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Real-Time Eye Blink and Facial Recognition System Using Computer Vision

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Abstract

People who suffer from paralysis or severe motor disabilities often experience major difficulties when trying to communicate with others. Traditional communication tools such as keyboards, switches, and specialized eye-tracking devices are not always convenient because they may require physical movement or expensive hardware. This research introduces a real-time communication system that uses computer vision and deep learning techniques to interpret eye blinks and facial expressions. The system detects eye movements using dlib-based facial landmark detection and calculates the eye aspect ratio (ear) to determine blink events. Continuous analysis of ear values allows the system to identify intentional blinks and translate them into commands. In addition, facial expressions are recognized using a lightweight convolutional neural network (cnn) that processes 64×64 grayscale facial images and classifies them into seven emotional categories. The cnn architecture combines standard convolution layers with residual blocks and depth wise separable convolutions to reduce computational complexity while maintaining accuracy, along with batch normalization, relu activation, and global average pooling for efficient feature learning and classification. A virtual keyboard is incorporated to allow users to select characters using blink-based inputs. The recognized gestures are further used to generate voice feedback through a text-to-speech module. The proposed system works with a standard webcam and does not require specialized hardware devices. Experimental observations indicate that the system can provide an efficient and affordable communication interface for individuals with limited physical mobility.

Keywords: *eye blink detection, dlib, eye aspect ratio, computer vision, facial expression recognition, cnn, virtual keyboard, assistive technology*

1. Introduction

Human communication relies heavily on physical actions such as speaking, writing, or interacting with devices. However, individuals affected by paralysis, spinal cord injuries, or neurological disorders may lose the ability to perform these activities. Limited control over body movements makes it difficult for such individuals to communicate their needs or emotions effectively. This situation can lead to increased dependence on caregivers and reduced independence in daily life. Advancements in artificial intelligence and computer vision have created opportunities to develop assistive technologies that can interpret subtle facial movements. Eye blinking is a natural facial action that remains controllable for many individuals even in severe paralysis conditions. By monitoring eye movement patterns through a camera, it is possible to detect blink gestures and convert them into digital commands. Apart from eye movements, facial expressions also convey valuable information about a person's emotional condition. Automatic recognition of facial expressions can help systems understand the user's emotional state and improve interaction between humans and machines. Modern deep learning methods, especially convolutional neural networks, have significantly improved the accuracy of facial expression recognition systems. The objective of this research is to design a real-time system that enables users to communicate through eye blinks and facial expressions. The proposed system integrates dlib-based facial landmark detection for eye tracking, eye aspect ratio analysis for blink detection, and a cnn model for emotion recognition. The combination of these techniques allows users to interact with a virtual

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keyboard and communicate using voice feedback without requiring physical input devices.

2. Methods

Computer vision-based video processing the proposed system operates using computer vision techniques to analyze facial movements captured through a webcam. Real-time video frames are continuously captured and processed to detect the presence of a human face and extract relevant facial features. Computer vision algorithms allow the system to interpret visual information from the video stream and convert it into meaningful data. Each frame is analyzed to identify facial structures such as the eyes, nose, and mouth. This processing stage forms the foundation of the system, enabling further analysis for blink detection and facial expression recognition.

2.1.Facial landmark detection using dlib

Facial landmark detection plays a critical role in identifying the exact positions of facial features. In this system, the dlib library is used to detect facial landmarks because it provides a reliable pretrained model capable of identifying 68 key points on the human face. These landmarks represent important facial components including the eyebrows, eyes, nose, and mouth. The eye landmarks are particularly important for blink detection. By tracking these landmark points across consecutive video frames, the system can accurately monitor eye movements and determine whether the eyes are open or closed.

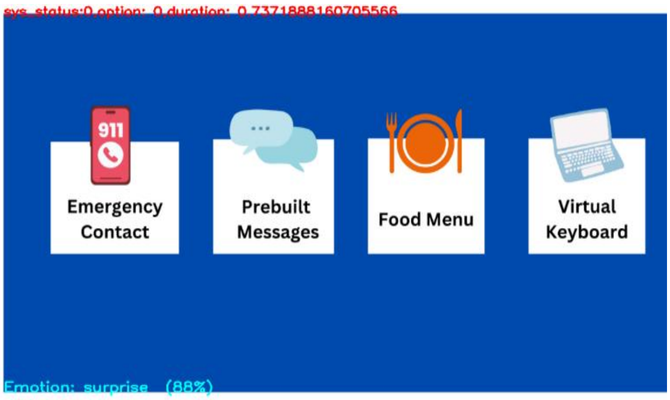

Figure 1. System user interface[a]

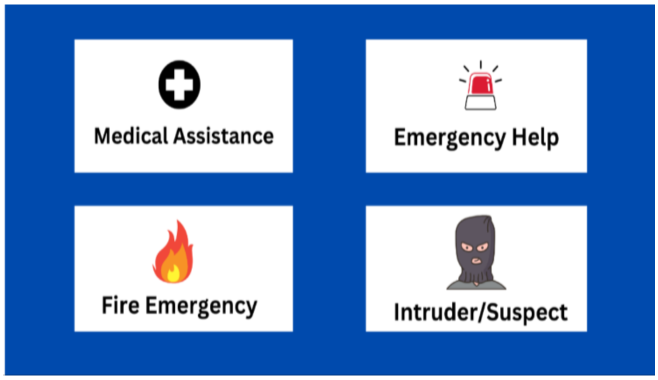

Figure 1. System user interface [b]

2.2.Eye blink detection using eye aspect ratio (ear)

Eye blink detection is performed using the eye aspect ratio method, which calculates the relationship between the vertical and horizontal distances of the eye. The eye aspect ratio is derived from specific eye landmarks detected by the dlib model. When the eye is open, the ratio remains relatively stable because the vertical distance between the eyelids is large. When a blink occurs, the eyelids move closer together, causing the vertical distance to decrease and the ratio value to drop significantly. By continuously monitoring this ratio across frames, the system can identify blink events in real time. The blink detection mechanism allows the system to interpret voluntary blinks as commands for user interaction.

2.3. facial expression recognition using convolutional neural networks (cnn)

To recognize emotional states from facial expressions, the system uses a lightweight convolutional neural network designed for efficient image classification. The model processes 64×64 grayscale facial images extracted from video frames and classifies them into seven emotional categories. The architecture begins with standard convolutional layers that capture basic visual features, followed by residual blocks that improve feature extraction while maintaining efficiency. These blocks incorporate depth wise separable convolutions to reduce computational complexity, along with batch normalization and relu activation to ensure stable and effective training. Max-pooling is applied to reduce spatial dimensions and learn hierarchical features,

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while shortcut connections support residual learning and preserve important information across layers. In the final stage, a convolution layer with seven filters maps the features to the corresponding classes, followed by global average pooling and a softmax function to generate probability outputs. With approximately 58,000 parameters, the model remains computationally efficient and suitable for real-time applications, enabling accurate recognition of facial expressions and improving user interaction.

2.4. virtual keyboard interface and user interaction

The virtual keyboard is integrated into the system to enable users to communicate through eye blink-based inputs. It is displayed on the screen as a graphical interface where each key is highlighted sequentially or selected based on detected user actions. The system uses eye blink detection as a control mechanism, where a voluntary blink is interpreted as a selection command. When the user blinks while a specific key is highlighted, that key is chosen and added to the output text. This hands-free interaction method allows users, especially individuals with limited mobility, to communicate effectively without the need for physical input devices. The virtual keyboard thus serves as the final output interface, translating detected facial movements and expressions into meaningful communication.

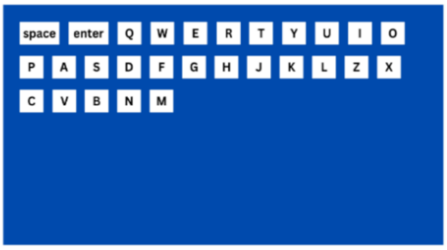

Figure 2 Virtual keyboard

3. Results and discussion

3.1.Results

The proposed system was tested to evaluate the performance of eye blink detection and facial expression recognition in real time. A webcam was used to capture video frames, which were processed using computer vision techniques. Facial landmarks were detected using the dlib library, allowing accurate tracking of the eye region. The eye aspect ratio (ear) was calculated from the detected eye landmarks to determine blink events. When the ear value decreased below the threshold level, the system successfully detected eye blinks. The facial expression recognition module used a convolutional neural network (cnn) to analyze facial images and classify expressions such as happy, sad, angry, and neutral. The results showed that the system could correctly detect blink gestures and basic facial expressions under normal lighting conditions, enabling users to interact with the virtual keyboard and generate messages.

Conclusion

This work presented a real-time eye-blink and facial expression recognition system designed to support communication for individuals with limited physical mobility. The system uses computer vision techniques to process live video captured from a webcam and detect facial features. Eye blink detection is performed using dlib facial landmark detection and the eye aspect ratio method, which allows the system to identify blink gestures accurately. In addition, facial expressions are recognized using a convolutional neural network to understand the emotional state of the user. The detected blinks can be used to interact with a virtual keyboard and generate messages that are converted into speech. The results show that the system can detect eye movements and facial expressions in real time using commonly available hardware. This approach provides a simple and low-cost assistive communication solution. Future improvements may include improving detection accuracy under different lighting conditions and expanding the system with additional features for enhanced user interaction.

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