Gesture-Based Virtual Mouse: A Contactless HCI Paradigm Using AI and Fingertip Dynamics

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Abstract- **Human–Computer Interaction (HCI) has witnessed substantial progression with the advent of the conventional mouse; however, even contemporary wireless and Bluetooth variants continue to exhibit dependency on peripheral hardware components such as transceiver dongles and battery modules. The unprecedented circumstances of the COVID-19 pandemic underscored the critical demand for contactless, hygienic, and intuitive interaction paradigms, thereby exposing the inherent limitations of traditional input devices. This study proposes an AI-augmented virtual mouse as a solution to such limitations by replacing the physical pointer with gesture-based controls. Architecture uses an inbuilt camera or webcam that captures hand movements and fingertip dynamics, recognizable through state-of-the-art computer vision algorithms supported by deep learning models. More particularly, this study will adopt MediaPipe for high-fidelity real-time hand landmark detection and use OpenCV at the base of sophisticated image preprocessing and feature extraction tasks. Also integrated are higher-level automation libraries, such as PyAutoGUI, Autopy, and PyInput to map detected gesticulation features to actual system cursor motion events - click event and scroll events as well as even providing interfaces for dynamic system brightness and audio volume. Empirical evaluations demonstrate high inference accuracy, low interaction latency, and smooth runtime performance, even within CPU-constrained computational environments devoid of GPU acceleration. By eliminating the requirement for direct physical interaction, the proposed AI-driven virtual mouse architecture constitutes a hygienic, resource-optimized, and practically deployable paradigm for human–computer interfacing, sustaining pronounced relevance across both pandemic and post-pandemic computational ecosystems.**

KEYWORDS

Virtual Mouse, Gesture Recognition, Hand Tracking, Contactless Computing.

I. INTRODUCTION

In a period, set to the side by fast mechanical developments, how we assist with outing PCs and undeniable level contraptions has changed basically. Standard PC mice, yet overall utilized, have limits in giving dependable and standard facilitated endeavours. This article makes a man-made information simulated mouse framework that makes use of fingertip and hand signs region utilizing PC vision to perform mouse limits on a PC. Using improvements like OpenCV, Python, and Media Pipe, the framework draws in contactless control of the mouse cursor and researching limits utilizing a webcam or secret camera, getting out the need for certifiable mice, dongles, and batteries. The framework involves man-made brainpower assessments for exact sign assertion, further creating openness for people with veritable handicapped people and diminishing pollution prospects, particularly suitable concerning Coronavirus. By arranging man-made understanding and PC vision, the virtual mouse framework offers a more instinctual, competent, and versatile method for managing talking with PCs, working with undertakings through static and dynamic hand developments and voice orders. This examination bounces into the new turn of events, hidden away advances, and accommodating purposes of the virtual mouse, featuring its ability to change human-PC correspondence (HCI) across different spaces like gaming, clinical advantages, coaching, and industry. Through fussy improvement of programming calculations for development confirmation and consistent following, this imaginative design means to moreover cultivate client solace and diminishing time spent on taking care of errands, offering a cutting-edge strategy for overseeing HCI that lines up with the constant trip for direct association focuses.

Problem Statement:

The anticipated man-made intelligence simulated mouse framework utilizing hand gesture acknowledgment can address difficulties in conditions with restricted space for a conventional mouse and give an answer for people with hold issues who can't deal with an actual mouse. With regards to the Coronavirus pandemic, limiting actual contact with gadgets is fundamental to forestall the spread of the infection. The computer-based intelligence virtual mouse framework conquers these difficulties by utilizing hand signal and fingertip discovery with a webcam or underlying camera, taking out the requirement for actual mice, dongles, and batteries. This framework, created with PC vision strategies utilizing OpenCV, precisely identifies and tracks hand signals, permitting clients to control the PC cursor and use the mouse works like a **left or right click, snap, brightness control, volume control** and looking without actual info gadgets. By utilizing progressed picture handling and AI calculations, the framework makes an interpretation of explicit signals into mouse developments, giving an instinctive and sterile method for interfacing with PCs. This creative methodology upgrades client solace as well as decreases the time spent on registering errands and offers a cutting edge, contactless option in contrast to customary mice, adding to more effective and flexible human-PC connections.

II. LITERATURE SURVEY

[1] On Walk 12, 2015, Ashish Mehtar and Ramanath Nayak presented a Virtual Mouse utilizing an IR sensor and an infrared pen that goes about as a fictitious marker. This framework use equipment parts to accomplish its usefulness. They proposed an item that capabilities as a virtual marker while likewise consolidating the capacities of a conventional mouse. By adjusting the current Virtual Marker to act both as a mouse pointer and a t-marker the framework accesses every one of the highlights of a normal mouse. Their article definite an equipment execution of a virtual mouse that upgrades execution by constructing a "Virtual Marker" exceptionally responsive continuously, in this manner further developing the general client experience.

[2] The PC based knowledge virtual mouse system gives a contactless and normal choice rather than customary mouse contraptions by utilizing a webcam to get hand signs and fingertip improvements. This system uses OpenCV and artificial intelligence computations for consistent sign affirmation, allowing clients to perform mouse works like left click, right snap, and looking without genuine data contraptions. By tending to limits in space-obliged conditions and offering a perfect plan amidst Covid concerns, the man-made reasoning virtual mouse structure updates transparency, decreases the necessity for additional hardware, and further creates client comfort and capability in human-PC participation.

[3] Their Hand in 2018 by Sherin Mohammed and VH Preetha Motion Human-Mouse Virtualization PC Cooperation used Python and OpenCV required the arrangement of two high-priced cameras. They review centres around the development of hand gestures in three-dimensional room for a PC user interface frameworks involving two cameras are set up. The location on the screen framework corresponds roughly and strategically to the hand token of showing. To fulfill the capability we use the virtual mouse, likewise utilize different changes in the hands. They employ different motions, for example, choosing an envelope or an item, notwithstanding hand developments to point at the screen.

[4] By utilizing vision to operate the Virtual Mouse's cursor Utilizing Item Following exploration by Christina Daniel, Monali Shetty, Manthan Bhatkar, and Ofrin Lopez in the year 2020 catches HSV-based hand signals from a camera variety acknowledgment strategy. They want to foster a framework cooperating object following application. Their methodology, which makes use of hand signals that are recorded by a webcam. utilizing a HSV variety recognition strategy, is a PC vision-based mouse cursor control framework. Utilizing shaded covers or tapes that are monitored by the PC's webcam, their innovation empowers clients to move the structure's pointer and use the mouse like double taps with a different hand, left, right, and so on movements. The framework is executed involving continuous PC vision in OpenCV and Python

bundle. On the, the result is shown. screen the camera away.

[5] The Virtual Mouse of Vantukal Reddy, Thumma Dhyanchand, Galla Vamsi Krishna, and Satish Maheshwaram Control Utilizing Shaded Hand and Fingertips Signal Acknowledgment, distributed in 2020, consists of two methods for following the fingers include: concentrate in the human factor PC communication utilizes a virtual mouse with hand and fingertip discovery movement following in view of in real-time video. They advise using your hands. movement acknowledgment and fingertip ID to control their virtual mouse article. In their examination, two methods are used to follow the fingers: hand signal discovery and the utilization of covers with hues. It consists of three fundamental stages: finger movements after hand movements through variety recognizable proof, and cursor execution. In their examination, a raised frame is conformed to the form that is distinguished to create hand motion following. With the area proportion of the created body and form, hand highlights are recovered.

III. TECHNOLOGIES IMPLEMENTED

OpenCV possesses a product library for computer vision and AI. A typical framework for PC vision applications, OpenCV was utilized to accelerate the incorporation of human consciousness into products. OpenCV being an Apache 2 authorized item, it is essential for businesses to use and modify the code. Additionally, it provides GPU speed amplify the highlights for ongoing activity. OpenCV is used in a lot of different areas, like as portable robots with faces and frameworks for signal acknowledgment, as well as 2D and 3D element toolboxes.

Media Pipe: A cross-stage structure created by Google, which generally utilized for the progress of pipelines in multiple modes AI. Given that the MediaPipe system fabricated utilizing factual information, it is generally useful for the process of configuration across stages. The structure of MediaPipe is multimodal, and that implies it is typically used for object recognition, face location, iris scanning, and movement tracking position, identification, hand detection, hair division, and where the complaint is. The structure of the MediaPipe is best choice for engineers while making, dissecting, and planning frameworks execution as diagrams. It has likewise been used for building an assortment of applications across stages and frameworks. Here, it is put to use. for use on the web, the video and motion acknowledgment.

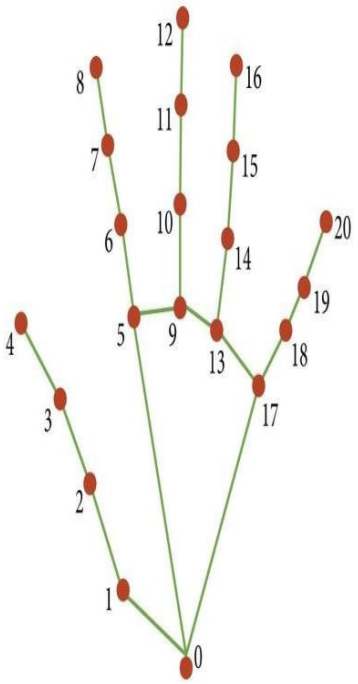
NumPy: NumPy is a generally useful tool compartment for managing clusters. It furnishes a multi-layered cluster object with extraordinary execution and the ability to work together with these exhibits. Logical for processing is the fundamental bundle for Python. The program is open-source. It has various qualities, including the accompanying urgent ones: Devices for blending Fortran and C/C++ code, an N-layered exhibit item, and modern (telecom) capabilities helpful Fourier change, irregular number, and straight polynomial math capacities.

PyAutoGUI: The computerization library PyAutogui for Python upholds console and mouse control. On the other hand, One could say that it makes it easier to automate the mouse and console clicks to use a Python script to establish collaboration with another program. A brief summary of the highlights It provides the following different applications, snapping with the mouse, and discussing keystrokes for various projects. As an illustration, completing a structure, and entering a search term into a program, for example. Another option is to take photos and share them. It gives us the ability to locate an application window and resize and move it expand, or minimize it. Display warning and message boxes.

IV. PROPOSED MODEL MECHANISM

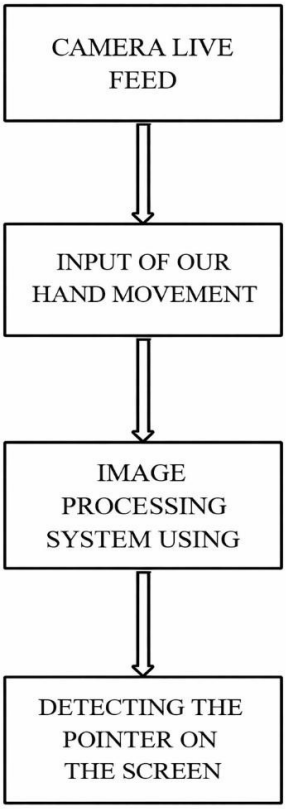
Pre-handling, or more specifically, a picture dealing with is an earlier development in PC vision in which the goal is to alter into an over an image design sensible for extra examination. Cases of undertakings, for instance, receptiveness amendment, concealing changing, reducing image noise, or improving image sharpness are extraordinarily huge and thoughtfully mentioned in order to obtain sufficient results. I propose to

present a piece of for this article. the image that is used frequently dealing with procedure utilizing an extraordinarily remarkable PC Vision library, Open-CV. I'll try to depict quickly how every development and focus more on controlling the point. significantly more fundamentally, providing you with all of the genuine code you require for a productive experience of the content.



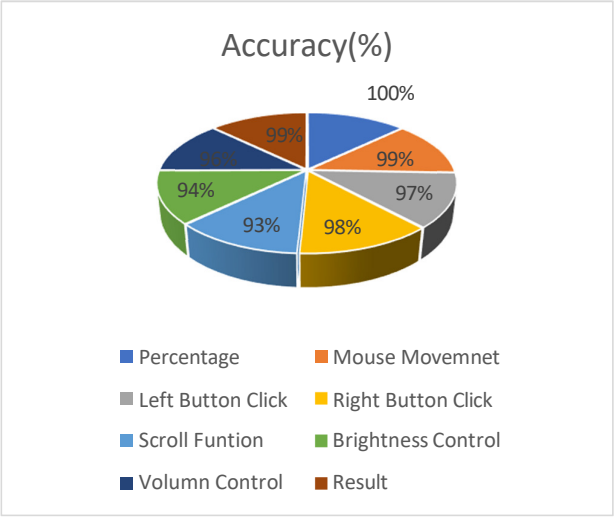
0 Wrist
1 Thumb - CMC Joint
2 Thumb - MCP Joint
3 Thumb - IP Joint
4 Thumb - Tip
5 Index Finger - MCP Joint
6 Index Finger - PIP Joint
7 Index Finger - DIP Joint
8 Index Finger - Tip
9 Middle Finger - MCP Joint
10 Middle Finger - PIP Joint
11 Middle Finger - DIP Joint
12 Middle Finger - Tip
13 Ring Finger - MCP Joint
14 Ring Finger - PIP Joint
15 Ring Finger - DIP Joint
16 Ring Finger - Tip
17 Pinky - MCP Joint
18 Pinky - PIP Joint
19 Pinky - DIP Joint
20 Pinky - Tip

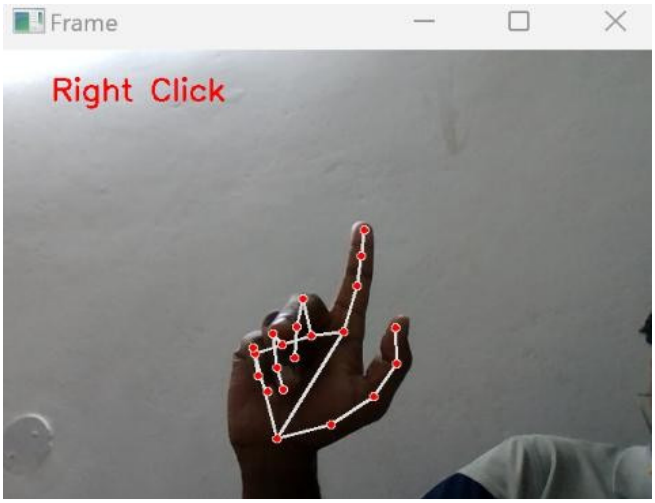
V. SYSTEM ARCHITECTURE

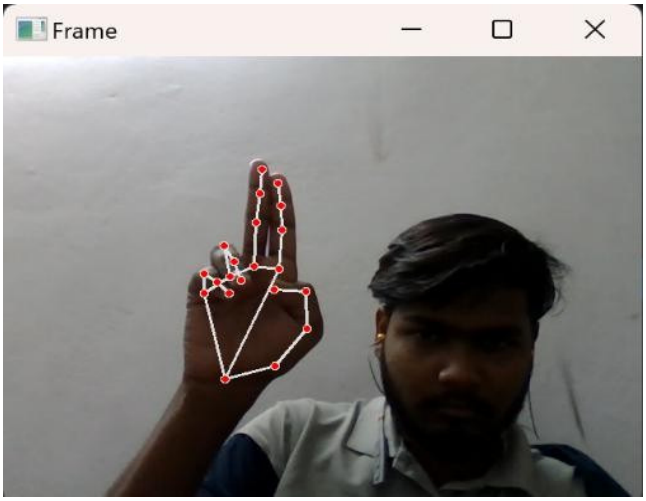


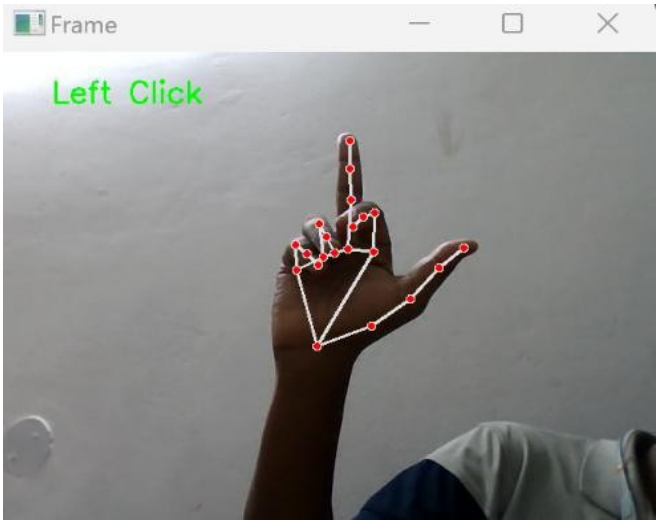
VI. RESULTS ANALYSIS

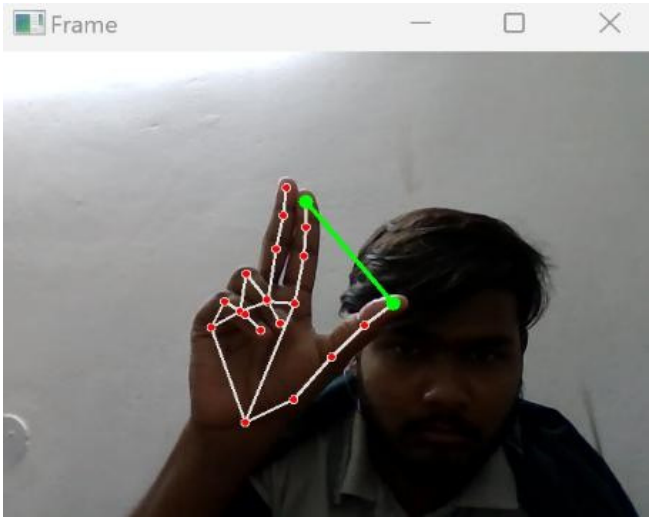
In our undertaking, the virtual mouse structure showed a moderate degree of accuracy and precision in following hand signals and making a comprehension of them into cursor enhancements. While the design satisfactorily performed, there is potential for additional refinement to chip away at its precision.

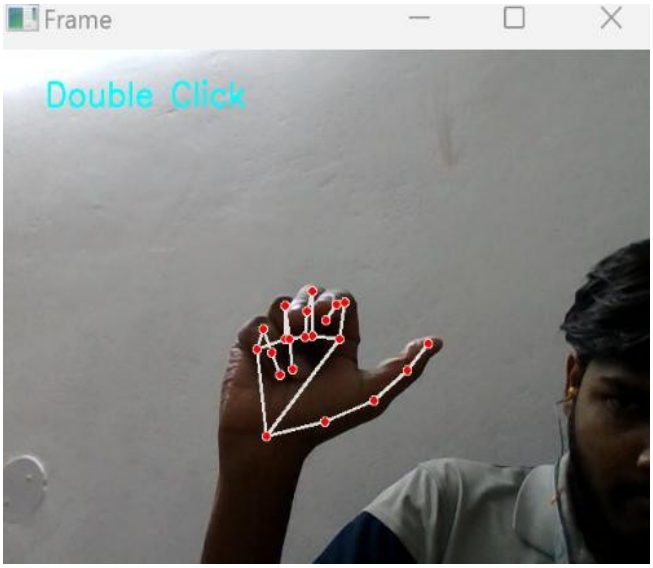












VII. CONCLUSION

The main goal of the computer-based intelligence virtual mouse system is to manage mouse cursor functions using hand gestures instead of a physical mouse. This is achieved through a webcam built-in camera that detects hand movements and finger positions, processing these frames to execute tasks such as left clicks, right clicks, and scrolling. The proposed system demonstrates high accuracy, surpassing existing models and addressing their shortcomings. Its contactless design helps reduce the spread of COVID-19 by eliminating the need for a physical mouse. However, there are some drawbacks, including decreased precision for right-clicking and difficulties with clicking and dragging. Future developments will aim to enhance the fingertip detection algorithm for improved performance. This project combines artificial intelligence and computer vision technologies to create a more intuitive, efficient,

and hygienic way to interact with computers, with potential uses in healthcare, education, gaming, and accessibility for individuals with physical limitations.

VIII. REFERENCES

[1] Abdul Wahid Ali" Energy efficieny in routing protocol and data collection approaches for WSN: A survey, view at: Publisher Sidewise explore.

[2] Aynur Unal" Smart Trends in Information Technology and Computer Communications, View at: Publisher Site|link.springer.com.

[3] S. U. Dudhane, "Cursor control system using hand gesture recognition," IJARCCE, vol. 2, no. 5, 2013. View at: Publisher Site| Google scholoar.

[4] K. H. Shibly, S. Kumar Dey, M. A. Islam, and S. Iftekhar Showrav, "Design and development of hand gesture based virtual mouse," in Proceedings of the 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT), pp. 1–5, Dhaka, Bangladesh, May 2019.View at: Publisher Site| Google Scholoar.

[5] A.Haria, A. Subramanian, N. Asokkumar, S. Poddar, and J. S. Nayak, "Hand gesture recognition for human computer interaction," Procedia Computer Science, vol. 115, pp. 367–374, 2017. View at: Publisher Site| Publish site |Scholoar.

[6] D.-H. Liou, D. Lee, and C.-C. Hsieh, "A real time hand gesture recognition system using motion history image," in Proceedings of the 2010 2nd International Conference on Signal Processing Systems, July 2010.

[7] L. W. Heng, D. Chunjian, and L. Yi, "Implementation Of Virtual Mouse Based On Machine Vision," International Conference on Apperceiving Computing and Intelligence Analysis., 2010.

[8] J. Katona, "A review of human–computer interaction and virtual reality research fields in cognitive Info Communications," Applied Sciences, vol. 11, no. 6, p. 2646, 2021

[9] K. K. Biswas and S. K. Basu, "Gesture recognition using Microsoft Kinect®," in The 5th International Conference on Automation, Robotics and Applications, Wellington, New Zealand, 2011, pp. 100–103.

[10] [10] B. J. Jo, S.-K. Kim, and S. Kim, "Enhancing Virtual and Augmented Reality Interactions with a MediaPipe-Based Hand Gesture Recognition User Interface," Ingénierie des Systèmes d'Information, vol. 28, no. 3, pp. 633–638, 2023.

[11] L. Zhang, Q. Tian, Q. Ruan, and Z. Shi, "A simple and effective static gesture recognition method based on attention mechanism," Journal of Visual Communication and Image Representation, vol. 92, p. 103783, 2023.

[12] Y. Liu, M. Y. Chiu, H. L. Li, K. H. Wu, Z. Lei, and Q. Ding, "A real time robust hand tracking method with normal cameras," in Computer Vision. CCCV 2015. Communications in Computer and Information Science, H. Zha, X. Chen, L. Wang, and Q. Miao, Eds., Springer, Berlin, Heidelberg, vol. 546, 2015.

[13] G. Xu, Y. Wang, and X. Feng, "A Robust Low-Cost Virtual Mouse Based on Face Tracking," in Proc. 2009 Chinese Conference on Pattern Recognition, 2009, doi:10.1109/CCPR.2009.5344072.

[14] A. Ghodichor, B. Chirakattu, Virtual mouse using hand gesture and color detection. Int. J. Comput. Appl. 128, 6–10 (2015).

[15] D.S. Tran, N.H. Ho, H.J. Yang, E.T. Baek, S.H. Kim, G. Lee, Real-time hand gesture spotting and recognition using RGB-D Camera and 3D convolutional neural network. Appl. Sci. 10 (2020)

[16] C.M. Taing, P.L.P. Rau, H. Huang, Handpad: a virtual mouse for controlling laptops in a smart home. Human-Centric Comput. Inf. Sci. 7 (2017)