iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** V **Month of publication:** May 2024

DOI: https://doi.org/10.22214/ijraset.2024.61942

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue V May 2024- Available at www.ijraset.com

Literature Review of "Gesture Navigator: AI Based Virtual Mouse"

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Abstract: ***The mouse is one of the wonderful inventions of Human-Computer Interaction (HCI) technology. Currently, wireless mouse or a Bluetooth mouse still uses devices and is not free of devices completely since it uses a battery for power and a dongle to connect it to the PC. In the proposed AI based virtual mouse system, this limitation can be overcome by employing webcam or a built-in camera for capturing of hand gestures and hand tip detection using computer vision. The algorithm used in the system makes use of the machine learning algorithm. Based on the hand gestures, the computer can be controlled virtually and can perform left click, right click, scrolling functions, and computer cursor function without the use of the physical mouse. The algorithm is based on deep learning for detecting the hands. Hence, the suggested system aims to minimize the risk of communicable diseases like COVID-19 transmission by reducing human contact and eliminating the need for additional devices to control the computer system.***

I. INTRODUCTION

A. *Description*

The proposed AI based virtual mouse system can be used to overcome problems in the real world such as situations where there is no space to use a physical mouse and for the persons who have problems in their hands and are not able to control a physical mouse. Also, amidst of the COVID-19 situation, it is not safe to use the devices by touching them because it may result in a possible situation of spread of the virus by touching the devices, so the proposed AI virtual mouse can be used to overcome these problems since hand gesture and hand Tip detection is used to control the PC mouse functions by using a webcam or a built-in camera. While using a wireless or a Bluetooth mouse, some devices such as the mouse, the dongle to connect to the PC, and a battery to power the mouse to operate are used, but in this paper, the user uses his/her built-in camera or a webcam and uses his/her hand gestures to control the computer mouse operations. In the proposed system, the web camera captures and then processes the frames that have been captured and then recognizes the various hand gestures and hand tip gestures and then performs the mouse function.

B. *Objective*

The main objective of the proposed AI based virtual mouse system is to develop an alternative to the regular and traditional mouse system to perform and control the mouse functions, and this can be achieved with the help of a web camera that captures the hand gestures and hand tip and then processes these frames to perform the mouse function such as left click, right click, and scrolling function.

The main goals of the Research work are:

1) To develop a cursor control system virtually using hand gestures which performs operations such as left click, right click and cursor movement.
2) A virtual assistant has to develop to enable users to give commands and access functions using either voice or hand gestures.
3) The System will have a voice to text converter which interprets the voice message and converts it into relevant text format.

II. RELATED WORK

People have tried different ways to make a virtual mouse. Some used gloves and recognized hand gestures, while others used colour tips on hands. However, these methods weren't very accurate. Wearing gloves could make recognition less accurate, and some users might not like wearing gloves. Also, not detecting colour tips well could affect accuracy.

In the past, there was a system where users wore a DataGlove, but it couldn't do some gesture controls. Another study in 2010 used motion history images for hand gesture recognition, but it struggled with complex gestures.

In 2013, another study required stored frames for skin pixel detection and hand segmentation. A paper in 2016 introduced a system for cursor control using hand gestures with different bands for different functions, relying on colours.

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In 2018, a model for a virtual mouse using hand gestures was proposed, but it only performed a few functions.
A recent approach involved tracking hand landmarks using colours and implementing a virtual mouse with an optical flow algorithm. The process included user initialization, cursor movement, and click detection.
Another technique detected relative head movements and converted them into mouse movements. This could replace traditional mouse by using hand gestures and a webcam for motion detection. The system moved the pointer based on the detected hand, controlling simple mouse functions without pressing buttons or manually moving a mouse on a physical computer.

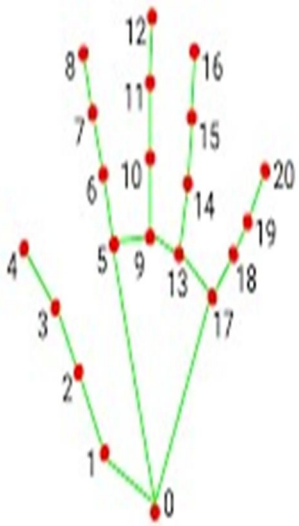
A. Challenges

1) Hand Detection: To ensure smooth operation, it's crucial to promote the identification and tracking of hands, distinguishing them from the surrounding environment. However, dealing with objects made of fabric can pose challenges to our ability to observe and differentiate. Variations in organic appearance and non-biological characteristics, as well as factors like temperature and surface differences, may contribute to issues in this regard.

2) Hand Tracking: Monitoring hands is dependable at short distances, especially when aiming to enhance visibility for individual viewing cameras. As virtual reality extends its reach to incorporate hands into daily activities, hand tracking is expected to become more trustworthy. However, the challenges may intensify in regions with limited visibility, making tracking and visualization more challenging.

3) Inclusivity and Involvement: Tracking hands and gestures poses various challenges associated with irregular embodiment and inclusivity. A crucial aspect of hand tracking involves separating the skin from the surrounding area, enabling the user to define and visualize the hand's movements and strength. An additional potential issue, not explicitly tackled, pertains to variations in skin color.

4) Gesture Recognition Based on Computer Vision: Currently, touch-based touch perception stands as the predominant diagnostic approach. Information from touch images is gathered through one or more cameras, and the acquired data undergoes pre-processing, including sound removal and information enhancement. Subsequently, a separation algorithm is employed to identify the target touch within the image. The differentiation between actual touch and its significance is achieved through video processing and analysis, ultimately identifying the target touch using the touch detection algorithm. Touch-based touch recognition comprises three key components: touch recognition, touch analysis, and touch detection. The initial stage involves tapping the input image to generate a segment.

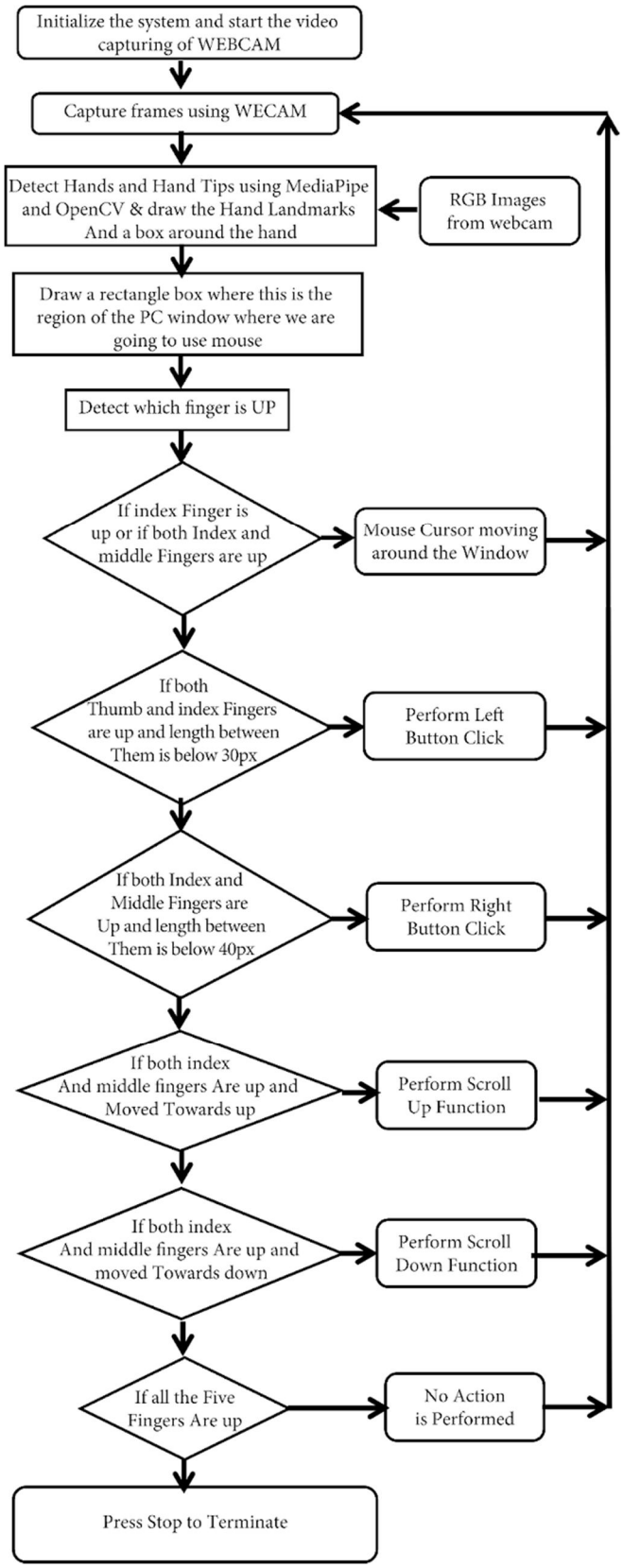


The touch separation procedure is divided into two primary components: touch and touch separation. In the touch area process, the touch circuit is eliminated from the intricate background by self-tracking the image containing the touch and applying touch separation. The touch phase segment utilizes a post-touch algorithm to distinguish the current touch from the background. Presently, touch modeling technologies predominantly encompass visual-based touch modeling and 3D model-based touch models. Appearance-based touch models can be categorized into static 2D models and dynamic models. Subsequently, touches are arranged and analyzed.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
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B. Work flow of system:

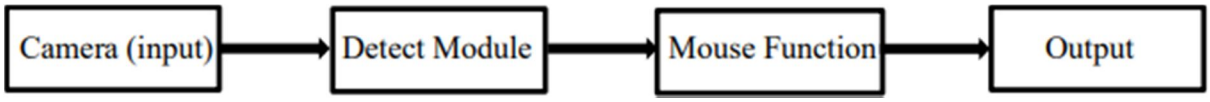
The flowchart outlines the different functions and conditions employed within the system.



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C. *Proposed System and Model*

The characteristics of hand signals and hand movements are analyzed using the MediaPipe system, while the OpenCV library is employed for general computer vision purposes on the PC. Through AI considerations, the system effectively captures and interprets hand movements and fingertip positions.

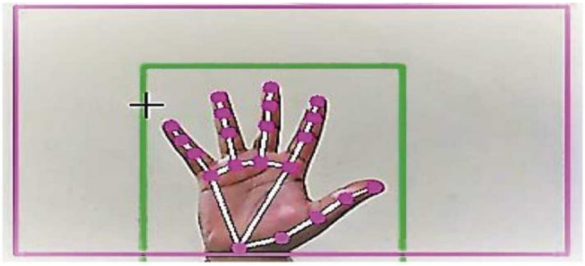


Pre-processing, specifically image handling, is an initial step in computer vision aimed at transforming an image into a format suitable for further analysis. Tasks such as exposure correction, colour balancing, image noise reduction, or enhancing image sharpness are crucial and often demanding to achieve satisfactory results.

III. METHOLODOGY

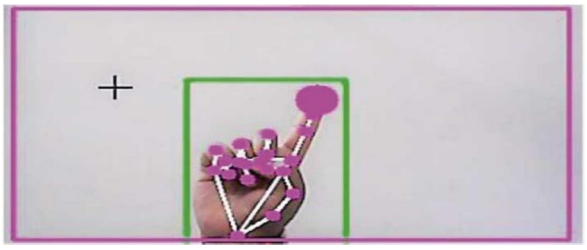
1) *The Camera in the AI Based Virtual Mouse System*

The suggested AI based virtual mouse system relies on frames captured by the webcam on a laptop or PC. Using the OpenCV Python computer vision library, a video capture object is created, initiating the webcam to capture video.



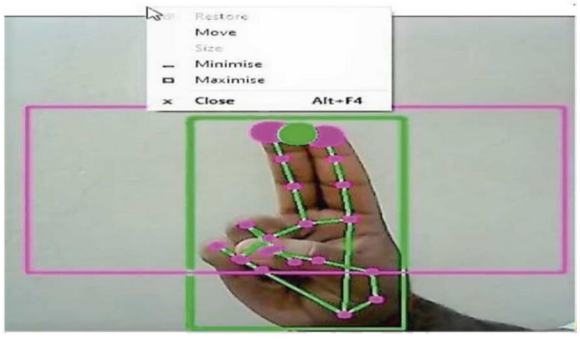
2) *Identifying the Raised Finger and Executing the Corresponding Mouse Action*

During this phase, we identify the raised finger by utilizing the tip ID obtained through MediaPipe and the corresponding coordinates of the lifted fingers, as illustrated in this figure. Based on this information, specific mouse functions are then executed.



3) *Initiating a Right-Button Click for Mouse Functionality*

When both the index finger with tip ID = 1 and the middle finger with tip ID = 2 are raised, and the distance between the two fingers is less than 40 pixels, the computer is instructed to execute a right mouse button click. This action is facilitated through the pynut Python package.

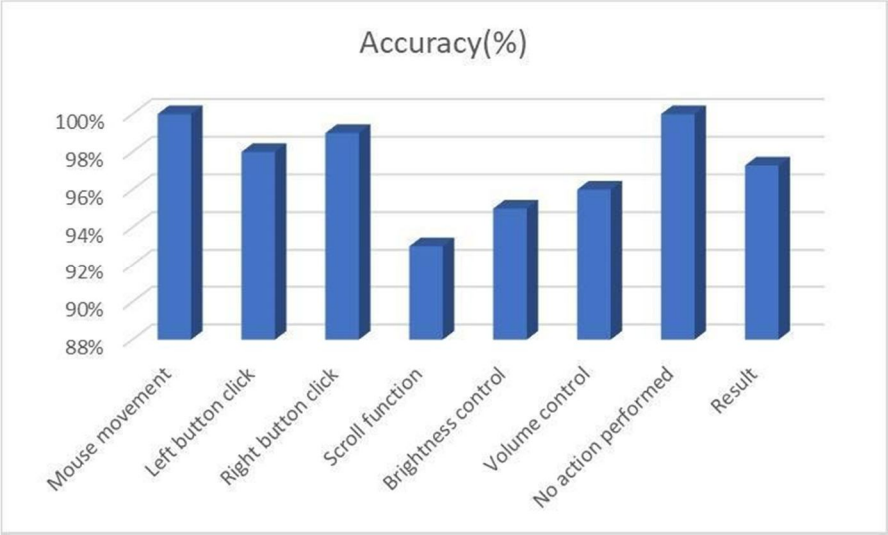


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IV. PERFORMANCE ANALYSIS

In the proposed AI based virtual mouse system, the emphasis is placed on advancing human-computer interaction through computer vision. However, the cross-comparison of the AI based virtual mouse system's testing poses challenges due to the limited availability of datasets. Extensive testing has been conducted on hand gestures and fingertip detection under various illumination conditions and at different distances from the webcam for tracking hand gestures and fingertip positions.

For experimental testing, the system underwent 25 trials by 4 individuals, resulting in a total of 600 gestures with manual labelling. These tests were conducted in diverse light conditions and at varying distances from the screen. Each participant tested the AI virtual mouse system 10 times in normal light conditions, 5 times in low-light conditions, 5 times in close proximity to the webcam, and 5 times in a distant position from the webcam. The detailed experimental results are summarized and tabulated in Table for further analyis.



V. OVERVIEW

As technology advances, virtualization becomes increasingly prevalent. Speech recognition, for instance, plays a vital role in translating spoken language into text. This technology has the potential to replace traditional keyboards in the future. Similarly, eye tracking allows the control of the mouse pointer through eye movements, indicating a potential replacement for traditional mice.

Gestures, taking various forms such as hand images or pixel images, or any human-provided pose, can offer solutions that require less computational difficulty or power to operate devices. Companies are introducing different techniques to gather necessary information and data for recognizing hand gestures. Some models utilize special devices like data gloves and colour caps to create a comprehensive understanding of the gestures provided by users. These advancements signify a shift towards more intuitive and efficient human-computer interactions.

The Proposed system signifies the following advantages:

1) Natural Interaction: Gesture control mimics natural hand movements, making it an intuitive way to interact with computers and devices.
2) Hands-Free Operation: Gesture control eliminates the need for physical contact with input devices, which can be useful in situations where hands-free operation is essential, such as in medical settings, clean rooms, or for users with limited mobility.
3) Creative and Artistic Applications: Gesture control is valuable in creative fields like digital art and design, as it enables more expressive and fluid input for tasks like drawing, sculpting, or 3D modeling.
4) Novelty and Innovation: Gesture-controlled interfaces are often seen as cutting-edge and innovative, appealing to tech-savvy users and early adopters.
5) Reduced Physical Fatigue: Gesture control can reduce physical fatigue associated with repetitive mouse movements and clicking, as it allows users to control the cursor and perform actions with minimal physical effort.

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VI. CONCLUSION

The primary objective of the AI visual mouse system is to enable users to control the mouse pointer through hand gestures, eliminating the need for physical manipulation. The system captures and processes hand gestures and fingertip movements, accessible through a webcam or built-in camera. The proposed model demonstrates high accuracy, making it applicable in real-world scenarios, such as reducing the spread of COVID-19 and eliminating the reliance on wearable devices. However, some limitations include a slight decrease in the accuracy of the right-click feature and challenges in clicking and dragging to select text. Future developments will focus on addressing these issues through the implementation of fingerprint capture methods for improved accuracy.

Gesture recognition facilitates optimal interaction between humans and machines, playing a crucial role in developing alternative human-computer interaction methods. It allows for a more natural interface, with applications ranging from sign language recognition for the deaf and dumb to robot control. Gesture recognition finds applications in augmented reality, computer graphics, computer gaming, prosthetics, and biomedical instrumentation. The Digital Canvas, an extension of this system, is gaining popularity among artists, enabling the creation of 2D or 3D images using Virtual Mouse technology, where the hand serves as a brush and a Virtual Reality kit or monitor acts as the display. This technology can also aid patients without limb control and is utilized in modern gaming consoles for interactive games tracking a person's motions as commands.

Future extensions of this work could focus on enhancing the system's ability to operate in complex backgrounds and diverse lighting conditions. The goal is to create an effective user interface encompassing all mouse functionalities. Research into advanced mathematical techniques for image processing and exploration of different hardware solutions could lead to more accurate hand detections. This project not only showcased various gesture operations but also highlighted the potential for simplifying user interactions with personal computers and hardware systems.

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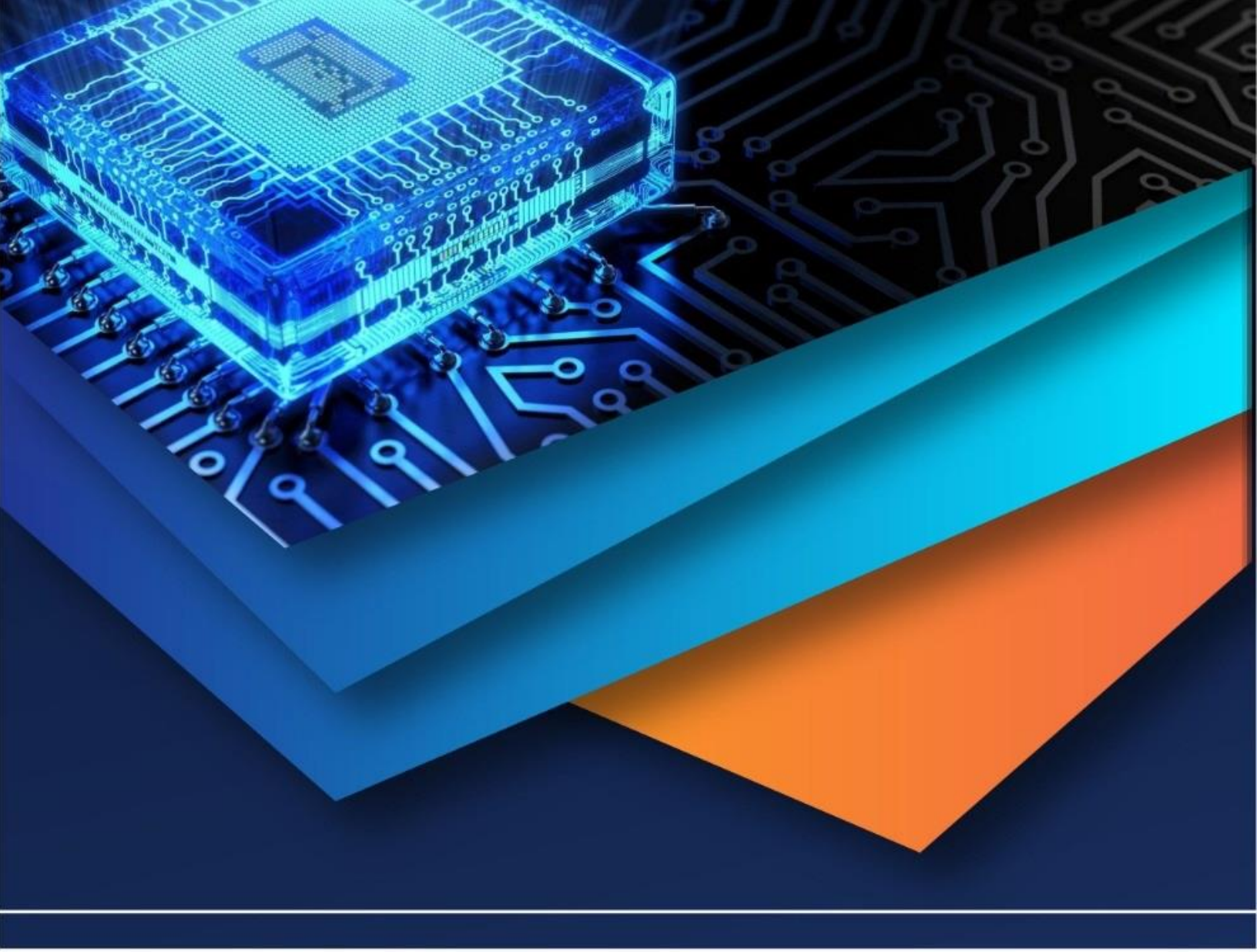
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