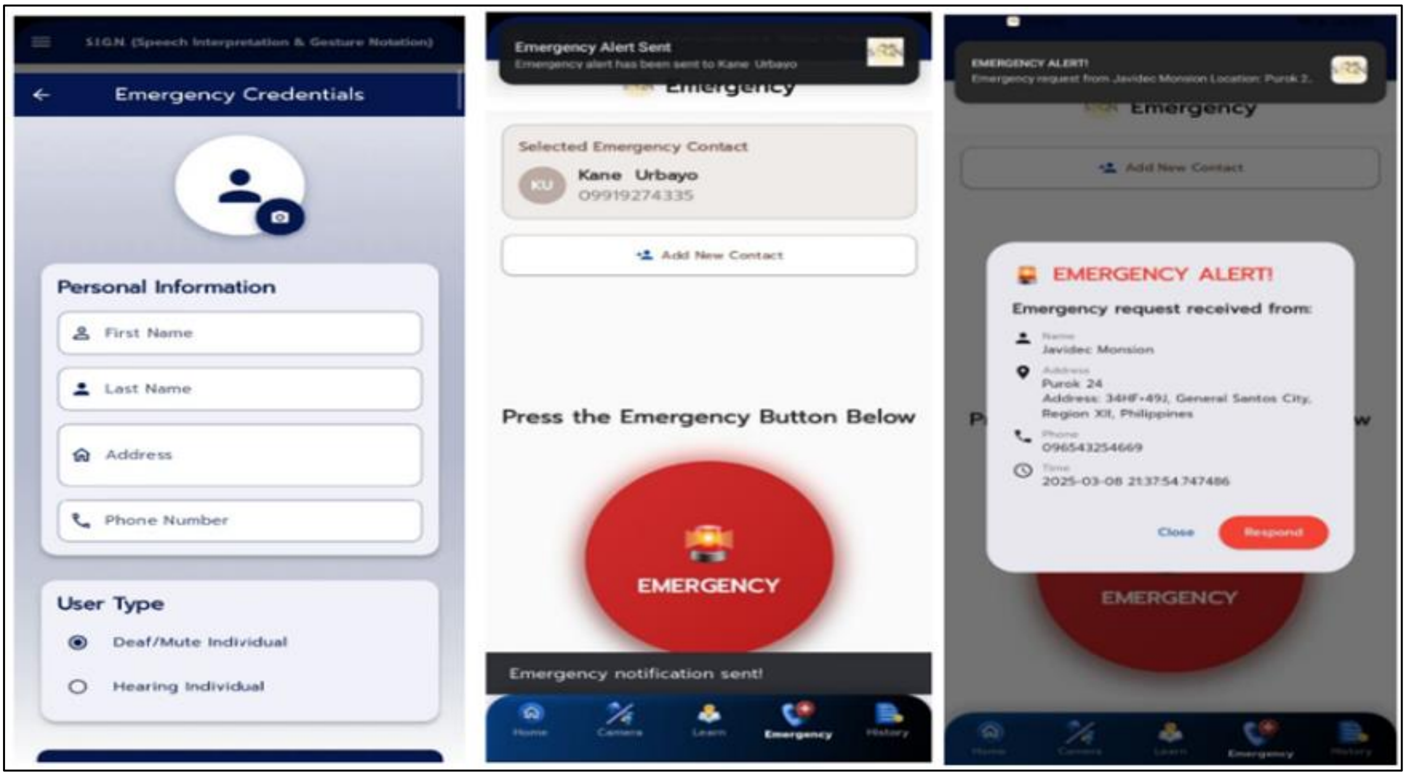

Fig 8 Emergency Alert Module

Figure 8 shows the Emergency Module of the S.I.G.N. Application, allowing users to add emergency contacts, send alerts, and notify responders in urgent situations.

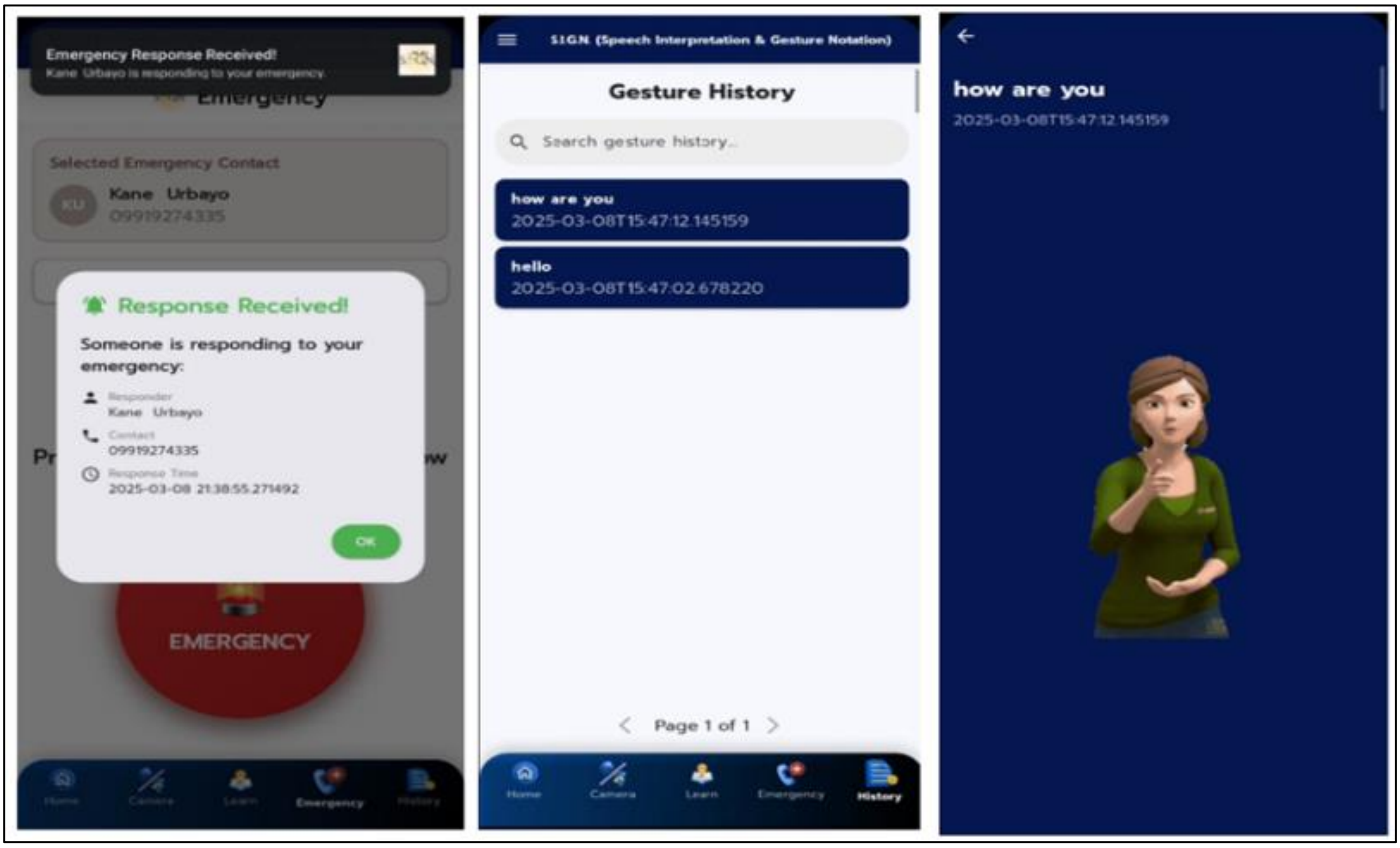

Fig 9 Gesture History Module

Figure 9 displays the Emergency Response and Gesture History Modules of the S.I.G.N. Application, allowing users to view emergency responses and review previously detected gestures.

➢ *Reports Generated*

First Name	Last Name	Address	Phone	User Type	Updated At	file Image URL
Jember	Calay	Simbo	9741225862	Hearing Individual	8 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Javidec	Monsion	Purok 24	9425653428	Hearing Individual	9 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Kane Joy	Urbayo	Quilantang	9638285660	Hearing Individual	10 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Ledon Jay	Jordan	Palkan	9741225862	Hearing Individual	11 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Rosemarie	Gepolani	Polomolok	9654736413	Hearing Individual	12 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Cristy Mae	Balaba	Banga	9545652313	Hearing Individual	13 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Vince	Guevarra	Polomolok	9741225862	Hearing Individual	14 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Rek	Bords	Gensan	9647223142	Deaf/Mute Individual	15 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me
Arc	Abanil	Uhaw	9645274523	Hearing Individual	16 March 2025 at 15:43:01 UTC+8	https://firebasestorage.googleapis.com/v0/b/sign-38db1.appspot.com/o/profile_images%2FFpzTB4xgG5e8ArFRAdqaYb656YB2.jpg?alt=me

Fig 10 Reports

V. RESULTS AND DISCUSSIONS

➢ *Development and Testing*

The development of the Speech Interpretation and Gesture Notation (S.I.G.N.) Application focused on improving communication between deaf/mute and hearing individuals by providing real-time speech and sign language translation. Key features include sign-to-text and voice-to-sign translation, assistive buttons for daily needs, gesture learning modules, emergency alerts, and gesture history tracking. These functionalities aimed to enhance inclusivity and ease of communication for users. The system was tested to validate its functionality, usability, and ability to meet project objectives. A 5-point Likert scale evaluation tool, part of the System Usability Scale (SUS), was used during testing. The testing involved 10 participants, including deaf, mute, and hearing individuals, and educators familiar with sign language, ensuring comprehensive feedback from diverse user perspectives.

➢ *System Evaluation*

The Speech Interpretation and Gesture Notation (S.I.G.N.) The application was evaluated by two participant groups: Deaf/Mute Individuals and Hearing Individuals. The System Usability Scale (SUS) was used to assess the system's usability, effectiveness, and efficiency agreement. Respondents rated the system on a 5-point Likert scale, where a score of 5 indicated strong agreement, 4 indicated, 3 indicated moderate agreement, 2 indicated disagreement, and 1 indicated strong disagreement. The SUS score was computed by adding the adjusted scores of the odd-numbered questions (Q1, Q3, Q5, Q7, Q9) and subtracting 5 from the total. Similarly, the even-numbered questions (Q2, Q4, Q6, Q8, Q10) were subtracted from 25. The final score was multiplied by 2.5 to calculate the overall SUS score. The final SUS scores for the participants were as follows: Deaf, Mute Individuals, and Hearing Individuals both received an average score of 85.75. These results indicate that S.I.G.N. is a highly usable and effective application, receiving positive feedback from both participant groups. The overall mean SUS score of 85.75 confirms that S.I.G.N. successfully meets its objectives by enhancing communication between deaf, mute, and hearing individuals, facilitating real-time interaction, and ensuring a smooth user experience. The positive reception highlights the application's potential to bridge communication gaps effectively and provide an accessible solution for its target users.

Table 1 Raw Results of Respondents Answers in 5-Point Likert Scale DMI – Deaf and Mute Individuals (5)
H – Hearing Individuals (5)

No. of Respondent	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
Question	**DMI1**	**DMI2**	**H1**	**H2**	**DMI3**	**DMI4**	**DMI5**	**H3**	**H4**	**H5**
1	5	4	5	5	4	5	5	4	4	5
2	1	1	2	1	1	2	1	2	1	1
3	5	4	4	4	3	3	4	3	5	4
4	2	1	1	1	1	1	2	1	1	1
5	4	5	4	5	4	5	3	4	5	4
6	1	2	1	1	1	1	1	1	2	1
7	3	5	4	3	4	5	4	4	3	5
8	1	2	3	1	3	2	1	2	1	1
9	4	4	4	5	5	5	3	4	4	4
10	1	1	1	2	2	2	1	1	1	1

Table 1 shows all the calculated odd and even scores, which are all based on the raw scores. SUS equation is: (Calculated Odd Score = ((q1 + q3 + q5 + q7 + q9) – 5)). (Calculated Even Score = (25-(q2 + q4 + q6 + q8 + q10)).

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

Table 2 Calculated Results of Odd and Even Numbers

Score	DMI	DMI	HI	HI	DMI	DMI	DMI	HI	HI	DMI
Odd Score	16	17	16	17	15	18	14	14	16	17
Even Score	19	18	17	19	17	17	19	18	19	20

Table 2 shows each respondent's calculated score using the SUS equation for the total SUS score (SUS Score: (Calculated Odd Score + Calculated Even Score) x 2.5 = SUS Score).

Table 3 System Usability Scale Calculated Score and Acceptability Score

Respondents	SUS Score
DMI	87.5
DMI	87.5
HI	82.5
HI	90.0
DMI	80.0
DMI	87.5
DMI	82.5
HI	80.0
HI	87.5
DMI	92.5
Average:	85.75

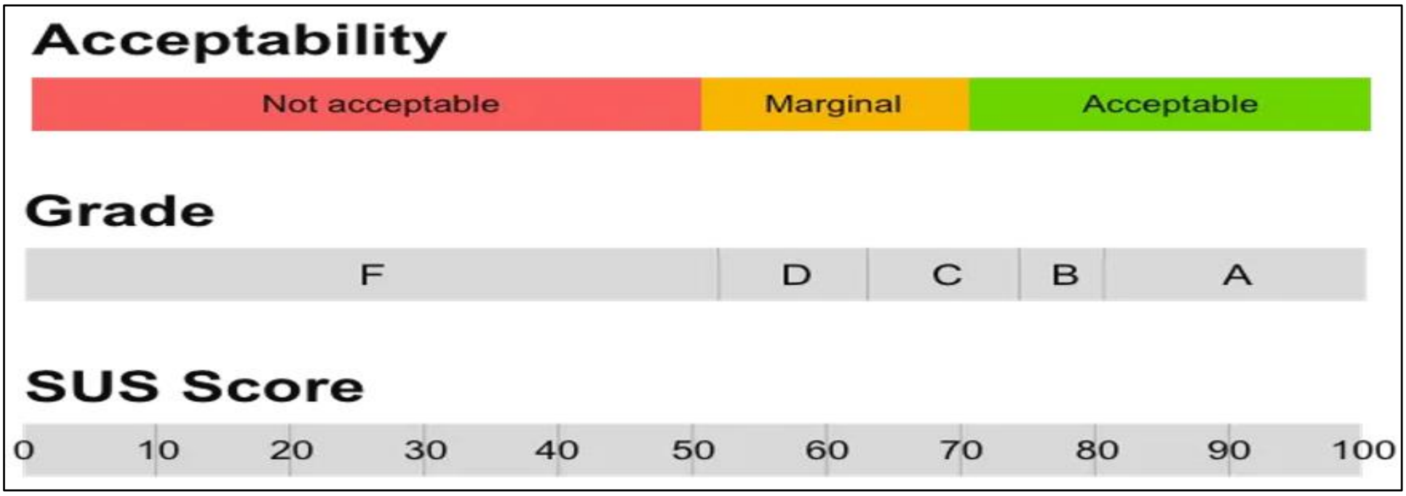

Fig 11 System Usability Scale

Figure 11 shows the usability assessment of the system based on the System Usability Scale (SUS). A SUS score above 68 is considered average, while scores below this threshold are deemed marginal or unacceptable. Scores between 51 and 70 fall into the marginal category, and scores below 50 are considered "Not Acceptable." Conversely, scores above 71 are regarded as "Acceptable," indicating a satisfactory user experience.

Table 3 shows the overall mean SUS score across all respondents, indicating that the S.I.G.N. Application achieved an "Excellent" average of 85.75, demonstrating its effectiveness in improving communication and enhancing user experience for both deaf/mute and hearing individuals.

VI. CONCLUSIONS

The Speech Interpretation and Gesture Notation (S.I.G.N.) The application achieved an overall mean SUS score of 85.75, indicating a high level of usability and user satisfaction. The application effectively facilitated communication between deaf, mute, and hearing individuals by addressing challenges in real-time interaction and enhancing accessibility.

All core features of the system were tested and verified to function smoothly, including sign-to-text and voice-to-sign translation, assistive buttons, emergency alerts, and gesture history. Users acknowledged the system's usefulness in improving communication, making interactions more accessible, and ensuring a smooth user experience.

In conclusion, S.I.G.N. provided a reliable and user-friendly solution that successfully met the communication needs of its target users, contributing to improved accessibility and interaction between diverse user groups.

RECOMMENDATIONS

Based on the panel reviewers' suggestions, future improvements for the Speech Interpretation and Gesture Notation (S.I.G.N.) The application may focus on enhancing

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/25mar1295

the gesture-to-text and speech-to-gesture features to support continuous recognition and sentence translation. These enhancements may include integrating half-face detection, tracking continuous hand movements, and enabling real-time speech-to-text conversion for generating accurate text outputs.

Expanding the sign language database and incorporating advanced accessibility features are also recommended to improve user experience and inclusivity. These advancements aim to further bridge communication gaps and promote better understanding between deaf, mute, and hearing communities.

ACKNOWLEDGMENTS

We are deeply grateful to **Reginald S. Prudente, MIT,** the CICT Dean and subject instructor, for his patience, support, and valuable insights that guided us throughout the development of the Speech Interpretation and Gesture Notation (S.I.G.N.) Application. His expertise and encouragement were essential in ensuring the success of this project. Our heartfelt appreciation goes to **Hernan E. Trillano Jr., MIT**, our project adviser, whose unwavering patience, dedication, and constructive feedback inspired us to improve the quality of our research. His continuous support motivated us to accomplish our goals. Above all, we give thanks to Almighty God for His constant guidance, strength, and protection throughout this journey. His unwavering love and compassion empowered us to overcome every challenge and complete this project successfully.

REFERENCES

[1]. S. Geetha, R. N. K. Prasad, and S. Choudhury, “Understanding vision-based continuous sign language recognition,” IEEE Access, vol. 8, pp. 12345–12358, 2020.
[2]. A. Garemilla, “Sign language recognition with advanced computer vision: Detecting sign language characters in real-time,” Proc. Int. Conf. on Machine Learning and Applications, pp. 523–531, 2022.
[3]. R. Maitland, P. Singh, and A. Patel, “Real-time sign language recognition using machine learning and neural network,” IEEE Trans. Neural Netw. Learn. Syst., vol. 34, no. 1, pp. 45–59, 2022.
[4]. J. Mendoza and L. Ramirez, “Improving communication for the deaf through sign language recognition applications,” Int. J. Comput. Appl., vol. 176, no. 1, pp. 15–21, 2020.
[5]. C. Alberto, P. Cruz, and J. Gonzales, “Continuous sign language recognition system using deep learning with MediaPipe Holistic,” IEEE Int. Conf. Signal Process., pp. 78–85, 2024.
[6]. J. Montefalcon, E. Javier, and M. Lim, “Filipino sign language recognition using deep learning,” Proc. Philippine Conf. on ICT and Applications, pp. 112–119, 2021.
[7]. K. Gezza and F. Hanani, “Kinect to connect: A two-way sign language gesture sensor application,” Int. J. Comput. Vis., vol. 15, no. 3, pp. 312–325, 2022.
[8]. D. Biswasa, H. Gupta, and S. Mishra, “Real-time American sign language interpretation using deep convolutional neural networks,” IEEE Trans. Image Process., vol. 32, pp. 89–102, 2023.
[9]. R. Banag, “Development of sign language tutorial mobile application for Filipinos,” J. Comput. Sci. Eng., vol. 14, no. 2, pp. 45–53, 2023.
[10]. J. Presto, A. Villar, and M. Santos, “Senyas: A 3D animated Filipino sign language interpreter using speech recognition,” IEEE Conf. Multimedia. Signal Process., pp. 134–141, 2022.
[11]. J. Empe, A. Castro, and G. Lopez, “SimboWika: A mobile and web application to learn Filipino sign language for deaf students in elementary schools,” J. ICT Research and Applications, vol. 18, no. 2, pp. 210–221, 2020.