Project Synopsis: Virtual Mouse

Project Title: Virtual Mouse

Objective: The primary objective of this project is to develop a virtual mouse system that allows users to control the computer cursor using hand gestures, eliminating the need for a physical mouse. This system uses a webcam to capture hand movements and processes these inputs in real-time to perform standard mouse operations such as moving the cursor and clicking.

Technologies Used:

- **Python**: Programming language used to implement the project.
- **OpenCV**: Library used for real-time computer vision tasks, such as capturing video and processing images.
- **NumPy**: Library for numerical operations, used for handling arrays and image processing tasks.
- **PyAutoGUI**: Library used to control the mouse and keyboard actions programmatically.

Project Scope:

- **Real-time Hand Gesture Detection**: The system captures live video feed from a webcam and processes it to detect hand gestures. A specific region of interest (ROI) is defined for improved accuracy and performance.
- **Skin Color Segmentation**: The captured frames are converted to HSV (Hue, Saturation, Value) color space to segment the skin color, which is used to detect the hand.
- **Contour and Convex Hull Analysis**: Contours are extracted from the segmented hand region to detect the shape and movement of the hand. The convex hull and convexity defects are analyzed to identify fingers and hand gestures.
- **Mouse Control**: The centroid of the detected hand is mapped to the screen coordinates to move the mouse cursor. Gestures like an open hand can be used to simulate mouse clicks.
- **User Interaction**: The system allows for natural and intuitive user interaction, providing an alternative way to control the computer.

Implementation Details:

1. **Video Capture**: The system continuously captures frames from the webcam and flips them horizontally to create a mirror-like experience.
2. **Region of Interest (ROI)**: A specific part of the frame is used for detecting hand movements, which focuses processing on the area where the hand is expected to be, reducing noise and improving detection speed.
3. **HSV Conversion and Masking**: The ROI is converted to HSV color space, and a mask is created to isolate the skin color of the hand.

4. **Contour Detection**: The system identifies the largest contour in the mask, which represents the hand. This contour is used to calculate the bounding box and convex hull.
5. **Cursor Control**: The centroid of the bounding box is mapped to the screen dimensions, and the mouse cursor is moved accordingly. The system also detects certain gestures, like the number of fingers shown, to simulate mouse clicks.

Potential Applications:

- **Touchless Interfaces**: Enhances user interaction in environments where physical contact with devices is minimized.
- **Accessibility**: Provides an alternative input method for users with physical disabilities who may have difficulty using a traditional mouse.
- **Gaming and Virtual Reality**: Can be integrated into VR systems to enhance immersion by using natural hand movements for interaction.

Conclusion: This project successfully demonstrates the use of computer vision techniques to create a virtual mouse system. By detecting and interpreting hand gestures in real-time, the system provides an innovative, touchless way to interact with computers. This technology has the potential to be further developed and integrated into various applications, offering an alternative and accessible method for user interaction.