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AI-Powered Morse Code Communication System using Eye Blink Detection

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***Abstract*—In modern healthcare and assistive communication systems, individuals suffering from paralysis, speech impairment, or severe physical disabilities often face significant challenges in communicating with others. Conventional communication methods require physical interaction, speech capability, or specialized expensive hardware, making them inaccessible in emergency or low-resource environments. To address this issue, this project presents an AI-powered real-time Morse code communication system using eye blink detection through computer vision techniques.**

The proposed system utilizes a webcam to monitor eye movements and detect intentional blinks using facial landmark tracking and Eye Aspect Ratio (EAR) analysis. Short-duration blinks are interpreted as Morse code dots (.), while long-duration blinks represent dashes (-). The detected Morse code patterns are translated into alphabets and displayed as readable text in real time. The system integrates computer vision, facial landmark detection, digital image processing, and heuristic pattern recognition to provide a lightweight and efficient communication solution.

The methodology involves capturing live video frames, detecting facial landmarks using MediaPipe Face Mesh, calculating eye blink duration using geometric eye ratios, classifying blink signals into Morse code symbols, and decoding the generated Morse patterns into textual output. The system operates in real time and provides visual feedback through a graphical interface, making it suitable for assistive communication applications.

The proposed system can significantly improve communication for differently-abled individuals, ICU patients, and individuals with temporary speech disabilities. Its low-cost implementation, real-time processing capability, and non-invasive design make it highly suitable for healthcare assistance, accessibility technologies, and emergency communication systems.

***Index Terms*—Computer Vision, Morse Code, Eye Blink Detection, MediaPipe, Assistive Technology, Human-Computer Interaction, Artificial Intelligence**

I. INTRODUCTION

Disabilities such as paralysis, locked-in syndrome, neurological disorders, and speech impairments severely affect an individual's ability to communicate effectively with others. In many medical and emergency situations, patients retain eye movement control even when they cannot speak or move other body parts. Existing assistive communication devices often require costly hardware, physical interaction, or invasive sensors, limiting their accessibility and affordability.

Recent advancements in artificial intelligence and computer vision have enabled the development of low-cost and real-time human-computer interaction systems. Eye blinking is a natural and controllable human action that can be effectively used for communication. By integrating eye blink detection with Morse code translation, users can generate words and sentences without speaking or typing.

Morse code is a universally recognized communication method that represents characters through combinations of dots and dashes. In this project, short eye blinks are interpreted as dots, while long eye blinks are interpreted as dashes. These Morse sequences are decoded into alphabets and displayed as readable text on the screen.

The AI-Powered Morse Code Communication System developed in this project aims to provide a real-time, affordable, and non-contact communication solution using only a webcam and computer vision algorithms. The system continuously captures facial video, detects eye landmarks using MediaPipe Face Mesh, analyzes blink duration using Eye Aspect Ratio calculations, and converts blink patterns into Morse code signals.

This system can be highly beneficial in hospitals, rehabilitation centers, smart healthcare systems, and assistive communication technologies. By combining artificial intelligence with real-time image processing, the project contributes toward inclusive and accessible technological solutions for differently-abled individuals.

II. SYSTEM ARCHITECTURE OVERVIEW

The system consists of five core layers:
- Video Acquisition Layer
- Face & Eye Landmark Detection Layer
- Eye Blink Detection Module
- Morse Code Translation Engine
- Visualization & Output Interface

Fig. 1 illustrates the complete system workflow.

Flowchart:
1. Webcam captures live video
2. Face detection using MediaPipe
3. Eye landmark extraction
4. Eye Aspect Ratio calculation
5. Blink duration analysis
6. Dot/Dash classification
7. Morse code generation
8. Morse code decoding
9. Text output display

Fig. 1. System Architecture for Eye Blink Morse Code Communication.

III. METHODOLOGY

A. Video Acquisition

The system captures live video frames using the OpenCV library through a webcam at real-time frame rates. Each frame is continuously processed to monitor facial movements and eye activity.

B. Face Detection and Landmark Extraction

MediaPipe Face Mesh is used to detect facial landmarks with high accuracy. Specific landmark points around both eyes are extracted to monitor blinking behavior. These landmarks help calculate geometric relationships required for eye state detection.

The following parameters are analyzed:
- Eye Aspect Ratio (EAR)
- Eye Closure Duration
- Blink Frequency
- Facial Landmark Coordinates

Fig. 2. Facial landmark detection using MediaPipe Face Mesh.

C. Eye Blink Detection

The Eye Aspect Ratio (EAR) is calculated using distances between vertical and horizontal eye landmarks. When the EAR falls below a predefined threshold, the eye is considered closed.

Short Blink → Dot (.)   Long Blink → Dash (-)

Blink duration is measured using timestamp analysis to classify Morse code symbols accurately.

Fig. 3. Eye Blink Detection using Eye Aspect Ratio.

D. Morse Code Translation

Detected Morse code patterns are matched against a predefined Morse code dictionary containing alphabet mappings. Once a valid Morse sequence is recognized, the corresponding alphabet is displayed as output text.

Example:

Morse Code	Output
.-	A
-...	B
...	S
---	O

E. Visualization and Output

The graphical interface displays:
- Live webcam feed
- Eye landmark visualization
- Detected Morse code symbols
- Generated text output
- Blink status indicators

The GUI allows users to monitor communication in real time.

Fig. 4. Full GUI showing Morse Code and Text Output.

IV. RESULTS & DISCUSSION

The system was tested under varying lighting conditions and user positions to evaluate detection accuracy and responsiveness. Intentional eye blinks were successfully detected with high precision using the Eye Aspect Ratio method. Short and long blinks were accurately classified into Morse code dots and dashes under normal webcam conditions.

The system demonstrated reliable real-time performance with minimal latency. Morse code sequences such as "SOS," "HELP," and other short emergency messages were translated successfully into readable text. MediaPipe Face Mesh provided stable facial landmark tracking even during moderate head movement.

The system performed efficiently in indoor lighting environments. However, excessive head movement, poor lighting conditions, and accidental blinks occasionally caused incorrect Morse symbol generation. Despite these limitations, the system showed strong potential for assistive communication applications.

V. LIMITATIONS

While the system performs effectively under controlled conditions, several limitations exist:

- Poor lighting conditions may reduce eye detection accuracy.
- Rapid involuntary blinking can introduce false Morse signals.
- Continuous long-duration use may cause user fatigue.
- The system currently supports only English Morse code alphabets.
- Webcam quality affects landmark detection performance.

VI. FUTURE ENHANCEMENTS

Future improvements may include:

- Deep learning-based blink classification
- Adaptive blink calibration for different users
- Text-to-speech conversion
- Mobile application integration
- Emergency alert system integration
- Multi-language Morse decoding
- AI-based fatigue reduction mechanisms

VII. CONCLUSION

The AI-powered Morse Code Communication System using Eye Blink Detection presents an innovative and affordable assistive communication solution for individuals with speech and movement disabilities. By combining computer vision, facial landmark detection, and Morse code translation, the system enables real-time communication using simple eye blinks.

The lightweight architecture, low hardware requirements, and non-invasive operation make the system suitable for healthcare, accessibility, and emergency communication applications. This project demonstrates the potential of artificial intelligence and computer vision in building inclusive technologies for differently-abled individuals.

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