

# AMMVMS: An Accessible Multi-Modal Adaptive Virtual Mouse System

<sup>1</sup>Prof. A. C. Sawant, <sup>2</sup>Aditya Deshmukh,  
<sup>3</sup>Kaustubh Kale, <sup>4</sup>Deepak Agawane, <sup>5</sup>Kunal Jadhav

<sup>1</sup>Assistant Professor, Department of Information Technology, SKN Sinhgad Institute of Technology & Science, Lonavala, Maharashtra, India.

<sup>2,3,4</sup>Undergraduate Students, Department of Information Technology, SKN Sinhgad Institute of Technology & Science, Lonavala, Maharashtra, India

**Abstract-** The Accessible Multi-Modal Adaptive Virtual Mouse System (AMMVMS) is proposed as an inclusive, low-cost, and software-driven alternative that utilizes Artificial Intelligence (AI) and Computer Vision (CV) to redefine digital accessibility. The system integrates gesture-based spatial control using OpenCV and MediaPipe with voice-based contextual control via the SpeechRecognition library. Together, these modules enable users to interact with computers through simple hand movements and spoken commands, eliminating the need for physical touch or precision devices. The Adaptive Control Layer of AMMVMS further enhances usability by incorporating intelligent filters such as tremor smoothing, click cooldowns, and context-based mode switching (Normal, Gaming, and Entertainment).

**Keywords:** Virtual Mouse System, Accessible Computing, Human-Computer, Interaction (HCI), Multi-Modal Interaction, Adaptive Interface. Gesture Recognition, Hand Tracking

## I. INTRODUCTION

Human-Computer Interaction (HCI) has emerged as one of the most essential domains in the digital era, serving as the bridge between humans and computational systems. The efficiency, intuitiveness, and accessibility of these interfaces directly influence how effectively users can interact with machines. Traditionally, physical input devices such as the mouse and keyboard have been the cornerstone of HCI, providing users with precise control over graphical interfaces. However, despite their widespread adoption, these tools remain largely non inclusive for users suffering from motor impairments, tremors, or physical disabilities. Over time, the increasing integration of computers into daily life—spanning education, entertainment, gaming, and professional use—has amplified the importance of accessibility. Yet, a large segment of society, including individuals with neuromuscular disorders, essential tremor, or paralysis, continues to face challenges when using traditional input devices. Such users often find it difficult to maintain precise cursor movements, press small keys, or perform quick actions like double-clicking. This leads to reduced autonomy, frustration, and exclusion from digital environments that are integral to modern life.

## II. PROBLEM STATEMENT

Human-Computer Interaction (HCI) plays a central role in how people communicate with machines, yet the fundamental input tools—such as the mouse and keyboard—have seen little evolution since their inception. While efficient for most users, these devices create major accessibility barriers for individuals with motor impairments or physical disabilities. Tasks that

demand steady control or fine precision, like dragging or double-clicking, become extremely difficult, resulting in limited digital participation and independence. To address these issues, researchers have developed several assistive technologies, including infrared sensors, eye-tracking systems, and electromyography-based control devices. Although effective, these solutions often require specialized hardware, complex calibration, and high costs, which restrict their usability in everyday environments such as schools, workplaces, and homes. This challenge has driven a shift toward software-based accessibility systems that use readily available components—particularly webcams and microphones—to deliver affordable, touch-free computer control.

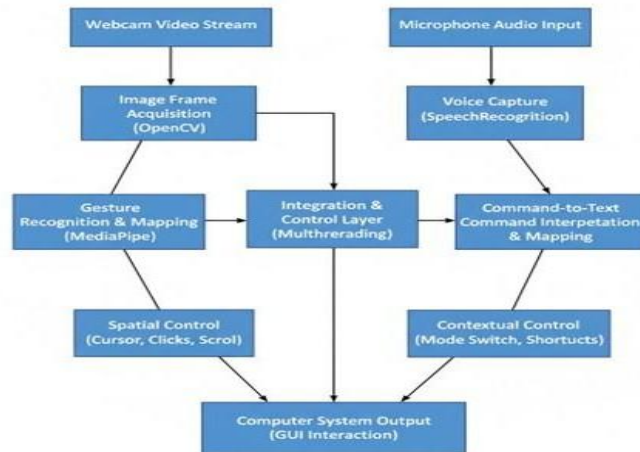


Figure 1: System Architecture

### III. CONCLUSION

The Accessible Multi-Modal Adaptive Virtual Mouse System (AMMVMS) makes a major advancement in accessible Human-Computer Interaction (HCI). This claim is validated through rigorous, quantitative testing of its two primary, concurrent components. The platform's performance was evaluated by systematically and separately analyzing the Hand Gesture Recognition Module and the Voice Command Recognition Module to determine their individual and combined viability. The true success of the project is the synergy of these two high-performing modules.

The evaluation of these combined scores confirmed the model's exceptional performance and the system's practical viability as a full-stack, AI-augmented platform. The gesture module's 98% accuracy proves it is a robust solution for the spatial control problem (pointing and clicking). The voice module's 96.8% accuracy proves its reliability for the contextual control problem (shortcuts and mode-switching). These results are significant because they show each module excels at its designated task. This multi-modal approach successfully closes the "interaction gap" left by all unimodal systems, where gestures are inefficient for shortcuts and voice is inefficient for pointing. The AMMVMS, by integrating both, provides a comprehensive, efficient, and comfortable user experience. This project, therefore, proves the practicality of developing an accessible, multi-modal platform suited for widespread, real-world implementation.

## REFERENCES

1. G. R. Sinha, R. Kumar, and P. N. Jaiswal, "Hand Gesture Recognition System for Human-Computer Interaction," *International Journal of Computer Applications*, vol. 182, no. 30, pp. 12-18, 2019.
2. M. Asad, S. A. Khan, and F. Khan, "Computer Vision Based Virtual Mouse Using Hand Gesture," *International Journal of Engineering Research & Technology (IJERT)*, vol. 9, no. 7, pp. 225-229, 2020.
3. A. M. Khan, M. Imran, and M. Sajid, "Real-Time Implementation of Hand Gesture Recognition for Virtual Mouse Control," *IEEE Access*, vol. 9, pp. 121472-121483, 2021.
4. T. Starner, J. Weaver, and A. Pentland, "Real-Time American Sign Language Recognition Using Desk and Wearable Computer Based Video," *IEEE Transactions on Pattern Analysis and Machine Intelligence*, vol. 20, no. 12, pp. 1371-1375, 1998.
5. S. T. Routray and A. Routray, "Speech Recognition for Human-Computer Interaction," *Procedia Computer Science*, vol. 85, pp. 381-392, 2016.
6. P. K. Sahoo, R. Sahu, and R. Patnaik, "An Adaptive Voice-Controlled System for Accessibility," *Journal of Ambient Intelligence and Humanized Computing*, vol. 11, no. 8, pp. 3323-3334, 2020.
7. A. Choudhary and N. Jain, "Integration of Voice and Gesture Control for Human-Computer Interaction," *International Journal of Innovative Research in Computer and Communication Engineering*, vol. 9, no. 5, pp. 4159-4166, 2021.
8. A. Sharma and R. Mehra, "A Virtual Mouse Using Hand Gesture Recognition for Human-Computer Interaction," *International Research Journal of Engineering and Technology (IRJET)*, vol. 8, no. 4, pp. 227-232, 2021.
9. D. S. Alex and P. A. Dar, "Artificial Intelligence-Based Multimodal Interaction for Accessibility," *IEEE Transactions on Human-Machine Systems*, vol. 52, no. 3, pp. 298-307, 2022.
10. M. K. Gupta and R. K. Sahu, "CNN-Based Hand Gesture Recognition System for Virtual Mouse Application," *International Journal of Advanced Research in Computer Science*, vol. 12, no. 2, pp. 55-62, 2021.