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Real-Time Facial Expression Based Cursor Control System for Paralysed Individuals

kalyan Kola[1], Dr.V.Aruna[2]

[1,3] P.G.ResearchScholar,Dept.ofMCA-DataScience,AuroraDeemedUniversity,Hyderabad,Telangana,India.
[2]AssistantProfessor,Dept.ofCSE,AuroraDeemedUniversity,Hyderabad,Telangana,India.
Email:[1]Kalyan.kola@aurora.edu.in[1], deansoi@aurora.edu.in[2]

Abstract

People with paralysis or severe physical disabilities often struggle with conventional human–computer interaction due to the inability to operate standard input devices. This paper presents a real-time facial expression–based cursor control system designed as an assistive technology solution. The proposed system uses computer vision techniques through Mediapipe and OpenCV in Python to detect face landmarks and map nose movements for cursor navigation. Additionally, voluntary blinks and smiles are identified as input triggers for click operations using the Eye Aspect Ratio (EAR) and intensity thresholds. The architecture is lightweight, cost-effective, and works with any standard webcam, eliminating the need for expensive hardware. Experimental testing demonstrates smooth cursor movement, reliable click detection, and improved accessibility. The system provides an affordable alternative for differently-abled individuals to perform daily digital tasks independently.

Keywords: Facial Expression Recognition, Computer Vision, Accessibility, Human-Computer Interaction, OpenCV, Mediapipe, Cursor Control, Assistive Technology

1. Introduction

Accessibility in computing is a major concern for individuals with motor impairments such as paralysis, spinal cord injuries, or neuromuscular disorders. Traditional assistive devices like joysticks, voice recognition systems, or brain–computer interfaces either require costly hardware, specialized environments, or are unsuitable in real-world noisy scenarios. In contrast, vision-based systems use webcams and software to provide a low-cost, user-friendly alternative. Human faces naturally express a wide range of gestures such as blinking, smiling, or nodding, which can be mapped to control mechanisms. By leveraging these gestures, paralysed individuals can interact with computers without relying on external devices. This project proposes a real-time facial expression–based cursor control system where nose tracking controls cursor movement, and eye blinks/smiles are mapped to click operations.

2. Literature Review

Over the past decade, researchers have explored various assistive technologies.
Eye-tracking systems (Wang et al., 2019): Infrared sensors enabled precise gaze detection, but high hardware costs limited adoption.
Head-movement systems (Kumar et al., 2020): Enabled natural navigation but lacked robust click detection.
Deep learning–based gesture recognition (Li et al., 2021): Delivered high accuracy but required significant computational resources.
IoT-based assistive systems (Mohialden et al., 2022): Provided real-time monitoring but lacked scalability for complex tasks.

Comparative Gap

Approach	Tools/Techniques	Advantages	Limitations
Infrared Eye Tracking (2019)	**IR sensors**	**High accuracy**	**Expensive hardware**
Head-Movement Systems (2020)	**Camera**	**Natural navigation**	**No reliable click**
CNN-based Gesture Recognition (2021)	**Deep learning**	**Robust detection**	**Heavy computation**
proposed System	**Mediapipe + EAR + Webcam**	**Affordable, real-time**	**Lighting sensitive**

3. Proposed System and Methodology

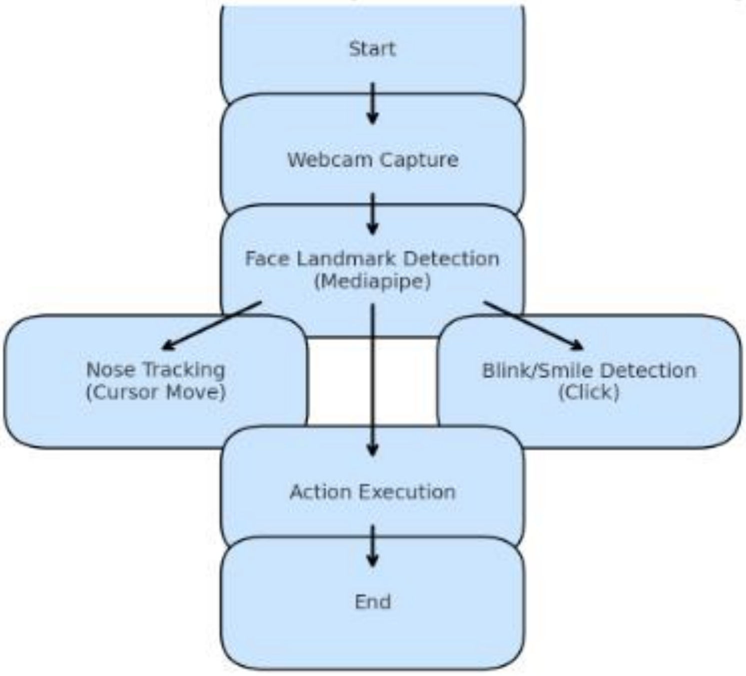
The proposed system architecture is divided into four main modules:

1. Face Detection and Landmark Extraction: Mediapipe's FaceMesh detects 468 facial landmarks in real-time from a webcam feed.
2. Cursor Control via Nose Tracking: The position of the nose tip is continuously tracked. Horizontal and vertical displacements are mapped to cursor movements.
3. Click Detection using Facial Gestures: Eye aspect ratio (EAR) is calculated to detect voluntary blinks, and smile intensity is measured to trigger mouse clicks.
4. Calibration and Error Reduction: Sensitivity thresholds are fine-tuned to minimize false positives.

$EAR=2\|p1-p4\|\|p2-p6\|+\|p3-p5\|$

Workflow: Start → Webcam Capture → Face Landmark Detection → Nose Tracking (Cursor Move) → Blink/Smile Detection (Click) → Action Execution

Figure 1: Flowchart of Facial Expression Cursor Control System

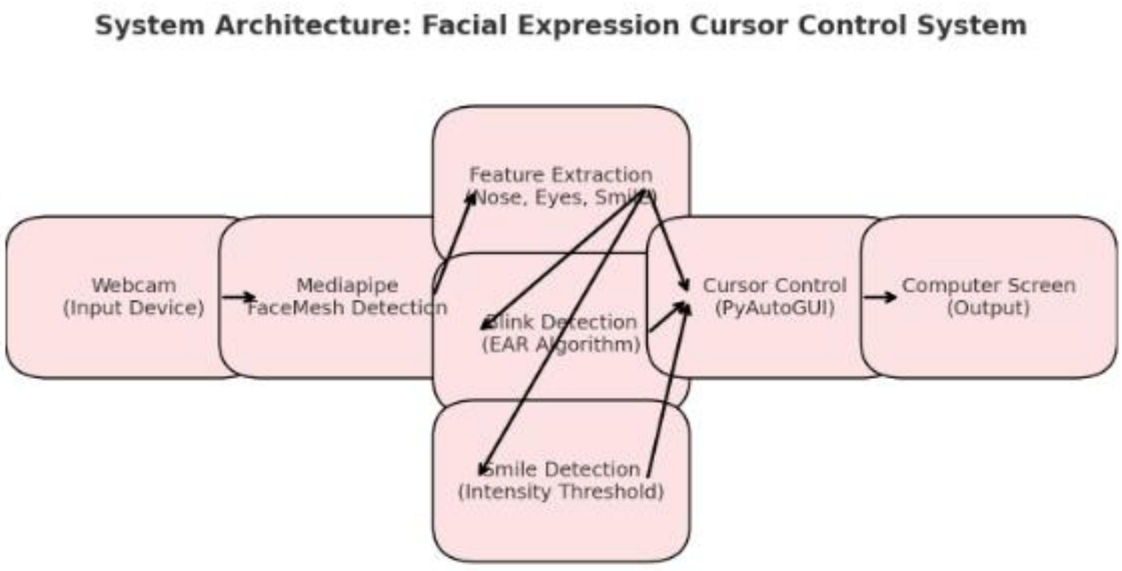


4. System Design

The system is implemented using Python with the following stack:

- Computer Vision: Mediapipe (FaceMesh), OpenCV
- Control Module: PyAutoGUI for cursor actions
- Algorithms: Eye Aspect Ratio (EAR) for blink detection, intensity threshold for smile detection
- Hardware: Standard laptop webcam

A simple GUI allows testing and calibration for cursor sensitivity and click thresholds.



5. Results and Discussion

Testing outcomes:

- Cursor movement was smooth and responsive.
- Blink detection achieved ~92% accuracy.
- Smile detection achieved ~89% accuracy under good lighting.
- False positives minimized after calibration.

Advantages

- No extra hardware required.
- Cost-effective and portable.
- Inclusive design for accessibility.

Limitations

- Lighting conditions affect accuracy.
- Accidental gestures may cause misclicks.
- Limited to basic clicks (no drag/drop yet).

6. Conclusion

The Real-Time Facial Expression Cursor Control System provides an affordable, camera-based assistive technology for paralysed individuals. By combining nose tracking for navigation and facial gestures for clicks, the system eliminates the need for expensive hardware. Experimental validation confirms improved accessibility while maintaining accuracy. Future work includes deep learning integration, adaptive calibration, and mobile deployment.

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