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Gesture Based Human Computer Interaction

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Abstract -Gesture-Based Human Computer Interaction (GB-HCI) is a technology that enables users to interact with computers naturally through body movements, without the need for physical input devices like a mouse or keyboard. It captures gestures using sensors or cameras and processes them through image analysis and pattern recognition techniques. The recognized gestures are then translated into corresponding commands that allow the computer to respond and perform actions. This form of interaction makes computing more intuitive, efficient, hygienic, and immersive. It is widely used in areas such as virtual reality, gaming, robotics, smart environments, and assistive technologies, improving accessibility and user experience.

***Key Words*:** Driver Monitoring, Computer Vision, YOLOv8, MediaPipe, EAR, MAR, Distraction Detection, Cloud Logging

1. INTRODUCTION

Gesture-based human–computer interaction is widely regarded as intuitive, natural, and user-friendly, enabling users to communicate with digital systems through simple, comfortable movements. This interaction style creates an immersive and engaging experience, as gestures support seamless and fluid communication that increases user involvement. Effective systems rely on accuracy, robustness, and real-time responsiveness, ensuring low latency and consistent recognition. They also prioritize ergonomics, minimizing fatigue while enabling expressive, versatile, and hands-free control that avoids physical strain.

Gesture-based human–computer interaction allows users to control digital systems using simple and natural movements, making the experience intuitive and engaging. These systems are designed to be accurate, fast, and easy to use, responding in real time without causing strain or fatigue. They aim to be comfortable, predictable, and accessible for all users, offering a hands-free and contactless way to interact with technology. Overall, gesture-based interaction provides a modern, user-friendly, and efficient approach to communicating with computers.

2. METHODOLOGY

Gesture-based human–computer interaction begins with designing and selecting gestures that are meaningful, easy to perform, and suitable for the intended application. This step focuses on understanding user needs and deciding which hand or body movements will be used for commands. Once the gestures are defined, data is collected using devices such as cameras, depth sensors, or motion detectors to capture the user's movements.

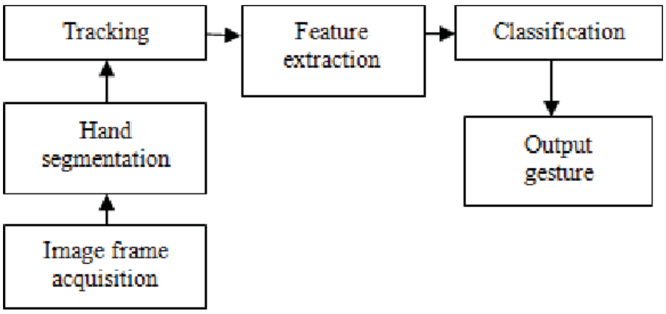
After collecting the data, preprocessing is carried out to improve its quality. This includes removing noise, separating the user from the background, and identifying motion segments. The cleaned data is then used for feature extraction, where important characteristics like movement path, speed, direction, and shape are identified. These features are given to gesture recognition methods—often machine learning or deep learning models—to accurately classify and understand the user's gestures.

2.1 System Architecture

The architecture consists of a video input module, MediaPipe landmark extractor, fatigue detection unit .The webcam captures the driver's face, while MediaPipe provides 468 facial landmarks that help analyze eyes and mouth. YOLOv8 detects objects related to distractions, such as mobile devices. A decision engine reviews the driver's state and decides when to issue an alert. Integration with a cloud interface enables remote monitoring through web dashboards, offering long-term visibility of driving behavior. The system is modular, scalable and adaptable to many environments.

2.2 Control Logic

The control logic combines results from MAR, EAR and



YOLOv8 into timebased decisions to reduce false positives. If the EAR drops below a threshold for several consecutive frames, it suggests drowsiness. A MAR above the threshold indicates a yawn. Frequent detection of a mobile phone by YOLOv8 indicates driver distraction. The control engine manages error checking, normalizes blinks, weights frames and handles fallbacks due to partial face visibility in different driving conditions.

2.3 Actuation Block

The actuation block includes real-time alerts based on the user's current gestures. These alerts consist of

Visual Alerts: On-screen messages, for example, "GESTURE RECOGNIZED"

Audio Alerts: Notification sounds via an audio library such as Pygame

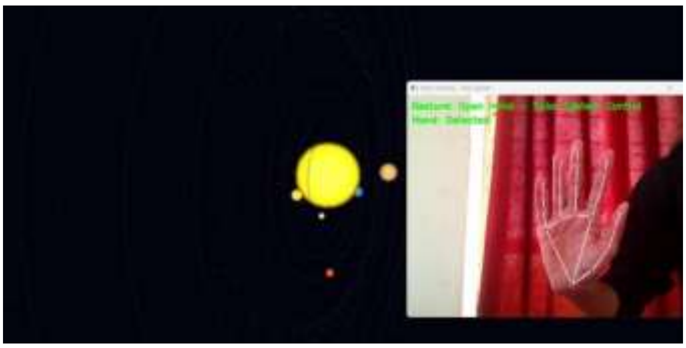
SMS Alerts: Notifications using Fast2SMS or Twilio APIs

Cloud Logging: Storing timestamped events in Supabase for analysis

This module translates digital decisions into real-time feedback that enhances user interaction and system responsiveness. Its multi-channel design ensures alerts remain effective even if one method fails.

2.4 User Interface

The user interface shows a live video feed with detection boxes, gesture recognition status, and alert messages. This simple design allows users and testers to quickly understand the system's status. Cloud dashboards provide visualization of past events, enabling deeper insights into user interactions, gesture trends, and the system's reliability over time.



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2.5 Key Components

2.5.1 Camera

A standard HD webcam captures real-time hand gestures for analysis.

2.5.2 Processing System

A computer running Python executes MediaPipe and YOLOv8 for gesture recognition and system logic.

2.5.3 AI Models

MediaPipe Hands for hand landmarks; YOLOv8 for detecting hand positions and gestures.

2.5.4 Cloud Backend

Supabase for event logs, timestamps, and user interaction analytics.

2.6 Advantages

This proposed AI-driven system offers real-time gesture recognition, hands-free interaction, less reliance on physical input devices, operation in various scenarios, cloud-based analytics, and a scalable software solution.

3. RESULTS AND ANALYSIS

The gesture-based system performed well in real-time testing. Hand-tracking and gesture recognition remained accurate under varying lighting conditions. YOLOv8 reliably identified hand positions and gestures with low latency. The cloud dashboard enabled comprehensive logging, and alerts were triggered consistently. Time-based validation helped reduce false positives. The system effectively detected:

- Specific hand gestures
- Swipe and click actions
- Pointing or selection gestures
- Complex multi-finger gestures

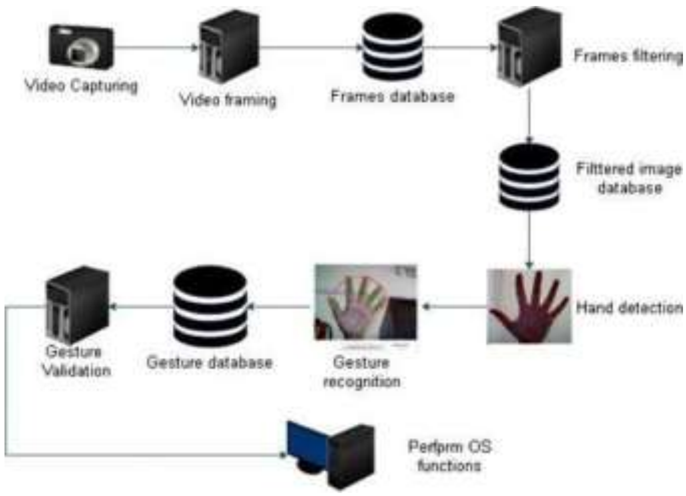
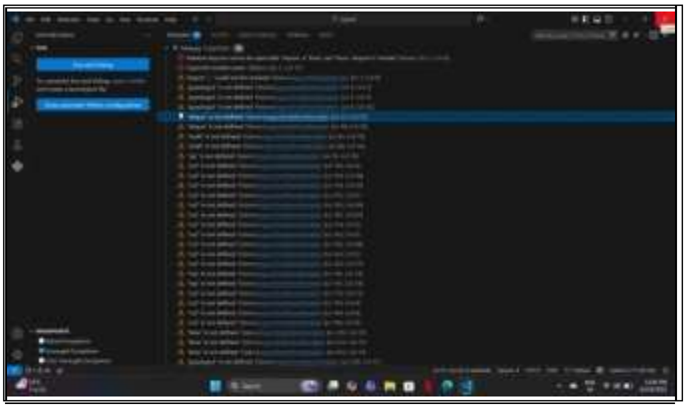


Table 3.1 Peformance Comparison Accuracy (%)



4. CONCLUSIONS

The hand gesture-based virtual mouse system offers a new way to interact with computers without using traditional devices. Using computer vision, the system can track hand movements and recognize gestures to move the cursor and perform click actions. Tests show that it works well for basic tasks like pointing and clicking, but there is room for improvement in accuracy, reliability, and the number of supported gestures.

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