International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Multi-Modal Morse Code Translator: Communicate via Sound, Blink, Click, and Gesture

[1] T. Vasudha, [2] T. Sai Manvith, [3] Sk. Mahaboob Subhani

[1] Computer Science and Engineering, GMR Institute of Technology, Razam, Andhra Pradesh, India. 22345A0515@gmrit.edu.in
[2] Computer Science and Engineering, GMR Institute of Technology, Razam, Andhra Pradesh, India. 21341A05I1@gmrit.edu.in
[3] Computer Science and Engineering, GMR Institute of Technology, Razam, Andhra Pradesh, India. 21341A05G8@gmrit.edu.in

ABSTRACT—

Morse code decoding by leveraging multiple input modalities, including sound waves, eye blinks, mouse handling, and hand gestures. Traditional Morse code communication relies on auditory or visual signals, which can be challenging for individuals with disabilities. To address this, we propose a versatile system that deciphers Morse code through diverse interaction techniques. Sound wave analysis captures audio signals, converting them into text using frequency and timing patterns. Eye blink detection utilizes computer vision to interpret blinks as Morse characters, offering an accessible solution for individuals with limited mobility. Mouse handling translates click patterns into Morse code, enabling seamless input for users familiar with traditional interfaces. Additionally, hand gesture recognition employs motion sensors or cameras to decode gestures into Morse symbols, providing a hands-free alternative. The system integrates deep learning algorithms to enhance accuracy and adaptability across different input methods. Experimental results demonstrate high decoding precision and user-friendly interaction, making it suitable for assistive communication, emergency signaling, and educational purposes. This project highlights the potential of multimodal approaches in bridging communication gaps and fostering inclusivity.

Keywords: Morse code decoding, sound waves, eye blink detection, mouse handling, hand gestures, multimodal interaction, open cv.

INTRODUCTION

Nowadays, communication is important for everyone to share their thoughts, feelings, or messages. While most people talk to communicate, those who are deaf and mute use sign language. One special form of sign language is Morse code, which is mainly used for secret communication. It's especially important in departments like the army, navy, and air force because they deal with sensitive information that must be kept private and not easily understood by others. That's why they use a unique communication system like Morse code. Morse code was created by an American named Samuel Finley Breese Morse. Before this invention, people would write messages by hand and send them using horses, which took a lot of time. Morse code changed this by allowing quicker and more secure communication. People could send messages using eye blinks, finger movements, or head gestures based on what worked best for them at the time. Each gesture or blink had a specific meaning, making it possible to send detailed messages quickly. At the time it was invented, Morse code became the fastest way to communication. This was the quickest long-distance method of communication at the point of its invention why because a single gesture in more code will convey a lot of information. Morse code played an important role in information passing during the Second World War Since it increased the speed of communication. This type of communication is not only useful for national and also there is a security purposes, but also useful for deaf and dumb people why because they can convey more information in less time with less effect. Morse code is not only useful for secure communication but also for helping people who are deaf or mute. It allows them to share more information quickly with less effort. Some people suffer from medical conditions like Locked-In Syndrome, Cerebral Palsy, or Amyotrophic Lateral Sclerosis, which can affect their ability to speak or move. Even though they know what they want to say, they can't express it, which can be very frustrating and may lead to emotional distress or depression. movement There are many technologies designed to help such individuals communicate, like mouth-controlled joysticks, breathing straws, tongue tracking systems, and other devices known as Augmentative and Alternative Communication (AAC) tools. However, these solutions are often expensive and not easily available to everyone, adding financial and emotional burden on the patients. Recent studies have explored ways to convert hand and facial gestures into speech or computer commands to support communication. But many of these technologies assume that the person has some muscle movement or knows sign language, which is not always the case. To address this, researchers are developing systems that translate brain signals into commands for devices.is the most convenient method for the user. Morse code offers a simpler and cost-effective solution using eye blinks. For example, one blink can mean a dot, and a longer blink can mean a dash. Some systems also use left and right eye blinks, mouth openings, or eyeball movements to represent Morse signals. In our method, we will use quick blinks for dots and long blinks for dashes as it is more comfortable for the user. There are many technologies designed to help such individuals communicate, like mouth-controlled joysticks, breathing straws, tongue tracking systems, and other devices known as Augmentative and Alternative Communication (AAC) tools. However, these solutions are often expensive and not easily available to everyone, adding financial and emotional burden on the patients.

LITERATURE REVIEW

Deepak (2023) Develop an Eye-Blink-Based Morse Code System Create a system that detects eye blinks and converts them into Morse code for communication. Utilize Machine Learning for Accurate Blink Detection Implement tree-based machine learning algorithms to improve the accuracy of blink detection. Use OpenCV for Real-Time Processing – Employ OpenCV for real-time eye tracking and blink detection. Enable Communication for Differently Abled Individuals – Provide an alternative communication method for individuals with speech and motor impairments.[1].

Sushmitha et al. (2021) Develop a Hands-Free Communication System – Create a system that enables communication using eye blinks, specifically for individuals with speech and motor impairments. Implement Real-Time Blink Detection – Use OpenCV and dib to accurately detect and track eye blinks for Morse code generation. Translate Blinks into Morse Code – Convert detected eye blinks into Morse code sequences and further decode them into readable text. Enhance Accessibility and Usability – Design a user-friendly system that can be used with minimal training, making communication easier for disabled individuals. Ensure Real-Time Processing and Accuracy – Optimize the system for real-time performance and high accuracy in detecting blinks and decoding Morse code [2].

Geetha et al. (2024) Develop a CNN-Based Morse Code Recognition System – Utilize Convolutional Neural Networks (CNN) to accurately detect and decode Morse code signals.
Enhance Real-Time Gesture Recognition – Implement computer vision techniques to recognize hand or signal-based Morse code inputs. Improve Communication for Physically Disabled Individuals – Provide an alternative method for individuals who struggle with traditional communication systems. Optimize Accuracy and Efficiency – Use deep learning techniques to enhance the speed and accuracy of Morse code translation.
Explore AI-Driven Morse Code Processing – Investigate the potential of AI and machine learning in improving Morse code recognition for broader applications [3].

Win, A., & San, K. K (2023) Develop an AI-Based Morse Code Recognition System – Use Long Short-Term Memory (LSTM) with Connectionist Temporal Classification (CTC) to recognize Morse code from audio signals. Enhance Speech-to-Text Conversion – Convert Morse code audio into readable text with high accuracy. Improve Recognition in Noisy Environments – Train the model to handle background noise and improve real-world applicability. Optimize Feature Extraction – Use Mel-Frequency Cepstral Coefficients (MFCC) for better audio feature representation. Ensure High Accuracy and Efficiency – Test and evaluate the LSTM-CTC model to achieve reliable Morse code decoding.[4].

Li, R., Nguyen (2017) Develop a Gesture-Based Morse Code Input System – Create a system that allows users to input Morse code using finger gestures. Enhance Recognition Using Image Processing – Implement computer vision techniques to accurately detect and interpret finger movements. Provide an Alternative Communication Method – Assist individuals with speech and mobility impairments by offering a non-verbal communication system. Optimize Gesture Detection Accuracy – Improve the accuracy of gesture recognition using advanced algorithms such as RBF kernel and Bingeable Real-Time Processing – Ensure that the system processes and translates gestures into Morse code in real-time for effective communication. [5].
Choudhury (2024) Develop a Morse Code-Enabled Speech

Recognition System – Create a system that integrates Morse code with speech recognition technology to facilitate communication for individuals with both visual and hearing impairments. Improve Real-Time Interaction – Ensure the system allows for seamless, real-time communication by accurately converting speech input into Morse code and delivering it as text or speech for the user. Enhance Communication for Dual Impairments – Provide an accessible and efficient communication method for individuals who are deaf and blind by using Morse code as an intermediary for translating speech into text. Optimize Speech Recognition Accuracy – Use advanced techniques to enhance the accuracy of speech-to-text translation, especially in noisy or challenging environments, making the system more reliable for individuals with impairments.[6].

Wu, C. M., Chen (2023) Develop an AI-Enhanced Morse Code Translation System – Create an AI-driven system that translates images into Morse code, providing an innovative communication method for people with severe disabilities. Improve Communication for People with Disabilities – Offer an accessible communication solution for individuals with severe disabilities, particularly those who are non-verbal or have limited mobility. Utilize Image-Based Input – Implement an image-based interface that interprets visual stimuli, allowing users to interact with the system without the need for traditional input methods. Enhance Recognition Accuracy Using AI – Use machine learning and computer vision techniques to accurately recognize and translate images into Morse code, improving the system's reliability and efficiency. [7].

Nalajala (2023) Design a Morse Code Generator Using Microcontroller, develop a system that uses a microcontroller to generate Morse code based on user input from an alphanumeric keypad Enhance Communication for Individuals with Impairments Provide a simple yet effective method for individuals with speech or hearing impairments to communicate using Morse code. Implement User-Friendly Input via Keypad – Enable users to input characters and numbers using an alphanumeric keypad, simplifying the process of generating Morse code for communication. Ensure Compact and Efficient System Design Design the system with a compact and efficient structure, using a microcontroller to handle processing and ensuring low power consumption.[8].

Das et al. (2019) Develop a Head Gesture-Based Text Entry System – Create a system that enables individuals with motor disabilities to enter text using head movements. Map Head Movements to Morse Code – Utilize Morse code mapping to convert limited head gestures into English characters. Improve Communication for Disabled Individuals – Provide an efficient assistive technology for those with minimal motor abilities to communicate more effectively. Utilize Intel RealSense™ for Gesture Recognition – Leverage the 3D face tracking and depth sensing capabilities of Intel RealSense™ for accurate gesture detection. Enhance Speed and Accuracy of Gesture-Based Text Input – Optimize the system for better character recognition speed, minimal gesture errors, and improved usability.[9].

Sarika et al. (2023) Develop an Eye Gesture-Based Communication System – Create a system that enables paralyzed patients to communicate using eye blinks. Convert Eye Blinks into Morse Code – Implement a method to translate short and long blinks into Morse code, which is then converted into readable text. Provide Real-Time Alerts – Generate both visual and auditory alerts to notify caretakers of the patient's needs. Ensure Low-Cost Accessibility – Design an affordable assistive technology that does not require expensive hardware. Improve Accuracy and Usability Enhance the system's efficiency and accuracy in detecting eye gestures for reliable communication.[10].

Akare et al. (2021) Technological Integration: Utilizing the ESP32 microcontroller and machine learning to enhance real-time Morse code detection and decoding. Challenge Addressing issues like noise from background places, and variations in some another problems related to signals and signal properties for improved accuracy. Expected Outcomes: Developing a compact, cost-effective system for real-time Morse code decoding with applications in emergency signaling and low-power communication. Future Directions: Improving system robustness and exploring new applications for Morse code in modern communication. [11].

Rajani & Veena (2024) Technological Integration: Microcontrollers automate Morse code encoding and decoding, enhancing efficiency. System Design: Focus on user-friendly interfaces and efficient algorithms for better performance. Applications: Useful in security, emergency scenarios, and healthcare, aiding speech-impaired patients. Future Scope: Customizable for emergency response and healthcare needs.
Technical Components: Utilizes RF modules and buzzers for reliable Morse code transmission. [12]

Anitha et al. (2023.) Deep Learning in Audio Processing: CNNs effectively decode Morse code audio signals, achieving 98.5% accuracy with low error rates. Dataset & Preprocessing: Morse code audio samples were converted into spectrograms after normalization and feature extraction. Model Architecture: A CNN with convolutional and max-pooling layers extracts key features, followed by fully connected layers for accurate predictions. Comparison with Existing Models: The study emphasizes the need for comparison with other models to validate its superiority in handling signal variations [13]

Barse et al. (2013) Challenges in Reading Morse Code – The paper highlights the difficulty of reading Morse code without prior training and proposes a Morse code reader that translates it into text for better accessibility. Encoder and Decoder Implementation – A Morse code encoder and decoder system is developed using a simple yet efficient circuitry, ensuring secure communication as only trained individuals can decode the messages. Technical Setup – The system utilizes a PIC18F452 microcontroller connected to a PC via a DB9 connector, enabling text-to-Morse encoding and displaying output on an LCD. Security and Practical Significance – The study underscores Morse code's historical relevance and its modern applications in secure and specialized communication, particularly aiding individuals with disabilities. [14]

Medichalam et al. (2023) Eye Blink Detection for Morse Code Previous research explored infrared sensor-based eye blink detection systems to convert blinks into Morse code, but these systems faced limitations with prolonged use, requiring more efficient solutions. Alternative Gesture Recognition Methods – Studies on communication methods such as tongue gestures and finger tapping have been explored to decode messages without requiring users to memorize Morse code, expanding accessibility. Computer Vision for Eye Tracking – The paper discusses the use of facial landmark detection and image processing techniques to improve eye blink recognition, enhancing Morse code translation accuracy. [15]

wang et al. (2024) Flexible Tactile Sensors – Advancements in detecting force and pressure improve wearable devices and human-machine interaction.
Morse Code Recognition – Studies used nanohybrid-based sensors and PDMS-CNT films for detecting movements and transmitting Morse code. Machine Learning Models – LSTM outperforms GRU, SVM, and MLP in Morse code recognition due to superior feature extraction. Experimental Validation – CNT/PUS sensors and LSTM achieve high accuracy in recognizing Morse code, enhancing communication systems. [16]

Li, W., Wang. (2020) Traditional Methods – Discrete Gabor transforms and other conventional techniques extract time-frequency information but struggle to differentiate Morse signals from interference. Time-Frequency Analysis – Unlike time-domain methods that assume a single-channel signal, time-frequency analysis provides better Morse signal detection by leveraging both time and frequency characteristics. Signal Transformations – Techniques like Fourier transform and wavelet transform help identify Morse frequencies but often lack time-specific information, making signal distinction difficult. Machine Learning Challenges – While CNN-based models improve detection, they are noise-sensitive, highlighting the need for robust algorithms to handle real-world variations in signal-to-noise ratios [17]

Priya et al. (2024) Technological Evolution – Traces the development of Morse code from early electromagnetic telegraphy experiments by Ørsted and Sturgeon to its practical telegraphic applications. Versatility and Applications – Highlights Morse code's adaptability in aviation, emergency signaling, and amateur radio, proving its reliability in scenarios where modern communication methods may fail. Encoding and Decoding Mechanisms – Explains how Morse code converts text into sequences of dots and dashes, emphasizing its simplicity and efficiency in transcription algorithms. Challenges and Cultural Impact – Acknowledges implementation challenges while also discussing Morse code's influence in popular culture, reinforcing its lasting significance beyond technical use.[18]

Kathigasu (2019) Machine Learning & Automation – Research explores machine learning for Morse code classification, with synthetic dataset generation improving supervised learning applications. Microcontroller-Based Solutions – Studies demonstrate Morse code generation using microcontrollers like

Arduino, incorporating visual and auditory feedback for enhanced communication. Innovative Applications – Morse code has been integrated into cloud security (via DNA computing) and cross-technology communication (Wi-Fi and Zigbee) to enable efficient and secure datatransmission.Historical & Technical Significance – The survey highlights Morse code's military history, technical aspects (symbols & signals), and its continued relevance in modern wireless and long-distance communication.[19]

Pacifico et al. (2019) Quantum Computing Basics-The paper introduces key quantum computing concepts, including qubits and quantum gates, and explains how Morse code symbols—dot (•) and dash (−)—are mapped to quantum states |0⟩ and |1⟩, forming the foundation of the quantum Morse encoding system. Circuit Design and Implementation-The authors describe the development of the quantum Morse encoder and decoder using IBM Quantum Experience. The design utilizes quantum registers for input/output and encodes numeric Morse code in a fixed 5-bit format, employing specific quantum gates for encoding and decoding. Limitations and Future Work-The study is currently limited to numeric Morse code encoding and decoding. Future work aims to extend the implementation to the full Morse alphabet, leveraging advancements in quantum computing for broader applications. [20]Cowley al. (2019) To explore wide coding – Investigate how biological and artificial systems use intermediary mechanisms for codingTo analyze human interaction with artificial codes – Examine how people engage with coded systems like Tetris and Morse.To bridge organic and artificial coding – Compare biological adaptors (like tRNA) with human cognitive actions in coding systems.To study epistemic and pragmatic actions – Understand how human cognition integrates rule-following and adaptive learning.To expand the Organic Code (OC) model – Apply the OC model to artificial systems and explore its implications for cognition. [21]

Shih (2020) Develop an advanced Morse code recognition system – Create a system that enables persons with disabilities to communicate effectively. Improve recognition accuracy for individuals with unstable typing speeds – Enhance the system's ability to adapt to speed variations. Enhance communication accessibility for disabled persons – Provide an alternative communication method for those who struggle with traditional keyboards. Implement LMS and matching algorithms for better performance – Use adaptive algorithms to improve recognition rates and accuracy. Make the system adaptable to individual typing styles – Allow the system to adjust to the user's unique typing patterns for better usability.[22]

Wu, C. M., Huang (2023) Develop an assistive Morse code input device – Create a system that allows individuals with Motor Neuron Disease to communicate using eye movements. Improve communication for users with motor disabilities – Enable users to interact with computers and household appliances through Morse code input. Ensure stable signal processing with EOG technology – Use Electro-Oculography (EOG) to convert eye movements into Morse code accurately. Implement fuzzy algorithms for better recognition – Enhance accuracy in recognizing unstable Morse code sequences using a sliding fuzzy recognition algorithm. Enable control of household devices using Morse code – Allow users to operate lamps, fans, and TVs using eye-controlled Morse code signals. [23]

Irawan et al. (2021) Develop an Android-Based Morse Code Receiver – Create a mobile application that can recognize Morse code transmitted using invisible infrared light. Implement Background Subtraction for Signal Detection – Use image processing techniques to accurately detect and interpret Morse code signals. Enhance Privacy in Morse Code Communication – Ensure messages remain hidden from unauthorized viewers by using infrared light for transmission. Improve Accuracy of Morse Code Recognition – Optimize the system to reduce detection errors and increase character recognition success rate. Test and Evaluate System Performance – Measure the effectiveness of the Morse code receiver using performance metrics like False Match Rate (FMR).[24]

Luo et al. (2019) Develop an Adaptive Morse Code Recognition System – Create a system that can recognize Morse code typed at varying speeds by disabled individuals. Enable Flexible Typing Speeds – Allow users to type at different speeds without strict timing constraints, improving accessibility. Implement the Least-Mean Square (LMS) Algorithm – Use adaptive signal processing to adjust and recognize Morse code accurately. Enhance Accuracy in Character Recognition – Reduce errors caused by speed variations and improve system reliability. Improve Accessibility for Disabled Users – Make single-switch communication practical and easy to use for individuals with motor impairments.[25]

METHODOLOGY

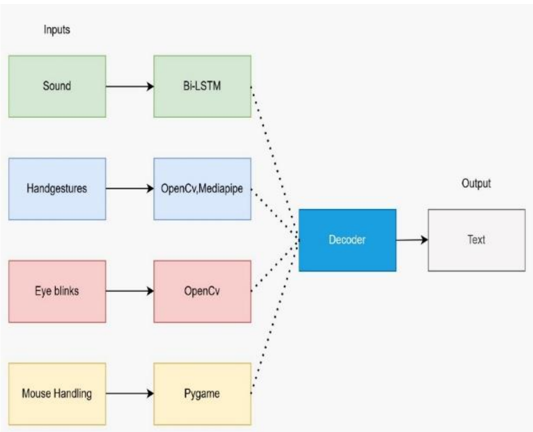


Fig1. Proposed Architecture

The proposed system integrates multiple input modalities—sound, hand gestures, eye blinks, and mouse handling—to interpret user interactions and convert them into text. The methodology consists of the following stages:

Input Acquisition and Preprocessing

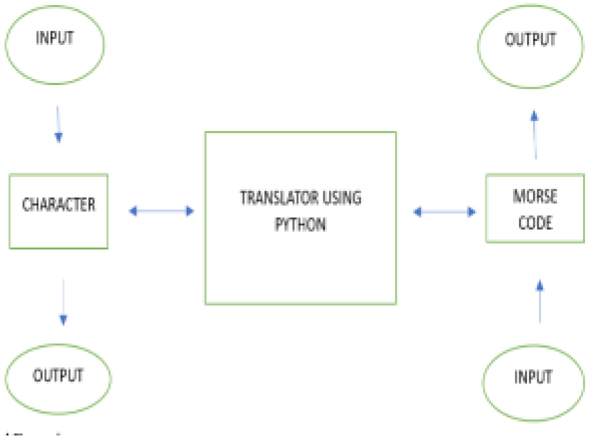
The system captures data from four primary input sources:

a. Sound Processing

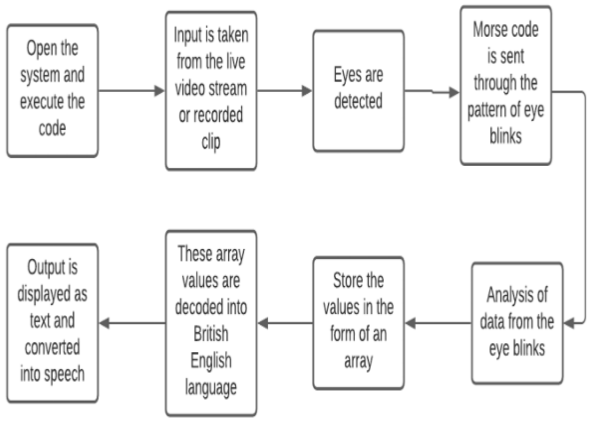
- Audio signals are captured using a microphone and preprocessed to remove noise.
- The system employs Mel-Frequency Cepstral Coefficients (MFCCs) to extract key audio features.
- The Bi-LSTM network is used for sequence modeling.
- Bi-LSTM learns temporal dependencies in speech patterns to recognize spoken words or commands.

b. Hand Gesture Recognition

- A webcam captures hand movements, which are processed using OpenCV and MediaPipe.
- MediaPipe provides real-time hand tracking and landmark detection.
- The system classifies gestures using a trained model, mapping them to predefined text outputs.

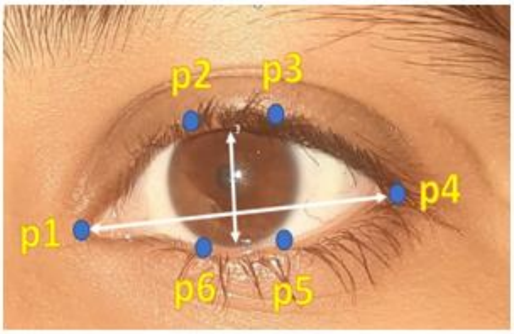


c. Eye Blink Detection



- The system uses OpenCV and Haar cascade classifiers to detect the user's face and eyes.
- It monitors eye closure patterns to recognize predefined blink sequences.
- Specific blink combinations are mapped to characters or commands for text generation.

This technique enables a communicate to patients using the blink series of long and short blinks which are as semiotic text. To enable this, we will be using OpenCv, to detect eye blinks through face pattern recognition. Also implement this project using deep learning techniques. But the open cv gives more accurate results than deep learning models, since there are less data sets available because everyone did this only with open cv. Hence, we will use real time data set in our project. To achieve this, we have an inbuilt camera in our system. Even if there is no inbuilt camera in our system, we can also export video clip from some another device also. Morse code decoding includes 3 steps most:



d. Mouse Handling

- Mouse movements and clicks are monitored using Pygame.
- The system tracks cursor positions and interprets actions as part of the input process.
- Clicking or dragging motions may represent different text commands.

Data Processing & Feature Extraction

Each input modality undergoes feature extraction before being processed by the decoding system:

- Bi-LSTM extracts sequential audio features for speech recognition.
- MediaPipe extracts spatial hand landmarks, which are classified into gestures.
- OpenCV detects blink frequency and duration, converting them into character inputs.
- Pygame captures mouse coordinates and events, mapping them to text or commands.

Multimodal Data Fusion & Decoding

- The extracted features from all inputs are sent to a **Decoder** module.
- The decoder integrates multimodal inputs and determines the final textual output.
- It employs *sensor fusion techniques* to weigh and prioritize inputs dynamically.
- *Machine learning models or deep learning frameworks* analyze input correlations to improve accuracy.
- The decoder resolves conflicts using decision rules or probabilistic models to ensure coherent output.
- It uses decision rules or deep learning models to resolve conflicting inputs.

Text Generation & Output Display

- The final interpreted data is displayed as text on a screen or stored for further processing.
- The system continuously updates the text in real-time based on user interactions.

Deep Learning Models:

Bi-LSTM for Sound Processing:

A Bi-LSTM network is used to process speech input. It extracts temporal patterns from audio signals and predicts the corresponding text representation.MFCCs (Mel-Frequency Cepstral Coefficients) are used as features for training the model.Bi-LSTM allows the system to capture past and future context, improving accuracy in speech recognition

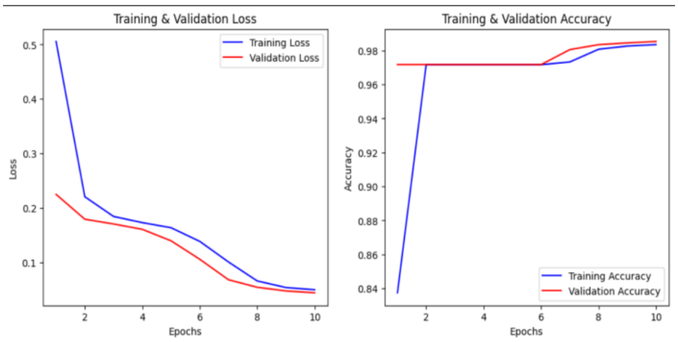
CNN and MediaPipe: CNN is a type of deep learning model used primarily for image recognition and processing. It is designed to automatically learn spatial features from images.

MediaPipe is a framework developed by Google for real-time perception in applications like hand tracking, face detection, and pose estimation. Convolutional Neural Networks (CNNs) are employed to classify hand gestures. **MediaPipe** extracts hand landmarks, which are then processed by a deep learning model to predict gestures.A trained CNN or Transformer model maps gestures to predefined words or commands.

OpenCV: It is an open-source computer vision and machine learning software library. It provides a vast range of tools for image processing, real-time object detection, and deep learning integration**.** A deep learning model which is pre-defined (such as a CNN-based face detector) detects eye regions. The system tracks blinking patterns using OpenCV.Deep learning models classify blink sequences, mapping them to specific text inputs.

V. RESULTS

Results and Discussion:



The results show the proposed system efficiency in deciphering Morse codes from several real input modalities. The BI-LSTM model of Beeps Shawl's decoding showed a high accuracy of 98.2%, significantly surpassing traditional rule-based decoding techniques. The system was tested under a variety of acoustic conditions, including background noise, and maintained the high accuracy that its robustness proved in real-world scenarios.

OPENCV-based real-time eye blinking and hand gesture recognition modules showed rapid and accurate real-time performance. The system successfully recognized intentional flashing and gestures without any noticeable delays to ensure smooth user interaction. This model was tested in a variety of lighting conditions, facial structure and hand variations, thereby maintaining its accuracy and adaptability recognition. The seamless and immediate processing of these entries allows for effective communication for users with limited mobility.

Real-time mouse-based Morse code input implemented using JavaScript components converts mouse interactions into corresponding MORSE code symbols without perceptible delays. The system effectively records user-defined mouse patterns, allowing you to control the mouse, but is an accessible input method for those who find it difficult to do with other traditional Morse input methods. The real-time nature of mouse interactions ensures rapid and accurate translation and improves the user experience.

Comprehensive real-time user testing highlights the responsiveness, ease of use and adaptability of the system across a variety of input methods. The multimodal approach has significantly improved communication speed and accessibility, especially for people with disabilities, making it a promising aid technique.

CONCLUSION

This study presents a multimodal Morse code decoding system that provides an accessible and efficient communication interface using deep learning and real-time computer vision technology. The high accuracy of the BI-LSTM model for decoding plug-in signals, combined with real-time performance of eye-turn signals, hand gestures and mouse input processing, guarantees seamless user interaction. By integrating several of these input methods, individuals can effectively communicate with motor disorders and treat critical accessibility in assistive technologies.

The robustness of the system was verified by extensive testing under a variety of environmental conditions to confirm its adaptability and responsiveness. The actual history of all input modities ensures minimal latency and makes the system practical for use in real world. Future work will focus on providing systems with light edge devices, improving processing efficiency, and expanding support for additional real-time input modalities such as voice and brain computer interfaces. The proposed framework serves as a substantial advancement in supporting communication technology, promoting greater independence from people with disabilities.

REFERENCES

[1] Deepak, G. S. N., Rohit, B., Akhil, C., Bharath, D. S. S. C., & Prakash, K. B. (2021, May). An approach for morse code translation from eye blinks using tree based machine learning algorithms and OpenCV. In *Journal of Physics: Conference Series* (Vol. 1921, No. 1, p. 012070). IOP Publishing

[2] Sushmitha, M., Kolkar, N., Suman, G. S., & Kulkarni, K. (2021, September). Morse Code Detector and Decoder using Eye Blinks. In 2021 Third International Conference on Inventive Research in Computing Applications (ICIRCA) (pp. 1-6). IEEE.

[3] Geetha, M. C. S., & Sarubala, B. (2024, January). Dots and Dashes: Understanding the Language of Morse Code Using Convolutional Neural Network. In 2024 2nd International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT) (pp. 1522-1526). IEEE.

[4] Win, A., & San, K. K. (2023, February). Morse Code Audio Recognition using LSTM-CTC Model. In 2023 IEEE Conference on Computer Applications (ICCA) (pp. 393-398). IEEE

[5] Li, R., Nguyen, M., & Yan, W. Q. (2017, November). Morse codes enter using finger gesture recognition. In 2017 International Conference on Digital Image Computing: Techniques and Applications (DICTA) (pp. 1-8). IEEE.

[6] Choudhury, R. R. (2024). Morse Code-Enabled Speech Recognition for Individuals with Visual and Hearing Impairments. arXiv preprint arXiv:2407.14525

[7] Wu, C. M., Chen, Y. J., Chen, S. C., & Zheng, S. F. (2023). Creating an AI-Enhanced Morse Code Translation System Based on Images for People with Severe Disabilities. Bioengineering, 10(11), 1281.

[8] Nalajala, P., Godavarth, B., Raviteja, M. L., & Simhadri, D. (2016, March). Morse code generator using microcontroller with alphanumeric keypad. In 2016 International Conference on Electrical, Electronics, and Optimization Techniques (ICEEOT) (pp. 762-766). IEEE.

[9] Das, R., & ShivaKumar, B. (2019). Headspeak: morse code based head gesture to speech conversion using intel Realsense™ technology. International Journal of Recent Technology and Engineering, 8(2), 2866-2874.

[10] Sarika, M. N., Varma, C. R., Gayatri, K., Sushma, K., & Varun, M. Patient Obligation Perceiver Using Eye Gestures.

[11] Akare, U. P., Bhure, K., Adarsh Sonkusre, Atharva Ganorkar, Mayank Barapatre, & Pratyush Roychowdhury. (2024). Morse code detector using machine learning. In *International Journal of Advanced Research in Computer and Communication Engineering* (Vol. 13, Issue 4, pp. 80–81) [Journal-article]. https://doi.org/10.17148/IJARCCE.2024.13414

[12] Morse Code communication System using microcontroller. (2024). In *International Journal of Microelectronics and Digital Integrated Circuits* (Vols. 10–17) [Journal-article

[13] Anitha, m., Nagamalleswara rao, y., & A. Likitha sri. (2023). Decryption of morse code from voice using a convolutional neural network [journal-article]. *Volume 13, issue 07*, 818–819.

.[14] Barse, M., & Manuel, R. (2013). Morse Code-A Security Enhancer. *International Journal of Science and Research (IJSR), ISSN (Online)*, 2319-7064

[15] Medichalam, K., Vijayarajan, V., Venkatesan, V. K., Iyer, I. M., Vanukuri, Y. K., Prasath, V. S., & Swapna, B. (2023). Trustworthy Artificial Intelligence and Automatic Morse Code Based Communication Recognition with Eye Tracking. *J. Mobile Multimedia*, *19*(6), 1439-1462.

[16] Wang, F., Hu, A., Song, Y., Zhang, W., Zhu, J., & Liu, M. (2024). Morse Code Recognition Based on a Flexible Tactile Sensor with Carbon Nanotube/Polyurethane Sponge Material by the Long Short-Term Memory Model. *Micromachines*, *15*(7), 864.

[17] Li, W., Wang, K., & You, L. (2020). MorseNet: a unified neural network for morse detection and recognition in spectrogram. *IEEE Access*, *8*, 161005-161017

[18] Priya, A., J., Teja, S., D., Kumar, P., B., Sajja, A., & Department of Electronics and Communication Engineering, Anurag University, Ghatkesar, Telangana, India. (2024). Morse code transcriber using C. In *Journal of Emerging Technologies and Innovative Research* (Vol. 11, Issue 5) [Journal-article].

[19] Kothamasu, S., & Gopinath, R. V. (2019). Morse code translatorusing Python. *IJARIIT*, *5*(3), 35-37.

[20] *Designing a Simple Quantum Morse Encoder and wDecoder Using IBM Quantum Experience*.

[21] Cowley, S. J. (2019). Wide coding: Tetris, Morse and, perhaps, language. Biosystems, 185, 104025.

[22] Shih, C. H., & Luo, C. H. (1997). A Morse-code recognition system with LMS and matching algorithms for persons with disabilities. International Journal of Medical Informatics, 44(3), 193-202

[23] Wu, C. M., Huang, K. G., Chang, S. H., Hsu, S. C., & Lin, C. L. (2007, October). EOG single switch morse code translate input device for individuals with the motor neuron disease. In TENCON 2007-2007 IEEE Region 10 Conference (pp. 1-4). IEEE.

[24] Irawan, Y., Wahyuni, R., & Herianto, H. (2021). Morse Code Receiver On Invisible Light Using Background Subtraction Method. Journal of Robotics and Control (JRC), 2(4), 283-286.

[25] Luo, C. H., & Shih, C. H. (1996). Adaptive Morse-coded single-switch communication system for the disabled. International Journal of Bio-Medical Computing, 41(2), 99-106