ISSN: 2581-3404 (Online) **IF: 5.86 (SJIF)**
IJIRTM, Volume-10, Special Issue-2, April-2026

AI-Based Hand Gesture Controlled Cursor System

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Abstract. *This paper presents a novel method for controlling mouse movement using a livewebcam. This research presents a new approach to live camera-based mouse movement control. Two popular methods are to add more buttons or move the tracking ball of the mouse. Instead, we propose redesigning the hardware. We propose using a camera and computer vision technology to control mouse functions (scrolling and clicking), and we show that it can do all the functions provided by current mouse devices. The creation of a mouse control system is demonstrated in this project. To boost the performance of virtual reality(VR)and Augmented Reality(AR) areas, virtual mice have been developed .The potential of virtual mice lies in captivating real world experience that it provides the users. Traditional methods like mouse and keyboard are not suitable for giving a a such lifelike and engaging experience.*

Keywords: Hand Gesture Recognition, virtual mouse, Finger Movement Detection, AI-Based Input System , Image Processing , Hand Landmark Detection.

Introduction

In this project we used a camera to create and test a virtual mouse program that tracks finger movements. The main goal was to make a program that can track objects and let people interact with computers in a natural way. A virtual mouse is a type of computer input device that allows users to interact with surroundings in a more intuitive way than traditional devices like keyboards and mice. Virtual mice were made to improve the usefulness of reality and augmented reality applications as well as for use in research and other fields. Traditional ways of interacting with computers, like using a keyboard and mouse can be hard to use in reality and augmented reality environments because they do not let users interact with virtual worlds in a natural way. This can make the experience feel less realistic and immersive. On the hand virtual mice can make the experience feel more natural and immersive by letting users interact with virtual worlds and objects using hand gestures and movements.

Using a keyboard and mouse in reality and augmented reality situations can make it hard to interact with virtual environments or control virtual objects directly. This can greatly reduce the experience of virtual reality and augmented reality applications. However virtual mice can provide a natural and immersive experience by allowing users to interact with virtual environments and objects using hand gestures and movements.

This research paper will cover the types of virtual mice that exist what they can and cannot do and how they might be used in the future. We will also look at the state of virtual mouse technology. Additionally we will discuss the advantages and disadvantages of using mice in different situations and think about how they might change the way we interact with virtual and augmented reality environments in the future. We will be talking about mice and how they can improve the way we interact with virtual reality and augmented reality.

2. Related Work

The earlier work Then in this field Includes Recognising the hand gestures using hardware Sturmen and Zeltzer In 1994 Use gloves with sensors To detect Finger movements And map these To the actions of computer Which was not successful Because the gloves were very expensive and uncomfortable to wear.

The hand gesture recognition systems Developed In our project Lets users Interact with Computers Without touching with no need of traditional Mouse or keyboard. Another contribution in this field Was a technique Based on Skin colour segmentation Hand region was identified By matching Pixels of human skin tone. Another work explores Contour analysis And convex hull based methods In these methods The number of convexity defect In the hand contour Were used to count fingers and identify the Hand gestures The limitation in these methods Was that they were sensitive to camera angle which Meet them Not feasible in real world. Several machine learning based approaches Have also been proposed To overcome Deficiencies in rule based vision methods Support vector machines and random forest Were commonly used classifiers trained on hand crafted features. System accuracy is affected by lighting conditions, background complexity, and camera quality. Many systems perform well in controlled environments but struggle in real-world applications [1], [4]. Vignesh et al. [1] developed an AI virtual mouse system using real-time hand tracking, where gestures such as finger movement and pinching are mapped to cursor operations like movement and clicking. Surse et al. [3] Explored machine learning-based gesture recognition for cursor control. Surse et al. [3] and Kao and Fahn [7] demonstrated that AI models can significantly improve recognition accuracy by learning complex gesture patterns. These models enable systems to adapt to different users and environmental conditions. Emerging research, such as GestLLM by Kobzarev et al. [9], explores the integration of large language models (LLMs) with gesture recognition. Although primarily focused on human-robot interaction, this approach indicates the potential for more intelligent and context-aware gesture-based systems. GestOS [10] extends gesture recognition capabilities by enabling control of multiple devices using AI-driven interpretation. Pisharady and Saerbeck conducted a review of hand gesture recognition methods in 2015. However these models still required engineered features, which needed considerable domain expertise and did not work well across different users and environments. Hand gesture recognition systems are still being. Improved.Hidden Markov Models were also used to recognize gestures that involve movement over time. Some people like Elmezain, Al-Hamadi and Michaelis used Hidden Markov Models in 2009 to recognize hand gestures for entering numbers. These methods Though what good results But They were not great at Recognising gestures That happened one after another Plus They were difficult to set up.

Hence in recognising hand gestures we have come a long way From the systems That employ Special gloves For recognising hand gestures Today we have camera and artificial intelligence Our project focuses on The tool that Makes it easy to recognise gestures in real time.

3. Methodology

Our proposed system Employs a Modular architecture With each module Implementing A different step Of processing The first one being Record unprocessed footage To carry out the last vows operation on the screen It makes a pipeline continuous pipeline Which immediately converts hand gestures into useful computer inputs.

A. input acquisition model

Input comes from a webcam That Records live video from the user surroundings Each frame Is then Move straight To the processing pipeline Hence hand movements can be detected instantly

B. Preprocessing in frame handling

Before starting our processing The raw frames of webcam Are converted from Bgr format to rgb Frame resizing Brightness modification And reduction of noise Is also handled at this stage

C. Hand landmark detection

The media pipe deep learning model That has the capability to recognise 20 Unique landmark locations And throughout the hand Is the centre of the detection process The 12 unique points Contain Key locations of hand including the fingertips knuckles And Palm base . After the Landmark Positions are available The module has the capability to analyse The gesture that has been performed

D. Cursor control and action execution

The recognised gestures Are Mapped The X and Y coordinates off screen Through a formula That determined the difference between the webcam View and the display resolution.

E.output rendering

In our entire System The visual information Passed on to the live video feed The users See Hand landmarks drawn And Gesture lab Which decide Action has been performed Hence it In Debugging and performance evaluation.

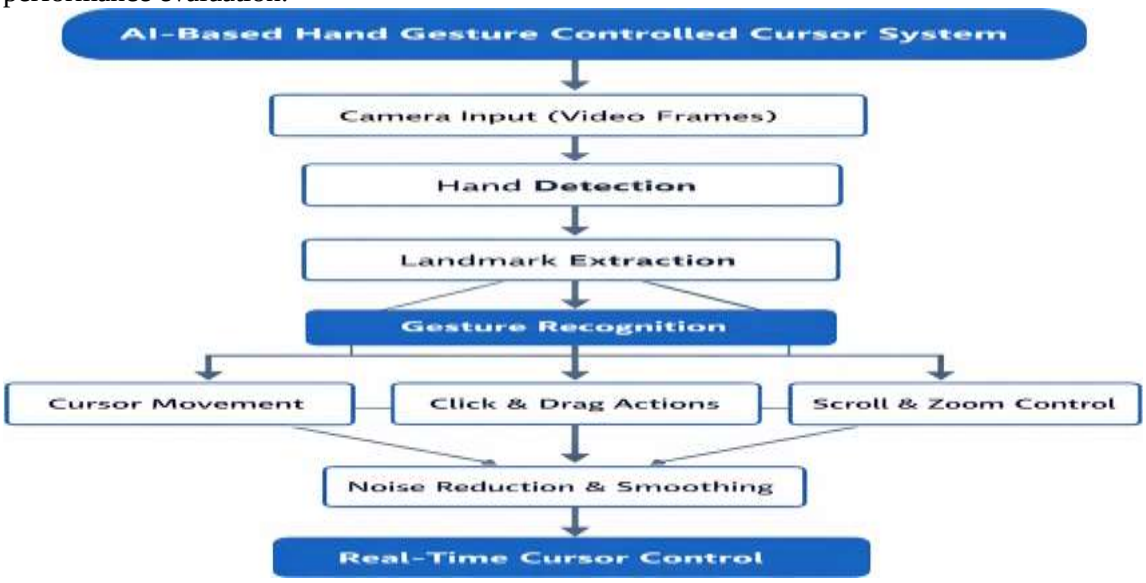

Fig. 1: System Architecture.

4. Results

This paper Presence Conclusions drawn Through thorough testing Hand gesture based Cursor control Instead of Just listing The Results We explain What happened During Implementation

A. MOUSE MODE ACTIVATE

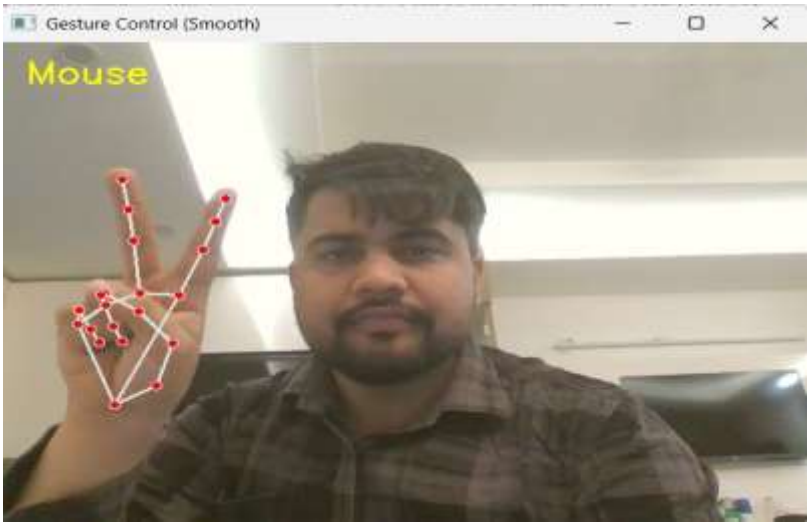

Figure 2: Gesture control

This image shows The real time Detection of your hand gesture Here the webcam Captures a And the computer vision Locates The key points on The fingers and pal Which are then connected Straight lines In this figure The user Holding up two fingers Which activates the mouse mode The system tracks the movement Off hand Which then Convert this movement into Cursor actions on screen..

B. The Flowchart of vision based human computer interaction

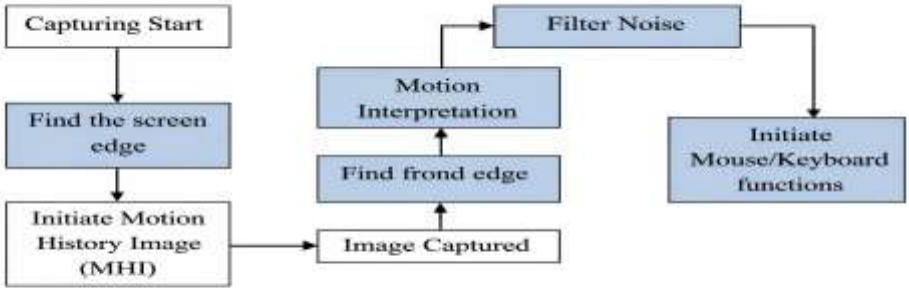

Figure 3: Flowchart of human computer interaction

5. Conclusion

In our project of Building Gesture based virtual mouse Opened up A new direction towards Human computer interaction Hci Map Ar and v Environments. The basic concept Bing The live camera input paired with computer vision processing The testing phase Faces some problems Because of different skin tones in different users which creates inconsistencies in the current model. Varying Lightning conditions Also Creates Unpredictability. The gesture recognition Process has following stages move Left and right clicking scrolling. Many prototype systems perform well under controlled conditions but fall apart in practice. This system, while not without its limitations, held up across varying hand positions and modest changes in environment, suggesting that the underlying approach is sound; the testing phase surfaced some real-world friction points that deserve honest acknowledgment. Varying skin tones across different users introduced inconsistencies that the current model does not fully account for, and shifting lighting conditions in everyday environments added another layer of unpredictability. These are not minor edge cases they represent the kinds of situations any practical deployment would routinely encounter.

6. Future Scope

The virtual mouse system works Pretty good But it can be improved Also it makes some mistakes For example When a user tries to right click The system is not accurate Also The system is not good Click and drag actions In selecting text Copy paste or highlight text cannot be performed Hence Need to improve the system Following features can be added.

A. Support for gestures

Right now Only a few hand gestures can be Recognised We can add Some more gestures Like rotating things typing zooming etc Which will make our model more powerful And useful.

B. better performance in light

This model doesn't work in dim light Hence the future versions of this model can Account for Camera support This will help The Model work Even when the lightning is not good.

C. Integration with VR and air technologies

The system should be combined with Ar and vr Which would Users interact with Environments Using hand gestures It will Very useful in education gaming and training simulations.

D. Mobile and cross platform compatibility

Right now the model is designed only for desktops and laptops In the future we can optimize it for smart phones tablets Which will make it easy to work on all devices.

E. use in healthcare and accessibility

The virtual mouse system Can be used in hospitals Doctors can use To upgrade screens without touching Which will keep things clean This model can also prove useful for People with disabilities.

F. integration of virtual keyboard functionality

We can also add a virtual keyboard in this Which will let users Control mouse and keyboard hand Using hand gestures Make which will make it completely touch free Powerful and efficient Hence the Mouse and the virtual keyboard Lets Interact with computers well Which proves useful in human Computer interaction hci.

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