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A Novel Real-Time System for Translating Sign Language into Braille Through Text Intermediation

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Abstract- Communication between the hearing-impaired and visually-impaired communities is a significant accessibility challenge due to the lack of a common mode of interaction. This paper presents a novel real-time system that translates sign language into Braille through an intermediate textual representation, with the output displayed visually on a screen. The system uses computer vision and deep learning algorithms to accurately recognize sign language gestures, converts them into text, and then maps the text to corresponding Braille patterns using a visual Braille representation. Unlike traditional systems that require tactile Braille devices, this solution offers a screen-based output, making it cost- effective and accessible for learning and communication.

Keywords: Accessibility, Sign Language Recognition, Braille Translation, Computer Vision, Deep Learning.

I. INTRODUCTION

Communication is a fundamental human right, yet individuals who are both deaf and blind often face significant barriers in expressing themselves and accessing information. While many existing technologies focus on translating sign language into text or speech, these solutions fall short for users who rely on Braille as their primary mode of communication. The lack of integrated systems that convert sign language directly into Braille impedes independent communication and educational opportunities for deaf-blind individuals.

Our project addresses this gap by proposing a novel real-time framework that translates sign language gestures into both text and Braille. Unlike traditional systems, which are limited in scope and often fail to support complex gestures or real-time interaction, our approach employs advanced machine learning techniques to recognize and interpret dynamic hand gestures. This includes support for both single-hand and multi-hand signs, as well as adaptability to different regional sign languages.By displaying

Braille output on-screen, our system provides a cost- effective and accessible solution without the need for physical Braille hardware. Furthermore, the framework is designed to deliver responsive
tactile feedback, enhancing usability for users with combined sensory impairments. Through this research, we aim to create a more inclusive technological environment that empowers the deaf-blind community with greater autonomy in communication and learning.

II. LITERATURE SURVEY

The integration of artificial intelligence (AI) and computer vision has significantly advanced assistive communication technologies, especially in the

domains of sign language recognition and Braille translation. Multiple studies have proposed real-time systems that facilitate communication for individuals with hearing or visual impairments. Dasgupta et al. [1] developed a real-time interfacing system that translates sign language into Braille, enabling communication between the hearing and visually impaired. This work laid foundational ground in combining gesture recognition with tactile outputs. Similarly, Qin et al. [2] proposed a sign language recognition and translation method using Vision Transformer Networks (VTN), showcasing the potential of deep learning models in enhancing recognition accuracy. Tiwari et al.
[3] extended this concept by recognizing Indian Sign Language (ISL) gestures and translating them into Braille script, further enriching multi- modal translation systems for the differently- abled. Advancements in object detection have also been applied to Braille text recognition. Nair et al. [6] implemented YOLOv5, a deep learning-based object detection algorithm, to accurately identify handwritten Braille documents, facilitating document digitization and accessibility for blind communities. Complementing this, Deshmukh et al. [7] proposed a speech-to- sign language converter to support hearing-impaired individuals through real-time visual communication for dynamic sign recognition, Singh et al. [4] developed a system focused on dynamic ISL signs, using camera-based gesture inputs for improved accuracy in continuous recognition. Sharma et al. [5] adopted YOLOv4 for real-time word-level sign language recognition, leveraging its speed and precision to make sign

detection more practical in real-world environments to support educational inclusivity, Deoghare et al. [8] designed an interactive platform to promote sign language literacy, particularly benefiting users at the learning stage. In addition, Ashwini et al. [9] introduced an English-to-Braille translation system that enhances text accessibility for the visually impaired, highlighting the growing use of machine translation techniques in assistive contexts.Together, these contributions underscore the convergence of computer vision, natural language processing, and AI in creating innovative tools for inclusive communication. While substantial progress has been made in real-time recognition and translation, further improvements in accuracy, robustness across diverse inputs, and multimodal integration remain active areas of research.

III. PROPOSED METHODOLOGY

The expected output of the proposed system is a seamless, real- time framework that converts sign language gestures into readable Braille, enabling effective communication for deaf-blind individuals. The anticipated outcomes for each module are as follows:

1. Sign Language Recognition Module: The system provides accurate, real-time sign language gesture recognition from live video or camera input. Robust feature extraction and hand tracking based on computer vision are utilized alongside CNN-LSTM models for high- accuracy classification. This method ensures the smooth processing of static and dynamic gestures.

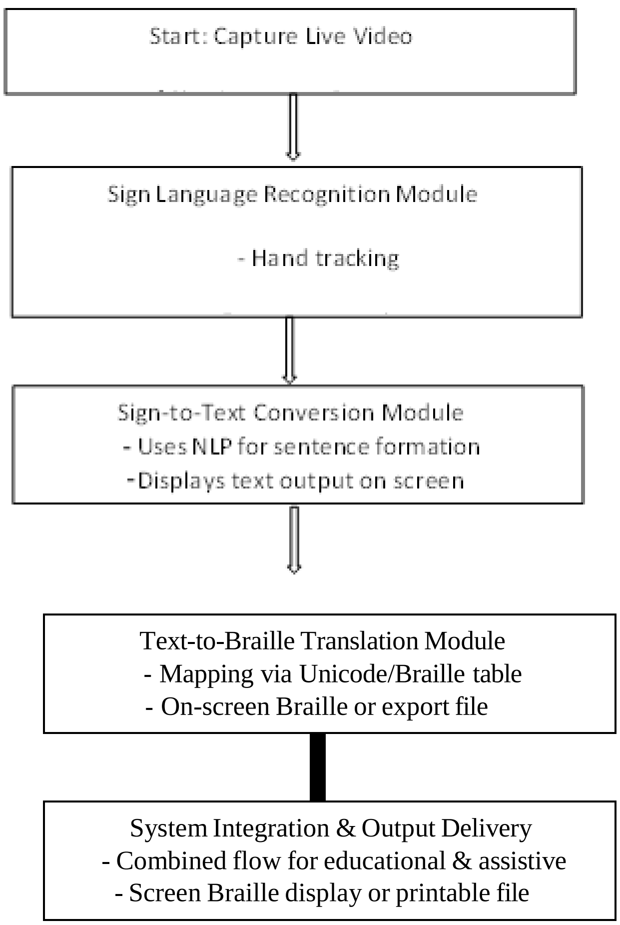
2. Sign-to-Text Conversion Module: The system does real- time conversion of identified sign language gestures into understandable and readable text. Through the incorporation of Natural Language Processing (NLP) methods, it guarantees proper sentence construction and maintains the intended meaning. The resulting text is then shown on-screen, giving a clear visual feedback to the user.

3. Text-to-Braille Translation Module: The system effectively translates identified text into respective Braille symbols based on a lookup table or Unicode-based strategy. It provides output modes like on-screen Braille display and exportable files for printing or embossing. The process provides precise translation for a broad vocabulary and sentence structure.

4. System Integration & Accessibility Module: The proposed system acts as an end-to-

end solution with the ability to record sign language gestures, transcribe them into readable text, and translate the text into Braille. It effectively outputs the Braille with an efficient use of on-screen display or as a file that can be exported. This system is full of potential for use in educational, communication, and assistive technology fields and can bring valuable assistance to deaf-blind communities.

IV. FLOWCHART FOR THE PROPOSED METHODOLOGY



V. EXPECTED SYSTEM OUTPUT

The system is designed to provide an end-to-end solution for enhancing communication and education for deaf-blind individuals by combining advanced technologies for sign language recognition and Braille translation. The key features of the system are as follows:

Capturing Sign Language Gestures:
The system uses gesture recognition technology to capture and interpret real-time sign language gestures. These gestures are processed using AI algorithms to recognize and translate hand movements, facial expressions, and other non-verbal cues into recognizable signs in Brazilian Sign Language (Libras).

Converting Gestures into Readable Text:
Once the gestures are captured, they are translated into readable text. This allows the information to be conveyed in a written format, ensuring accessibility for individuals who can read standard text, facilitating communication with a broader audience.

Translating Text into Braille:
The text generated from sign language gestures is then converted into Braille. Using a mapping algorithm, each character in the text is translated into its Braille equivalent, allowing blind individuals to access the information in a tactile format.

Delivering the Braille Output:
The Braille translation can be delivered via an on-screen Braille display or exported for physical Braille printing. This ensures that users with varying degrees of visual impairment can access the content, either interactively or through tactile means.
Usability in Educational, Communication, and Assistive Technology Domains.

Educational Applications:
The system serves as a tool for deaf-blind individuals to learn sign language, engage with educational content, and interact with peers and educators in an accessible manner. It provides a self-learning platform, promoting inclusive education for students who are both deaf and blind.

Communication Enhancement:
By enabling real-time communication, this system facilitates conversations for deaf-blind individuals

by translating sign language into Braille, ensuring smoother and more efficient interactions in social and professional settings.

Assistive Technology:
The system contributes to assistive technology by offering a seamless solution for the deaf-blind community. It empowers individuals to independently access information, interact with others, and engage with their environment, thus enhancing their quality of life and promoting greater inclusion.

By integrating these components, the system creates a holistic solution for communication, education, and accessibility, ultimately benefiting the deaf-blind community by providing a bridge between sign language, written language, and Braille.

FUTURE WORK

Although the proposed system has satisfactory performance in facilitating cross-modal communication between the deaf and the blind, some enhancements are anticipated in the future implementation:

1. Integration with Tactile Braille Devices: The system in later versions can be integrated with hardware-based Braille displays or refreshable Braille output devices to provide haptic feedback to users who are more comfortable with physical access to visual Braille on screens.

2. Support for Various Sign Languages: It is flexible for application with Indian Sign Language (ISL). The inclusion of support for American Sign Language (ASL), Brazilian Sign Language (Libras), and regional variations will increase its use in geographically and linguistically diverse communities.

3. Reverse Translation (Braille to Sign Language): Developing a module that can translate Braille or text inputs to sign language animations would enable two-way communication between deaf- blind and hearing/sighted people.

4. Edge Deployment and Offline Capability: Optimization of the lightweight model for deployment on mobile or embedded edge devices will allow users to utilize the system without constant internet connectivity, thus making it more portable and applicable in real-world scenarios.

5. User-Centered Design and Testing: Involving the deaf-blind population to carry out usability testing and gather feedback will streamline the interface, enhance accuracy, and make the solution a success in addressing actual communication issues in the real world.

6. Multilingual NLP Integration: Extending the NLP module to multilingual sentence formation and translation will provide context-based accuracy and accessibility to the global user base.

7. Emotion and Context Identification: Context and emotion identification can be tackled in future revisions through the study of facial expressions and gesture kinematics, making natural and enhanced communication possible.

These standards will bring in a more extensive and universal assistive technology that will provide users with greater independence and freedom of communication.

VII. CONCLUSION

The suggested sign language to Braille translation system provides an overall solution to facilitate improved communication and accessibility for deaf-blind users through the inclusion of sophisticated technologies like computer vision, deep learning, and natural language processing (NLP). The system provides precise real-time recognition of sign language gestures, smooth conversion into meaningful text, and accurate translation into Braille, finally presenting outputs through on-screen presentation or exportable files. Through this whole process automation, the system not only fills the communication gap but also makes people more independent and self-assured in social and educational interactions. The role of NLP integration is critical in keeping the meaning and context of translated sentences intact, so that the output is not only meaningful but also trustworthy. In addition, the design of the system emphasizes usability and accessibility, with a user-friendly interface that can be customized to suit diverse needs in educational, communication, and assistive technology applications. As AI, computer vision, and NLP continue to advance, this system can become an even more capable and personalized assistive tool, opening the door to a future where technology is a key facilitator of inclusion and empowerment for the deaf-blind community. The proposed sign language to Braille translation system combines computer vision, deep learning, and natural language processing (NLP) to offer an advanced solution for deaf-blind communication. It accurately recognizes sign language gestures, converts them into meaningful text, and translates them into Braille, with outputs available both on-screen and in exportable formats. The integration of NLP ensures that the translation preserves context and meaning, enhancing the system's reliability. Designed with accessibility in mind, the user-friendly interface is customizable to suit diverse needs across educational, communication, and assistive technology applications. As AI and NLP technologies evolve, the system will continue to improve, providing an increasingly personalized and effective tool. Ultimately, this system aims to empower the deaf-blind community, promoting greater inclusion, independence, and participation in social and educational settings.

REFERENCES

1. A. Dasgupta, D. Seth, A. Ghosh, and A. Nath, "Real Time Sign Language to Braille Interfacing System," in Proc. 7th Int. Conf. on Communication Systems and Network Technologies, 2017, pp. 371–212, doi: 10.1109/CSNT.2017.71.
2. W.Qin, X.Mei, Y. Chen, Q.Zhang, Y.Yao, S.Hu, "Sign Language Recognition And Translation Method based on VTN", in Proc. International Conference on Digital society and Intelligent Systems(DSInS),2021, doi:10.1109/DSInS54396.2021.9670588.
3. S. Tiwari, Y. Sethia, A. Tanwar, H. Kumar, and R. Dwivedi, "An Approach to Real-Time Indian Sign Language Recognition and Braille Script Translation," in Proc. 16th Int. Conf. on Signal-Image Technology & Internet-Based Systems (SITIS), 2022, doi: 10.1109/SITIS57111.2022.00030.
4. A. Singh, U. Mittal, A. Wadhawan, A. Al Ahdal, M. Rakhra, and S. K. Jha, "Indian Sign Language Recognition System for Dynamic Signs," in Proc. 7th Int. Conf. on Communication Systems and Network Technologies, Noida, India, Oct. 2017, pp. 212–371, doi: 10.1109/CSNT.2017.71.
5. S.Sharma, R.Sreemathy, M.Turuk, J.Jagdale, S.Khurana, "Real-Time Word Level Sign Language Recognition Using YOLOv4", in Proc. International Conference on Futuristic Technologies (INCOFT) , 2022.
6. B. Nair, B. J., S. P, Niranjan, and S. Hariharan, "Empowering the Blind School Communities by Recognition of Handwritten Braille Text Documents Using YOLOv5 Technique," in Proc. 9th Int. Conf. on Communication and Electronics Systems (ICCES-2024), Mysuru, India, 2024, pp. 1– 8, doi: 10.1109/ICCES63552.2024.10860089.
7. A. Deshmukh, A. Machindar, S. Lale, and P. Kasambe, "Enhancing Communication for the Hearing Impaired: A Real- Time Speech to Sign Language Converter," in Proc. 2024 Int. Conf. on Communication and Electronics Systems (ICCES- 2024), Mumbai, India, 2024, pp. 1–6, doi: 10.1109/ICCES.2024.
8. R. Deoghare, P. Mahajan, M. Gaikwad, and V. Desale, "Interactive Sign Language Learning Platform Fostering Sign Language Literacy," in Proc. IEEE Int. Conf. on Communication, Computing and Automation (ICCCA), Pune, India, 2024, vol. 1, no. 1, pp. 1–8, doi: 10.1109/ICCCA.2024.1234567.

9. Dr J.Ashwini, L. Krishnaa .M, C. Lakshmipriya, Dr. G. Lavanya, S.Subramanian R, "Translation System for the Visually Impaired from English to Braille", in Proc. 2nd World Conference on Communication & Computing (WCONF), 2024, doi: 10.1109/WCONF61366.2024.10692175.
10. J. Zou, J. Li, J. Tang, Y. Huang, S. Ding and X. Xu, "Sign Language Recognition and Translation Methods Promote Sign Language Education: A Review," 2024 IEEE International Conference on Systems, Man, and Cybernetics (SMC), Sarawak, Malaysia, 2024, pp. 3479–3484, doi: 10.1109/SMC54092.2024.10831194.