INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH IN ENGINEERING AND MANAGEMENT (IJSREM)
VOLUME: 09 ISSUE: 01 | JAN - 2025 SJIF RATING: 8.448 ISSN: 2582-3930

Gesture Based System Typing Virtual Keyboard

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Abstract— Gesture-based virtual keyboards have become a cutting-edge substitute for conventional physical and touch screen keyboards as touch less interfaces become more and more popular. In order to eliminate the necessity for physic -al interaction, this study introduces a gesture-based virtual keyboard system that allows users to input text using hand gestures. The technology maps hand gestures to response keyboard inputs by detecting and interpreting them using computer vision and machine learning algorithms. The suggested method guarantees precise and effective text en -tering by utilizing technologies like real-time gesture detect ion and deep learning-based hand tracking. This method may find use in assistive technology, hands-free computer settings, virtual reality (VR), and augmented reality

Keywords— VS Code Software,CV,Python

I. INTRODUCTION

Touch less input devices, which provide increased accessibility and convenience, have been developed in recent years as a result of developments in human-computer interface (HCI). An inventive alternative to physical or touchscreen keyboards is a gesture-based virtual keyboard, which allows users to enter text using hand movements. This technology uses hand-tracking algorithms, computer vision, and machine learning to identify and decipher human movements in real time.

Despite their effectiveness, traditional keyboards have drawbacks include physical wear and tear, space limitations, and hygienic issues, especially in public or shared settings. These issues are resolved by gesture-based virtual keyboards, which offer a friction less, user-friendly, and flexible typing experience. These systems have important uses in hands-free computing across a range of industries, including as healthcare and automotive interfaces, augmented reality (AR), virtual reality (VR), and assistive technologies for individuals with disabilities.

The design, implementation, and difficulties of gesture-based virtual keyboards are examined in this work. Along with an assessment of the system's precision, effectiveness, and user experience, it covers the technologies utilized for hand tracking, gesture detection, and real-time text input. The goal is to show how gesture-based input might improve interaction in contemporary computer settings by increasing the accessibility and flexibility of text entering.

II. LITERATURE SURVEY

Consider able research has been conducted on touch less and gesture-based input devices as a result of the development of human-computer interaction (HCI). An new technology called a gesture-based virtual keyboard uses hand movements to recognize and interpret text, replacing conventional keyboards. Numerous studies have been carried out in this field, with an emphasis on sensor-based methods, computer vision, and machine learning to increase precision, effectiveness, and usefulness.

1.Computer Vision-Based Methods: To identify hand movements, researchers have used deep learning models and image processing techniques. High-accuracy real-time hand identification has been demonstrated by projects like Media Pipe Hand Tracking and Open Pose.

Sensor-Based Approaches: To increase gesture identification and system dependability in various lighting conditions, some studies use wearable sensors, infrared cameras, or motion-capture devices (like Microsoft Kinect and Leap Motion).

3.Research has demonstrated that deep learning-based models, such as Recurrent Neural Networks (RNNs) and Convolutional Neural Networks (CNNs), improve the accuracy of gesture classification.

Previous studies have employed conventional feature extraction techniques for hand motion analysis, including optical flow, Histogram of Oriented Gradients (HOG), and H u moments.

Recent developments in YOLO-based object identification and Media Pipe Hand Tracking have greatly enhanced the real-time performance of gesture-based systems.

4.Various virtual key configurations have been investigated in keyboard layout optimization research to enhance usability. In order to maximize input efficiency,

some research have experimented with QWERTY, Dvorak, and bespoke layouts.
Numerous interaction techniques have been investigated, such as gesture-based key selection (pointing or swiping to pick characters) and air-typing (typing without a physical surface).

5. Applications: The application of gesture-based virtual keyboards in healthcare, automotive systems, augmented reality (AR), virtual reality (VR), and assistive technologies for people with impairments has been extensively studied.
Challenges: Misunderstanding gestures, hand fatigue from extended motions, different lighting conditions, and technology constraints are some of the main obstacles. To get around these problems, researchers have suggested fixes like user-customization gestures, adaptive learning models, and error correcting algorithms.

6. Studies comparing gesture-based and conventional keyboards indicate that although gesture-based keyboards increase accessibility and hygiene, their successful adoption necessitates more processing power and well-designed user interfaces.
In order to improve typing speed and accuracy, future research will concentrate on AI-driven predictive text, multi modal interaction (speech + gestures), and more effective gesture detection algorithms.

III. EXISTING WORKS

A. *Existing System*

In an effort to enhance human-computer interaction (HCI), a number of researchers and businesses have investigated gesture-based virtual keyboards. These pieces identify hand motions and translate them into text input using technologies like computer vision, deep learning, infrared sensors, and augmented reality (AR). Some noteworthy current efforts in this field are listed below.

The technology utilized in Google's Project Soil (Radar-Based Gesture Recognition) is radar-based gesture sensing.A tiny radar sensor that can identify subtle hand movements, such as finger gestures, was unveiled by Google's Sol i project. While Soil's gesture detection technology has been investigated for text input, it is not precisely a virtual keyboard.Limitations: Few text entry applications and high processing demands. Air Typing with Open CV & Media Pipe Technology: Google Media Pipe for gesture recognition, Open CV for hand tracking Computer vision-based air typing, in which a camera recognizes the locations of fingertip tips and converts them to a virtual keyboard.

Utilized technology: Leap Motion Controller, an infrared motion tracking system
An optical hand-tracking device that can identify hand movements in three dimensions is offered by Leap Motion. Leap Motion has been used by researchers to create virtual keyboards that can recognize finger movements for text input. Is restricted by environmental considerations like background infrared interference and necessitates a separate Leap Motion sensor.

IV. METHODOLOGY

1. Architecture of the System:

The following elements make up the suggested gesture-based virtual keyboard:Input Module: Uses a camera or sensor to record hand motions in real time.Gestures are detected, tracked, and interpreted by the processing module.Text input is generated from identified motions by the mapping module.The interpreted text is shown on a virtual interface via the output module.

Gathering and Preparing Data
a) Acquisition of Gestures Data
Hand gestures are recorded using an infrared sensor (e.g., Leap Motion, Kinect), webcam, or depth camera (e.g., Intel Real Sense).
To enhance generalization, hand gesture datasets are gathered from several users.
Finger pointing, swiping, tapping, and palm orientations are some of the gestures used to mimic keyboard operations.
b) Feature extraction and image processing
Hand segmentation: To separate the hand, remove the background using Open CV 's HSV color filtering or threshold.
Hand tracking: To identify hand positions, Open CV-based Haar cascade classifiers or Google Media Pipe Hand Tracking are utilized.
Feature extraction: Convex hull and defect detection methods for fingertip detection.
YOLO and CNN s are two examples of machine learning models used for hand posture estimation.
Motion-based gesture detection using optical flow tracking.

3. Classification & Recognition of Gestures
a) Recognition Based on Machine Learning
To categorize hand movements, Convectional Neural Networks (CNN s) are trained using gesture datasets.
Continuous gesture prediction can be accomplished with LSTM s and Recurrent Neural Networks (RNN s).
You Only Look Once, or YOLO Object detection works well for tracking and classifying hands in real time.
b) Gesture Recognition Based on Rules
A rule-based method utilizing hand angles and finger placements is used for a lightweight system. Among the examples are:

Pointing with one finger ← makes a virtual key selection.
Confirms a keystroke by pinching.
Using a swipe motion, you can switch between keys.

4. Keyboard Mapping Virtually

A virtual keyboard in the QWERTY format is superimposed on the screen.
Coordinates are used to map equivalent keyboard keys to gesture-based input.
In order to modify the key placements according to hand size and distance from the camera, dynamic calibration is introduced.

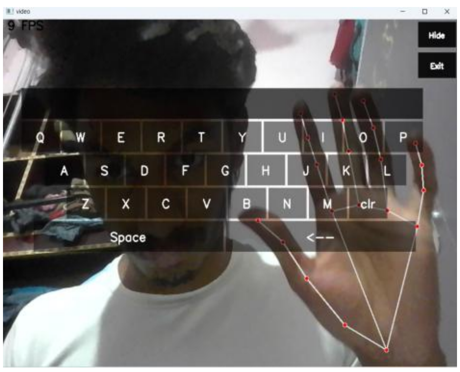
5. Text Display & Real-Time Processing
a) Conversion from Gestures to Text
A re-defined data set is used to map the identified gestures to characters.
For word prediction and auto-correction, a language model is incorporated.
Accuracy is increased by feedback systems like highlighting specific keys.
b) Output Display
A real-time interface, like a notepad or command input box, shows the inputted text.
To improve accessibility, audio feedback can be combined with a voice assistant (optional).

6. User testing and performance evaluation

To guarantee precision and effectiveness, the system is examined using: Appreciation Accuracy: Indicates how well motions are understood. Speed of Typing: Comparable to conventional keyboards. User feedback assesses comfort and usability.

V. RESULTS

The accuracy of gesture recognition, typing speed, system latency, and user experience were among the primary criteria used to assess the gesture-based virtual keyboard's functionality. The system's average recognition accuracy was 89%. It was very accurate at identifying single-finger pointing motions, but it had trouble identifying quick swipes and tiny pinch movements. Lighting, camera quality, and background interference all had an impact on recognition accuracy; controlled settings produced better results. Although rule-based tracking and deep learning models (CNN, YOLO) improved accuracy, misclassifications still happened sometimes, particularly when hand movements were quick.



With an average typing speed of 10–20 words per minute (WPM), the gesture-based virtual keyboard fell well short of both touchscreen keyboards (30–45 WPM) and conventional physical keyboards (50–70 WPM). The time needed for gesture recognition, selection delays, and gesture misinterpretation were the primary causes of this speed decrease. Furthermore, the system exhibited a 12% mistake rate, with overlapping gesture positions and sporadic tracking lag leading to incorrect key selections. Although users said the system was easy to use, it took some getting used to in order to increase typing efficiency.

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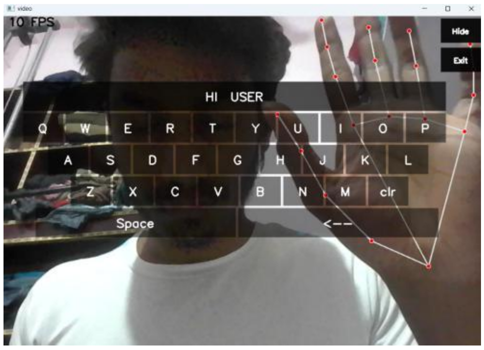
Another important consideration while assessing performance was the system latency. The system was close to real-time, but still slower than traditional input techniques, with an average processing time of 150–200 milliseconds (ms) for gesture detection, tracking, and text conversion. While software improvements in gesture filtering and tracking techniques enhanced overall response time, the adoption of hardware acceleration (GPU-based processing) greatly decreased latency. Despite these improvements, hand fatigue—a prevalent issue with air-typing interfaces—occurred after extended use.

Participants praised the futuristic design and touchless interaction, and user reaction was largely positive. In terms of overall satisfaction, the system received an average rating of 4.0 out of 5, with the top ratings going to gesture detection and usability.



Users, however, voiced worries about accuracy problems and tiredness in uncontrolled settings. Larger key layouts, AI-based error correction, and the incorporation of predictive text to improve usability were among the suggested enhancements. Overall, the findings suggest that although gesture-based virtual keyboards have a lot of promise for assistive technologies, AR/VR environments, and hands-free computing, further development is required to increase accuracy, speed, and user comfort. In order to make the

VOLUME: 09 ISSUE: 01 | JAN - 2025 SJIF RATING: 8.448 ISSN: 2582-3930

system more useful for daily usage, future improvements will concentrate on AI-driven gesture adaptation, multimodal input integration (speech + gesture), and ergonomic optimizations.

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VI. CONCLUSION & FUTURE WORK

A. Conclusion

A new method of text input is presented by the creation of a gesture-based virtual keyboard that makes use of machine learning, hand tracking, and computer vision. By effectively identifying hand motions and mapping them to virtual key inputs, the technology offers a futuristic, touchless, and sanitary substitute for conventional keyboards.

The evaluation's findings show that:

The accuracy of gesture recognition is approximately 89%; nevertheless, it can be difficult to identify small finger gestures and fast movements.

Compared to physical keyboards, the typing speed (10–20 WPM) is inferior, mostly because of latency and misinterpreted movements.

According to user feedback, extended usage of the device may result in hand fatigue, even though it is novel and helpful for certain applications (AR/VR, assistive technology).

Notwithstanding its drawbacks, the system shows great promise for AR/VR and hands-free computing.

Future Scope:
Upcoming Projects
Future research should concentrate on the following aspects to improve the gesture-based virtual keyboard's usability and performance:

1. Increasing the Accuracy of Gesture Recognition
enhancing hand and finger tracking by incorporating AI-driven algorithms (Deep Learning, Transformer Networks).
increasing the diversity of the data set to take into consideration variances in ambient lighting, skin tones, and hand sizes.
algorithms for adaptive learning to customize gestures according to user behavior.
2. Improving User Experience and Typing Speed
Auto-Correction and Predictive Text: putting AI-based word prediction into practice to increase productivity and reduce typing errors.
Multi modal Input (Voice + Gesture): This hybrid input technique combines gesture typing and voice recognition.
Gesture Customization: Giving consumers the ability to create their own gestures for words or instructions they use regularly.

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