IPEC Journal of Science & Technology, Vol. 02 (01), June 2023
ISSN: 2583-3286(Online)

Human computer interaction using hand gesture recognition system

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***Abstract*: Human-Computer Interaction (HCI) is an essential aspect of modern technology, as it enables users to interact with devices in a more natural and intuitive way. Gesture recognition systems are a novel and promising approach to HCI that allows users to control their devices using body movements. This technology has already found applications in a variety of fields, including gaming, healthcare, automotive, and smart home automation. However, there are several challenges associated with developing and implementing gesture recognition systems, including accuracy, reliability, and user adoption. As there is a significant barrier between the user and the machine, using a physical device for human-computer interaction, such as a mouse or keyboard, prevents natural interface. An organic, cutting-edge, and contemporary method of nonverbal communication is provided by a hand gesture recognition system. It can be used in many different contexts for human-computer interaction. We have developed a reliable hand gesture recognition system that effectively tracks hand gestures in this paper. Our system transforms the observed gesture into customized actions like print, save, copy, and paste. Our findings demonstrate that intuitive HCI is feasible with the least amount of hardware. The goal of a HCI system is to assist the user in daily tasks seamlessly such that there is no performance effect on the tasks that the user is doing. HCI system acts as a background program and hence it is imperative that it utilizes the minimum amount of hardware resources possible.**

***Keywords* - Hand Gesture Recognition System, Gesture, recognize, Human Computer Interaction.**

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I. INTRODUCTION

Technology has swiftly advanced and integrated into our daily lives in recent years. Our interactions with technology have gotten more fluid and intuitive, from smartphones to smart homes. The effectiveness of conventional human-computer interface (HCI) techniques like the keyboard and mouse is, however, declining as technology develops. This prompted researchers to investigate novel HCI techniques, such as gesture recognition systems, speech recognition systems, and touch-based interfaces.

Researchers and developers are paying close attention to the innovative and promising approach to HCI known as gesture recognition technology. By using their body movements as commands, users are able to engage with their gadgets in a more natural and intuitive way thanks to this technology. A more natural contact between people and computers is made possible by gesture recognition systems, which employ sensors and cameras to follow the movements of the user's body and translate them into commands.

Systems for gesture recognition have previously been used in a number of industries, including gaming, healthcare, the automobile industry, and automated smart homes. Gesture recognition technology has made it possible for gamers to control games with their bodies, creating a more engaging experience. Gesture recognition technology has been applied to healthcare for rehabilitation, enabling patients to do physical therapy activities in virtual reality settings. To make driving safer, the automotive industry has created gesture recognition systems that let drivers operate several aspects of their car without taking their hands off the wheel. Gesture recognition technologies in smart home automation have made it possible for consumers to manage home appliances with basic hand gestures, offering a more practical and approachable experience.

Despite the potential benefits of gesture recognition systems for HCI, there are still a number of problems that need to be solved. One of the primary problems is accuracy. It can be challenging for gesture recognition systems to accurately detect the user's body motions in real-world situations when lighting, background noise, and occlusion might hinder the

Date of Submission: 5 May 2023
Date of Acceptance: 20 June 2023
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system's effectiveness.
Additionally, there are questions regarding how precisely gesture recognition systems can recognize a user's movements. The question of user approval is the last but certainly not the least. Users could be hesitant to utilize new technology if it is foreign to them or requires a lot of work to master.

II. LITERATURE REVIEW

Gesture recognition technology is a promising new approach to Human-Computer Interaction (HCI) that has gained significant attention from researchers and developers in recent years. The technology allows users to interact with their devices using body movements, enabling a more natural and intuitive user experience. This section provides a literature review of gesture recognition systems in HCI, including their benefits, limitations, and potential applications. One of the primary benefits of gesture recognition systems is their ability to provide a more natural and intuitive user experience. Traditional methods of HCI, such as the keyboard and mouse, can be challenging for some users to learn and use effectively. Gesture recognition systems, on the other hand, enable users to control their devices using natural body movements, which can be more accessible and convenient for many users.

Gesture recognition systems have already found applications in a variety of fields, including gaming, healthcare, automotive, and smart home automation. In gaming, gesture recognition technology has enabled users to control games using body movements, providing a more immersive experience. In healthcare, gesture recognition systems have been used for rehabilitation purposes, allowing patients to perform physical therapy exercises using virtual reality environments. In the automotive industry, gesture recognition systems have been implemented for safer driving, enabling drivers to control various functions of their vehicle without taking their hands off the steering wheel. In smart home automation, gesture recognition systems have enabled users to control home appliances using simple hand gestures, providing a more convenient and accessible experience.

Despite the potential benefits of gesture recognition systems for HCI, there are also several limitations that need to be addressed. One of the primary limitations is accuracy. Gesture recognition systems need to be able to accurately interpret the user's body movements, which can be challenging in real-world environments where lighting conditions, background noise, and occlusion can affect the system's performance. Additionally, there are concerns regarding the reliability of gesture recognition systems, as they may not always detect the user's movements correctly. Finally, there is the issue of user adoption, as users may be hesitant to adopt new technology if they are not familiar with it or if it requires significant effort to learn [1].
Current research in gesture recognition systems for HCI is focused on addressing the limitations of these systems and exploring new applications [2]. One area of research is improving the accuracy of gesture recognition systems, through the use of machine learning algorithms and improved sensor technology. Some proposed solutions use accelerometers and gyroscopes [3][4][5] as sensors while others make use of Two-Antenna Doppler Radar [6] or Kinect sensor [7]. These systems are often coupled with intelligent Neural networks that process the inputs provided. There is also vast research in making use of algorithms and machine learning models coupled with image processing techniques that aim to provide HCI using cameras as input to develop low resource hungry systems of HCI [8][9]. Some techniques being used for gesture recognition include finger segmentation [10], Deep Learning [11][12]. Another area of research is exploring new applications for gesture recognition systems, such as in education and virtual reality environments. Additionally, there is ongoing research into the development of more intuitive and natural gesture-based interfaces, which may involve the use of haptic feedback [13] or augmented reality. Some Systems are working on real time hand gesture recognition [14].
Gesture recognition systems are a promising new approach to HCI that enables users to interact with their devices using natural body movements. These systems have already found applications in a variety of fields, including gaming, healthcare, automotive, smart home automation as well as recognition of sign language [15]. However, there are also several limitations associated with these systems, including accuracy, reliability, and user adoption. Current research in gesture recognition systems for HCI is focused on addressing these limitations and exploring new applications. Overall, gesture recognition systems have the potential to revolutionize the way we interact with technology, providing a more natural, intuitive, and accessible user experience.

III. PROPOSED SYSTEM

This Paper discusses a solution which will resolve the problem of hand gesture recognition in a way that utilizes minimal hardware resources. This system will work on hand gesture recognition approach for HCI using 3 modules – The Sensing module is responsible for capturing or sensing input from the various types of image sensors. In our system we will be using the camera/webcam as the sensor. The sensor will capture the image and pass it to the detection module to be processed frame by frame. The detection module will take the input frame and process it to detect hand gestures within that frame. Upon detecting a valid hand gesture, the detection module will call the action module which will map the detected hand gestures to their associated actions. The actions are then performed according to the gesture detected.

ISSN: 2583-3286(Online)

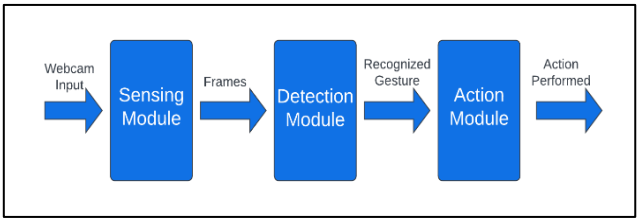

Figure 1: The proposed system and it's modules

Technical Specifications -

Hardware

- Processor: Intel Core i3-5th gen CPU or better
- RAM: 2GB (minimum) or 4GB (recommended)
- Input Device: Webcam (Good Quality)

Software

- Operating System: Windows
- Disk Usage: 700 MB

IV. METHODOLOGY

This solution will resolve the problem of recognizing/detecting hand gestures for Human Computer Interaction. The basic concept of this system is based on Hand detection using computer vision approach with adds on the gesture recognition feature which help in increasing the accuracy and the ease of use precisely as the simple and easy to remember gestures are used in the system and their recognition is done using mathematical pattern-recognition and geometric analysis techniques. Existing hand gesture recognition systems use machine learning and AI to identify complex gestures and while these systems boast high accuracy, they also have a very large hardware resource consumption. This solution also depends on the quality of the device used to capture the hands and gestures of a person as the very first step of this system is to take the image as input and later to detect and identify the hand gestures present in the image.

The system detects the number of fingers being held up by the user as the gesture. In this way our system can support up to 10 gestures using both hands. This way these gestures are easy to remember for the user as well as it is easy for the user to perform these gestures. The first step in the system after the input is received is to detect hands in the image. For this we are using MediaPipe which is a python library and has a pretrained hands detection module as it is accurate, fast and has low resource requirement. Only when the system detects hands in the image it starts the gesture recognition process else it waits for the next frame.

Hand gesture recognition is done after the presence of hands is confirmed in the frame. The hand gesture system counts the number of fingers being held up using mathematical pattern-recognition and geometric analysis techniques. The hand gesture recognition system repeats itself for 20 continuous frames and identifies the gesture in all 20 of these frames. The system will then calculate the gesture with the maximum occurrences in those 20 frames and that gesture will be the final gesture that will be passed to the action module. This process is done to improve the accuracy of the system and decrease the likelihood of false positives. This 20-frame parameter is called detection time and the user can increase or decrease this parameter to suit their needs.

The final detected gesture is then passed to the action module which maps the detected gesture to its corresponding action and performs it. This corresponding action is customizable by the user as our system uses hotkeys to perform the actions and these hotkeys can be mapped to perform various actions and the user can also customize the hotkeys associated with each gesture.

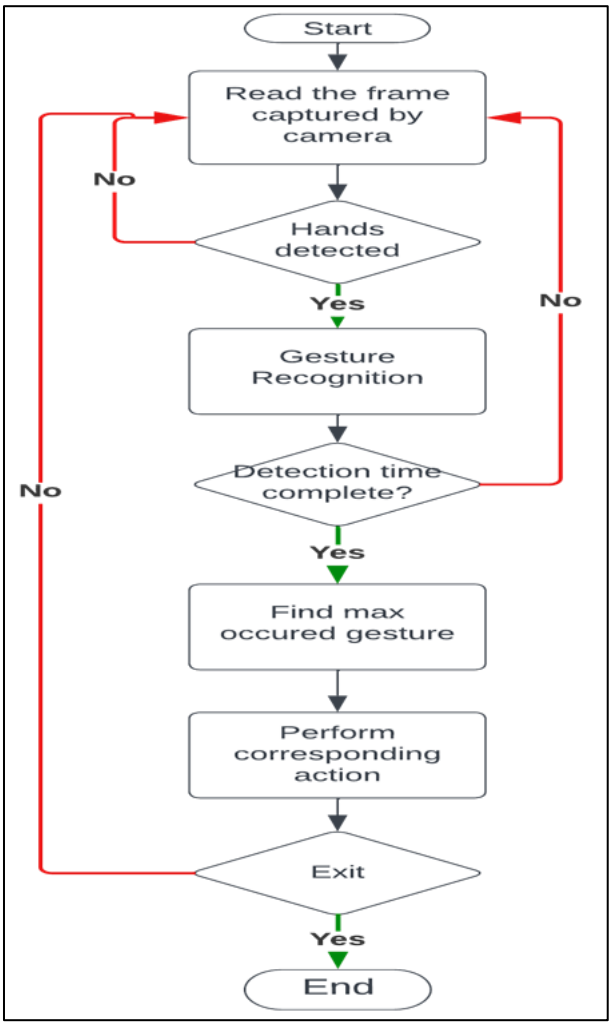

Figure 2: The Flowchart of the system

V. IMPLEMENTAITION

MediaPipe is a platform that provides customizable Machine Learning (ML) solutions (such as face and hand detection, hair segmentation, motion tracking, and so on) for live and streaming media. Their solution for hand detection and tracking is called MediaPipe Hands, and it employs ML to provide palm detection and a hand landmark model which consists of 21 3D landmarks, as shown in Figure 3.

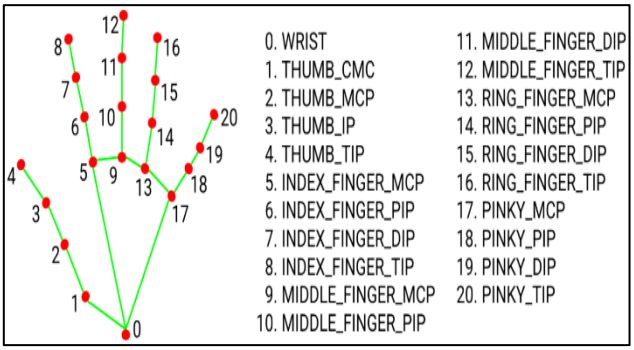

Figure 3: The Hand Landmark model used in hand and gesture recognition

Every one of these 3D landmarks is made up of x, y, and z coordinates. The image's width and height are used to normalize the x and y landmark position from 0 to 1. The landmark's proximity to the camera is indicated by the z component. For the purposes of this implementation, just x and y coordinates will be used. Every frame of the webcam video capture is used to run the MediaPipe Hands process function in the implementation. The outcomes include a 3D landmark model for each hand found in each frame. For each of the hands detected, these are the steps followed:

1. Check detected hand label.
2. Store x and y coordinates of each landmark.
3. Check each finger's coordinates to determine if it is raised to increase finger count.
4. Draw hand landmarks with draw_landmarks function.

For the third step, there are two approaches to test if a finger is raised:

•For the thumb, we'll check the values of the THUMB_TIP and THUMB_IP x coordinates, and the hand label. The thumb is considered raised if the _TIP is located to the right of the _IP, for the left hand, and the opposite for the right hand.

•For the other fingers, we'll check the values of the _TIP and _PIP y coordinates. The finger is considered raised if the _TIP is located higher than the _PIP.

Figure 4: The system detecting Gesture 7

VI. RESULTS & CONCLUSIONS

In our gesture recognition system, we have included a total of ten gestures. In Figure 4 we see an example of the 7th gesture being used. The numerical value at the bottom left indicates the gesture number as well as the number of fingers being held up by the user.

In this paper, we were able to create a robust gesture recognition system that did not utilize any markers, hence making it more user friendly and low cost. Our system had an accuracy of 94.52% in case of plain background in classifying the 10 types of gesture. The testing was done using a dataset of 900 images.

We are able to provide a solution for Human Computer Interaction using Hand Gesture Recognition that is user friendly, low cost, easy to use and learn while at the same time being able to run as a background task with low resource utilization.

In this gesture recognition system, we have aimed to provide gestures, covering almost all aspects of HCI such as system functionalities, launching of applications and opening some popular websites. In future we would like to improve the accuracy further and add more gestures to implement more functions. Finally, we target to extend our domain scenarios and apply our tracking mechanism into a variety of hardware including digital TV and mobile devices. We also aim to extend this mechanism to a range of users including disabled users.

REFERENCES

[1] M. Oudah, A. Al-Naji, and J. Chahl, "Hand Gesture Recognition Based on Computer Vision: A Review of Techniques," Journal of Imaging, vol. 6, no. 8, p. 73, Jul. 2020, doi: 10.3390/jimaging6080073

[2] Yasen M, Jusoh S. 2019. A systematic review on hand gesture recognition techniques, challenges and applications. PeerJ Computer Science 5:e218 https://doi.org/10.7717/peerj-cs.218

ISSN: 2583-3286(Online)

[3] Y.-C. Chu, Y.-J. Jhang, T.-M. Tai, and W.-J. Hwang, “Recognition of Hand Gesture Sequences by Accelerometers and Gyroscopes,” Applied Sciences, vol. 10, no. 18, p. 6507, Sep. 2020, doi: 10.3390/app10186507

[4] S. Zhao, H. Cai, W. Li, Y. Liu, and C. Liu, “Hand Gesture Recognition on a Resource-Limited Interactive Wristband,” Sensors, vol. 21, no. 17, p. 5713, Aug. 2021, doi: 10.3390/s21175713

[5] Luzhnica, Granit & Simon, Joerg & Lex, Elisabeth & Pammer-Schindler, Viktoria. (2016). A Sliding Window Approach to Natural Hand Gesture Recognition using a Custom Data Glove. 10.1109/3DUI.2016.7460035

[6] S. Skaria, A. Al-Hourani, M. Lech and R. J. Evans, "Hand-Gesture Recognition Using Two-Antenna Doppler Radar With Deep Convolutional Neural Networks," in IEEE Sensors Journal, vol. 19, no. 8, pp. 3041-3048, 15 April15, 2019, doi: 10.1109/JSEN.2019.2892073

[7] Z. Ren, J. Yuan, J. Meng and Z. Zhang, "Robust Part-Based Hand Gesture Recognition Using Kinect Sensor," in IEEE Transactions on Multimedia, vol. 15, no. 5, pp. 1110-1120, Aug. 2013, doi: 10.1109/TMM.2013.2246148

[8] Aashni Haria, Archanasri Subramanian, Nivedhitha Asokkumar, Shristi Poddar, Jyothi S Nayak, Hand Gesture Recognition for Human Computer Interaction, Procedia Computer Science, Volume 115, 2017, Pages 367-374, ISSN 1877-0509, https://doi.org/10.1016/j.procs.2017.09.092

[9] She, Yingying & Wang, Qian & Jia, Yunzhe & Gu, Ting & He, Qun & Yang, Baorong. (2014). A Real-Time Hand Gesture Recognition Approach Based on Motion Features of Feature Points. 1096-1102. 10.1109/CSE.2014.216

[10] Zhi-hua Chen, Jung-Tae Kim, Jianning Liang, Jing Zhang, Yu-Bo Yuan, "Real-Time Hand Gesture Recognition Using Finger Segmentation", The Scientific World Journal, vol. 2014, Article ID 267872, 9 pages, 2014. https://doi.org/10.1155/2014/267872

[11] A. Mujahid et al., “Real-Time Hand Gesture Recognition Based on Deep Learning YOLOv3 Model,” Applied Sciences, vol. 11, no. 9, p. 4164, May 2021, doi: 10.3390/app11094164

[12] M. Al-Hammadi et al., "Deep Learning-Based Approach for Sign Language Gesture Recognition With Efficient Hand Gesture Representation," in IEEE Access, vol. 8, pp. 192527-192542, 2020, doi: 10.1109/ACCESS.2020.3032140

[13] Moin, A., Zhou, A., Rahimi, A. et al. A wearable biosensing system with in-sensor adaptive machine learning for hand gesture recognition. Nat Electron 4, 54–63 (2021). https://doi.org/10.1038/s41928-020-00510-8

[14] George Sung, Kanstantsin Sokal, Esha Uboweja, Valentin Bazarevsky, Jonathan Baccash, Eduard Gabriel Bazavan, Chuo-Ling Chang, and Matthias Grundmann. "On-device Real-time Hand Gesture Recognition." arXiv preprint arXiv:2111.00038 (2021)

[15] Huong, Thao & Huu, Tien & Xuan, Thanh & Van, San. (2015). Static hand gesture recognition for vietnamese sign language (VSL) using principle components analysis. 138-141. 10.1109/ComManTel.2015.7394275