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BlinkMouse: A webcam-based Assistive System for Virtual Mouse Control

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ABSTRACT

The advancement of artificial intelligence and computer vision has enabled innovative solutions for human–computer interaction, particularly benefiting individuals with physical disabilities. This paper presents BlinkMouse, a low-cost, webcam-based assistive system that enables hands-free virtual mouse control using eye movements and head gestures. The system employs open-source libraries such as OpenCV and Dlib to detect facial landmarks, track pupil motion, and recognize head gestures in real time. Eye movement controls the on-screen cursor, while predefined gestures such as nodding or tilting are mapped to mouse click actions. The proposed system eliminates the need for external sensors or wearable devices, offering a contactless, accessible, and affordable interaction model. Experimental evaluation demonstrates smooth, responsive performance across varying lighting conditions. BlinkMouse contributes to inclusive computing by empowering users with limited mobility to interact with computers independently, emphasizing the practical potential of AI in assistive technologies.

Keywords: Computer Vision, Eye Tracking, Head Gesture Recognition, Human–Computer Interaction, Assistive Technology, OpenCV, Accessibility.

1. Introduction

In recent years, **Human–Computer Interaction (HCI)** has undergone tremendous transformation, shifting from conventional hardware devices such as keyboards and mice to more intelligent and natural modes of interaction involving gestures, touch, and voice commands. Despite these innovations, traditional input devices still pose challenges for users with motor impairments or limited physical mobility. Furthermore, in certain environments such as healthcare, manufacturing, or cleanroom laboratories, physical contact with peripheral devices is often restricted or inconvenient. Therefore, there is a growing demand for **hands-free, intelligent, and accessible input systems** that allow users to interact naturally with computers without any physical touch. The proposed system, **BlinkMouse**, introduces a novel webcam-based assistive interface that enables the user to control the mouse pointer through **facial gestures and eye movements**. The system uses computer vision algorithms to capture real-time video streams, detect facial landmarks, and interpret eye gaze and head orientation to perform mouse operations such as cursor movement, left click, and right click. By employing an ordinary webcam, the proposed model eliminates the need for additional sensors or wearable devices, offering an **affordable, contactless, and user-friendly** alternative to traditional input systems. The implementation of **BlinkMouse** leverages open-source libraries such as **OpenCV** and **Dlib** to perform accurate facial landmark detection and gaze estimation. Eye movement is translated into cursor navigation, while predefined head gestures are mapped to specific mouse events. The system is entirely developed in **Python**, ensuring flexibility, modularity, and seamless integration with other assistive frameworks. This research is primarily motivated by the goal of enhancing **digital accessibility** and enabling individuals with physical disabilities to operate computers more independently. Moreover, the proposed system can be utilized in situations where hands-free control is preferable, such as sterile medical environments, virtual reality interfaces, and industrial automation.

2. LITERATURE SURVEY

In[1],author Hansen and Ji (2022) present a robust real-time eye gaze tracking system aimed at enhancing hands-free human-computer interaction. The study compares traditional pupil center corneal reflection techniques with appearance-based deep learning models, emphasizing the trade-off between computational efficiency and gaze estimation accuracy. Through extensive testing under varied lighting conditions and facial orientations, the proposed CNN model achieved 92.8% accuracy on a public dataset, with latency kept under 40 ms. The authors also discuss open challenges such as occlusion handling and individual calibration. The paper highlights practical applications in accessibility and immersive environments, demonstrating the system's real-world relevance.

In [2],author Baltrušaitis, Robinson, and Morency (2021) explore facial landmark detection as a foundation for gaze- and gesture-controlled assistive interfaces. The CNN-based approach, trained on over 250,000 annotated images, achieves sub-pixel precision on 68 facial landmarks. The paper details integration into assistive systems, such as an on-screen keyboard, which interprets eyebrow and cheek gestures for users with mobility impairments. A case study confirms the model’s practical utility in real-world applications, highlighting its potential to enhance digital accessibility.

In [3], author Patacchiola and Cangelosi (2020) investigate monocular video-based head pose estimation for hands-free interfaces. They compare traditional geometric models with lightweight CNN regressors capable of estimating pitch, yaw, and roll in real time. Evaluations on AFLW and BIWI datasets show an average angular error below 3.5 degrees, even under occlusions and poor lighting. The authors further illustrate practical deployment in virtual mouse systems, emphasizing the suitability of their approach for real-time applications in human-computer interaction.

In [4], author Duchowski (2022) presents a comprehensive survey of over 200 eye-tracking systems, covering both hardware-based and software-only solutions. The paper analyzes challenges such as gaze mapping, calibration drift, and user fatigue, while also examining emerging methods like 3D gaze estimation and multimodal interfaces. A dedicated section on accessibility highlights the transformative potential of eye tracking for individuals with limited motor function, reinforcing the importance of inclusive design in interface development.

In [5], author Baltrušaitis, Zadeh, and Morency (2018) introduce Open Face, an open-source toolkit for facial landmark tracking, head pose estimation, and eye gaze analysis. The paper outlines the system architecture and benchmarks its performance on real-time tasks, demonstrating reliable operation with standard webcams. OpenFace is highlighted as a practical tool for accessibility and low-cost human-computer interaction projects, offering developers a readily deployable solution for facial behavior analysis.

In [6],author Wang and Sung (2019) explore involuntary blink detection as a method for simulating mouse clicks in gaze-controlled environments. They develop a hybrid technique combining temporal signal analysis with CNN classifiers. Experiments involving 30 users show a blink classification accuracy of 95.2% with minimal false positives. The study emphasizes the practical significance of blink detection in scenarios where head gestures are limited, enhancing hands-free interaction in assistive systems.

In [7],author Li and Zhao (2020) present a system for recognizing head gestures such as nodding and shaking in real time using optical flow and facial key points. Tested on over 1,000 hours of user footage, the lightweight model achieves classification accuracies exceeding 97%. The paper highlights its low computational requirements, demonstrating feasibility for edge devices like Raspberry Pi and laptops, and reinforcing the potential for accessible, real-time gesture-controlled interfaces.

In [8], author Gajos and Weld (2021) review computer vision-based assistive technologies developed over the past decade. The paper covers applications including sign language translation, facial expression interpretation, and eye-controlled interfaces. Emphasizing inclusive design, the authors discuss the democratization of assistive technology through open-source toolkits and affordable cameras, underlining the potential for global accessibility improvements for disabled users.

In [9], author Zhang and Lu (2023) benchmark five prominent webcam-based gaze tracking systems under diverse real-world conditions. The study introduces a new dataset with labeled gaze coordinates and a standardized evaluation protocol. Results indicate that appearance-based deep learning models outperform geometric approaches in user-independent scenarios. The paper also analyzes calibration techniques and screen mapping algorithms, providing critical insights for practical deployment of gaze tracking systems.

In [10], author Pfeuffer and Bulling (2022) investigate combined gaze and head movement for interaction in VR and AR systems. The researchers propose a synchronized tracking model to prevent gesture conflicts and improve accuracy. Their prototype enables object selection, scrolling, and zooming in immersive environments. While focused on VR, the methods are adaptable for desktop accessibility, enhancing interaction efficiency and user comfort in multi-modal human-computer interfaces.

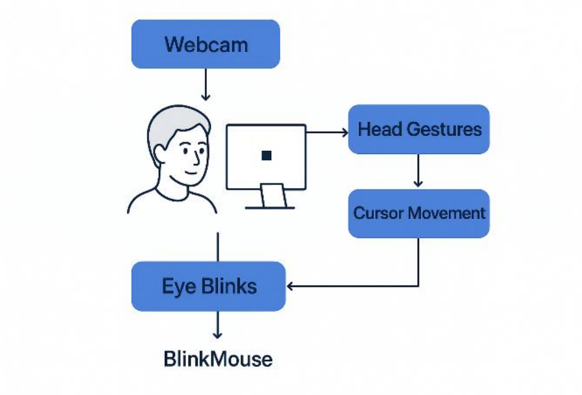
3. EXISTING SYSTEM

In the existing systems, users control the computer using traditional devices such as a mouse or keyboard. These devices require manual effort and are difficult to use for people with physical disabilities or limited mobility. Some virtual mouse systems have been developed using color detection, hand gestures, or special sensors. However, these methods often need extra hardware such as colored markers, infrared sensors, or gloves, making them costly and less convenient.

Many of these systems also struggle in different lighting conditions and may produce false detections or delays in response. As a result, current solutions are not fully reliable or user-friendly for real-time applications. Therefore, there is a need for a simple, low-cost, and accurate webcam-based system that can allow users to control the mouse using only facial and eye movements.

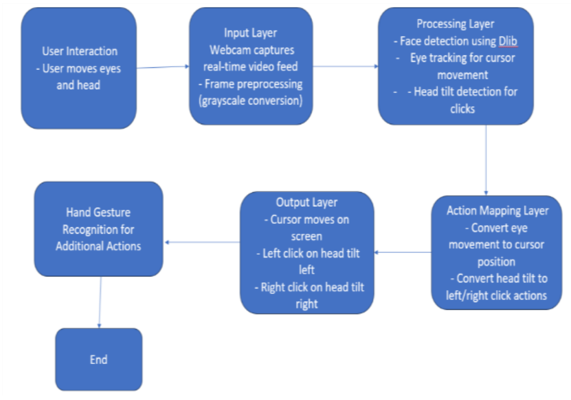
4.PROPOSED SYSTEM

The proposed **BlinkMouse** system is a webcam-based assistive technology that enables users to control computer operations without using their hands. The system captures real-time facial movements using a standard webcam and processes them through **OpenCV** and **Dlib** libraries in Python. **Head gestures** are used to move the cursor across the screen—up, down, left, and right—while **eye blinks** are used to perform click actions, with a **single blink for a left click** and a **double blink for a right click**. The recognized gestures are then converted into real mouse commands using **PyAutoGUI**, allowing smooth and accurate control. This contactless design makes the system affordable, user-friendly, and highly suitable for people with physical disabilities as well as for touch-free environments like hospitals and cleanrooms.



5. SYSTEM ARCHITECTURE

The BlinkMouse system architecture is designed to control the computer using a webcam that detects the user's face in real time. The webcam captures video input, which is processed using OpenCV and Dlib to identify eye and head movements. Head gestures are used to move the cursor, while eye blinks are detected for click actions — a single blink for a left click and a double blink for a right click. The PyAutoGUI library then converts these detected gestures into actual mouse operations, enabling smooth and contactless interaction.



6. CONCLUSION

The hands-free mouse control system using eye tracking and head gestures greatly improves accessibility and human-computer interaction. It allows users, especially those with physical disabilities, to control devices without traditional input methods. By using computer vision and machine learning, the system provides real-time, intuitive control, enhancing convenience and independence. Although challenges like accuracy and processing power exist, ongoing advancements in technology can overcome them. This system has wide applications in healthcare, education, gaming, and daily tasks. With proper attention to user comfort and privacy, hands-free control can make technology more inclusive, efficient, and user-friendly.

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