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Development of CNN-based Virtual Mouse

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Abstract: ***The technique of building a process of interaction between human and computer is evolving since the invention of technology. The mouse is a superb invention in HCI (Human-Computer Interaction) technology. Though wireless mouse technology is invented still, that technology isn't completely device free. A Bluetooth mouse has the need of battery power and connecting dongle.***
The proposed mouse system is beyond this limitation. This paper proposes a virtual mouse system supported HCI using computer vision and hand gestures. Gestures captured with a built-in camera or webcam and processed by a Convolutional Neural Network Model for classification among the desired mouse operations. The users are going to be allowed to regulate a number of the pc cursor functions with their hand gestures.
Primarily, a user can perform left clicks, right clicks, and double clicks, scrolling up or down using their hand in several gestures.
This technique captures frames employing a webcam or built-in cam and processes the frames to make them track-able and then recognizes different gestures made by users and perform the mouse functions. Therefore the proposed mouse system eliminates device dependency so as to use a mouse.
Keywords: HCI (Human-Computer Interaction), Convolutional Neural Network, Hand Gesture, Virtual Mouse, Gesture Recognition.

I. INTRODUCTION

As the technologies are developing day by day the devices are becoming compact in size. Some devices have gone wireless, some of them gone latent.Typically we use a mouse, keyboard or other interacting devices which is mainly compact with the computer machine. The wireless devices also need a power source and connecting technologies. Video conferencing is very popular nowadays.
For this reason, most of the computer users use a webcam on their computer and most of the laptops have a built-in webcam. The proposed system which is webcam based, might be able to eliminate the need of a mouse partially. The process of interaction with a computer using hand gesture is a very interesting & effective approach to HCI (Human-Computer Interaction).
There is some really good research on this interest. The hand gesture recognition technology is also popular in sign language recognition.
The objective is to develop and implement an alternative system to control a mouse cursor. This paper proposes a system that could make some the devices go latent in the future that is the future of HCI (Human-Computer Interaction). The proposal is the development of a Virtual Mouse using Gesture Recognition. The aim is to control mouse cursor functions using only a simple camera instead of a traditional or regular mouse device.
This system is implemented in Python programming language using the Computer Vision based library OpenCV along with a trained CNN model for image classification.
This system has the potential to replace the typical mouse and also the remote controller of machines. The only barrier can be is the lighting condition. That's why the system still can't be enough to replace the traditional mouse as most of the computers are used in poor lighting conditions.

A. Problem Description & Overview

To track hand gestures as movable objects, and to utilize it for mouse functions, the camera should be positioned in a way so that it can see the user's hands in the right positions. This can be used in space-saving situations, for those patients who don't have control over their limbs and for other similar cases.
It's a virtual mouse instead of a physical mouse which will work only based on webcam captured frames & tracking colored fingertips.

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B. Significance in Real World Application

Video conferencing is extremely popular nowadays. For this reason, most of the pc users use a webcam on their computer and most of the laptops have a built-in webcam. The proposed system which is webcam-based could be ready to eliminate the necessity of a mouse partially. The method of interaction with a computer using hand gestures may be a very interesting & effective approach to HCI (Human-Computer Interaction). There's some specialized research on this interest. The hand gesture recognition technology is additionally popular in signing recognition.

C. Objective

The objective is to develop and implement an alternate system to regulate a mouse cursor. The choice method is hand gesture recognition using webcam and trained CNN model to classify among gestures. The last word outcome of this paper is to develop a system which recognizes hand gesture and controls mouse cursor of any computer.

II. RELATED WORK ON THIS THEORY

Cursor control application using hand gesture is employed in some ways, but most of the time, it requires wearing a DataGlove. This reduces the efficiency of performance between the user and therefore the system. And system complexity is additionally a problem during this process.

There might be two possible gesture recognitions for HCI, one is hardware-based & the other is computer vision-based. “one among the first hardware-based systems was proposed by Quam (1990) during which, the user had to wear a bulky DataGlove to use the system” [1]. Though this method gives a high accuracy control, it's very difficult to use as some gesture isn't meant for everybody and also very impractical for mass users within the everyday world.

Meanwhile, vision-based hand gesture recognition is additionally two types: marker-based & non-marker-based. Non- marker-based recognition generally isn't as accurate because of the marker-based recognition.

And therefore the maker-based recognition has better accuracy compared to the opposite gesture recognition systems, though the user has got to use an easy color cap on the fingertip. But this manner is lighter and almost nothing as compared with the DataGlove of the hardware-based system.

Gesture recognition could be futuristic thanks to the computers to know human gestures (Body Language). It'll build a greater interaction between human & computer machines instead of primitive text-based interaction.

Most of the marker-based gesture recognition mouse uses a minimum of two color markers to trace. Due to detecting multiple colors, the system gets slow and a few laggings appear on the system during the time of performance.

In 2010, ChenChiung Hsieh and Dung-Hua Liou proposed a paper “A Real-Time Hand Gesture Recognition System Using Motion History Image” [2] supported adaptive complexion model & motion history image (MHI). In their work, they used an adaptive complexion model and a motion history image-based hand moving direction detection method. The prime limitation of the paper may be a problem with working for more complicated hand gestures recognition.

In 2011, Chang-Yi Kao and Chin-Shyurng Fahn published a paper “A Human-Machine Interaction Technique: Hand Gesture Recognition supported Hidden Markov Models with Trajectory of Hand Motion” [3] that's learning based interaction between human & machine. Their work is extremely accurate but it worked only in high configuration computers.

In 2013, Angel, Neethu. P.S proposed a paper named "Real-Time Static and Dynamic Hand Gesture Recognition"
[4] during which design, develop and study a practical gesture recognition which will be utilized in a spread of human-computer interaction applications framework for real-time. But, it had been unable to figure at a posh background and was computable only under good light.

In 2013, Ashwini M. Patil, Sneha U. Dudhane, Monika B. Gandhi proposed a paper titled “Cursor system Using Hand Gesture Recognition” [5] where they developed a machine-user interface that implements hand gesture recognition using simple computer vision and multimedia techniques. But a serious limitation is before working with gesture comparison algorithms, skin pixel detection and hand segmentation from stored frames must be done.

In 2014, Abhik Banerjee & Abhirup Ghosh proposed “Mouse Control employing a Web Camera supported Color Detection” [6] titled paper where the methodology is Hand gestures were acquired employing a camera supported color detection technique. the restrictions of their work are the operating background has got to be light and no bright colored objects are present. It works well on certain computers of high configuration. In 2016, Yimin Zhou, Guolai Jiang & Yaorong Lin published “A novel finger and hand pose estimation technique for real-time hand gesture recognition” [7] supported directly extract fingers from salient hand edges. Considering the hand geometrical characteristics, the hand posture is segmented and described to support the finger positions, palm center location, and wrist position. But this method is merely compatible with high configuration computer machines.

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In 2016, Pooja Kumari, Saurabh Singh & Vinay Kr. Pasi developed "Cursor Control using Hand Gestures" [8] ispredicated on multiple color bands where different colorsperform different actions. the amount of colors is that the key to performing mouse functions. But, multiple colors were wont to control the system. it's relied on the number of colors to perform a function rather than different gestures.

In 2017, Aashni Haria, Archanasri Subramanian, Nivedhitha Asokkumar, Shristi Poddar, Jyothi S Nayak developed "Hand Gesture Recognition for Human-Computer Interaction" [9] supported background extraction and contours detection system. But it's very slow to figure with.

In 2018, Abhilash SS, Lisho Thomas, Naveen Wilson, Chaithanya C published a paper on "Virtual Mouse Using Hand Gesture" [10] which designed to figure with the color detection system, functions works on the number of colors detected. But it can perform only a couple of mouse actions and doesn't work without static background.

III.METHODOLOGY

A. Camera

The system works on the frames captured by the webcam on the pc machine or built-in camera on a laptop. By creating the video capture object, the system will capture video using a webcam in real-time.

To use one camera with this technique the device index would be "0" to feature additional camera device index would be 1, 2 then on. The camera device index for the built-in camera in a pc/laptop should generally be '0'. If additional cameras are attached to the pc/laptop the user should experiment with different indexes until found the correct index of the desired camera.

The index of built-in camera changes with different operating systems. This camera will capture frame by frame and can pass it to the system.

B. Capturing

By using an infinite while loop the webcam captures each frame till the program termination. The User should perform appropriate gestures for the mouse operations. Preprocessing of frames captured by camera is done using the fuctionalities offered by the python library named mediapipe.

C. Gesture Recognition

In this proposed system, Gesture recognition is accomplished using a CNN model which is trained on hundreds of images to classify the gestures provided by the user among the known classes.

The model is trained to classify the hand gestures into 5 classes. The classes are left click, left double click, right click, scroll down, scroll up. Each gesture is assosiated with a specific mouse operation. As soon as the trained CNN-model classifies the hand gesture of the user, the operation of the mouse assosiated with the gesture gets executed i.e. if the hand gesture of the user is classified by the cnn model as left click, the left click operation of the mouse gets executed.

If the hand gesture of the user is classified by the cnn model as left double click, the left double click operation of the mouse gets executed. If the hand gesture of the user is classified by the cnn model as right click, the right click operation of the mouse gets executed. If the hand gesture of the user is classified by the cnn model as scroll down, the scroll down operation of the mouse gets executed. If the hand gesture of the user is classified by the cnn model as scroll up, the scroll up operation of the mouse gets executed . The mouse movement is accomplished by using mediapipe library, a good library for machine learning. In the project, the mediapipe library is used to detect the hand and track it.

The library detects the hand and draws the landmarks on the hand. A total of twenty one landmarks are drawn for each hand. The library is able to detect, track and draw landmarks on multiple hands but to obtain the correct working of mouse cursor we changed the configuration to be able to detect atmost one hand among many hands(if any) in the frames. After the landmarks are drawn on the hand, the position of land marks can be obtained. The position are in normalized form so we need to multiply the x-coordinate of the positon with width of the frame and the y-coordinate of the positon with height of the frame. After this, the poition of the landmark at the tip of the finger is obtained. This position is where the mouse cursor will point to. A rectangle bounding box is also drawn across the hand. The co-ordinates of the bounding box is obtained with the help of the co-ordinates of the landmarks of the detected hand. Appropriate tranformation such as resizing, grayscaling and thresholding are performed before the image is fed to cnn model for classification.

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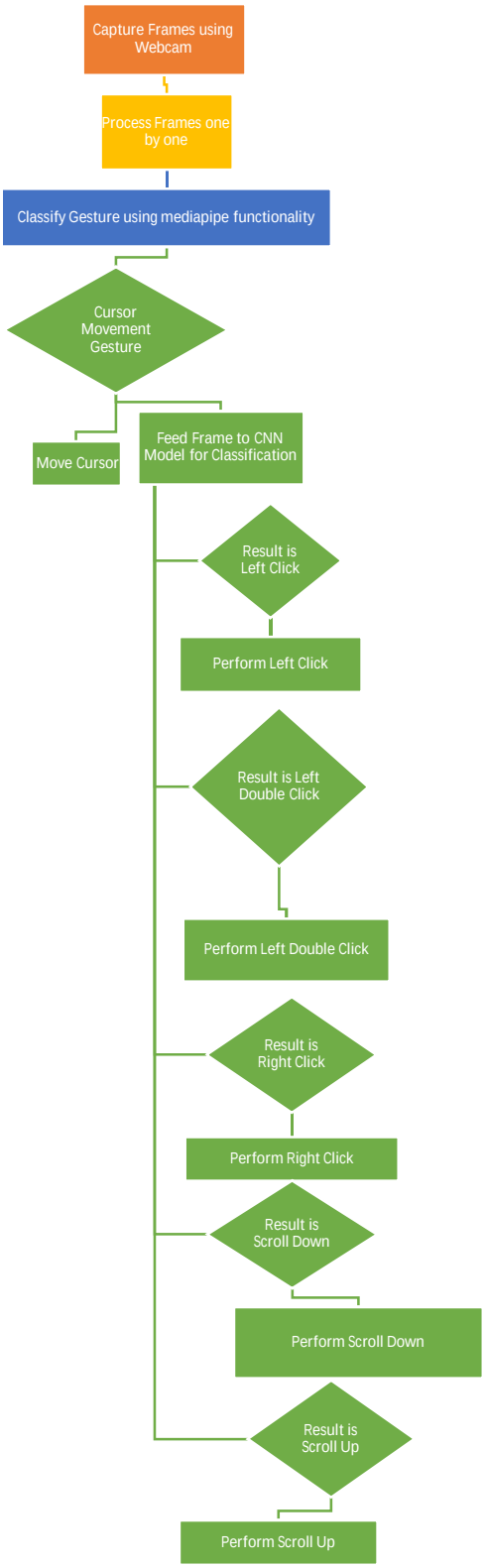

Fig.1 Flowchart of Mouse Model

D. Classify Gesture

The Gesture of the hand is classified as Cursor Movement Gesture or not. If the gesture is Cursor Movement Gesture then the mouse cursor will start moving according to the position of tip of the finger.

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IV. GESTURE RECOGNITION

A. Cursor Movement Gesture:

If the user holds the gesture of Cursor Movement, the mouse cursor will point to the position of index finger on the screen. If the user moves the index finger, the position of the mouse pointer will also change according to the index finger. In this way the user is able to move the mouse cursor.

B. Feed The Frames To CNN Model For Classification:

If the Gesture of the hand is not a Cursor Movement Gesture, then the frames are fed to the trained CNN model for classification.

The model classifies the gestures into following classes:

1) LeftClick.
2) Left Double Click.
3) Right Click.
4) Scroll Down.
5) Scroll Up.

C. Left Click

If the CNN model classifies the gesture as Left Click the Left Click operation of the mouse is perfomed.

D. Left Double Click:

If the CNN model classifies the gesture as Left Double Click the Left Double Click operation of the mouse is perfomed.

E. Right Click

If the CNN model classifies the gesture as Right Click the Right Click operation of the mouse is perfomed.

F. Scroll Down

If the CNN model classifies the gesture as Scroll Down the Scroll Down operation of the mouse is perfomed.

G. Scroll Up

If the CNN model classifies the gesture as Scroll Up the Scroll Up operation of the mouse is perfomed.

V. RESULT & EVALUATION

In this work, we have used HCI (Human Computer Interaction) and computer vision in order to contribute in future vision based interaction between the machine andhuman.

The proposed paper is on controlling the mouse functions using hand gestures. The main functions are mouse movement, left button click, right button click, double click and scrolling up or down.

This system may not work well with colorful backgrounds as the cnn model may not be able to classify the gestures properly.

Also it may not work well in poorly lighted environment. These are the disadvantages of our system. With sufficient light and less intense(colorless) background, this system works very well.

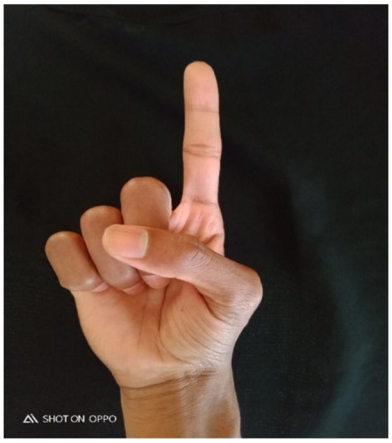

Fig 2. Gesture for Mouse Cursor Movement

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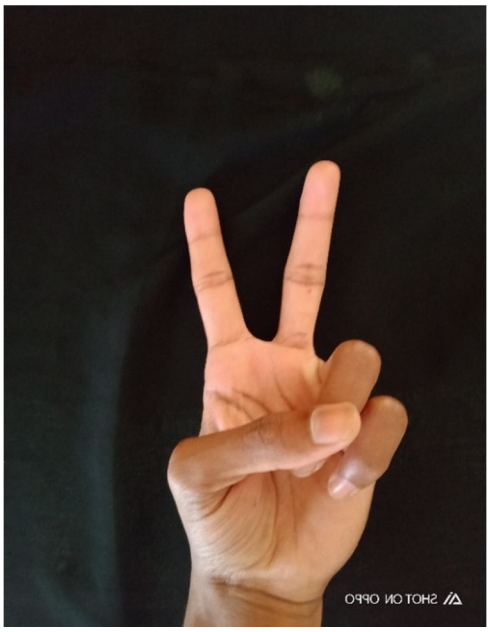

Fig 3. Gesture for Mouse Double Click

Fig 4. Gesture for Mouse Right Click

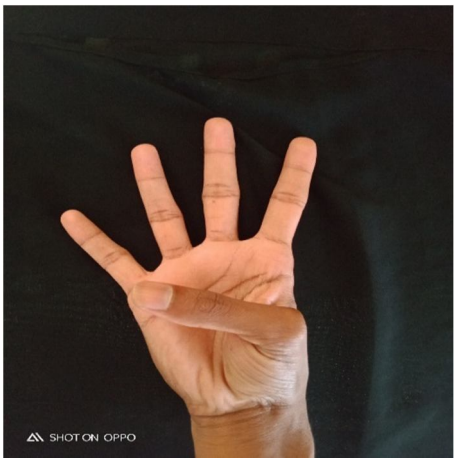

Fig 4. Gesture for Mouse Scroll Down

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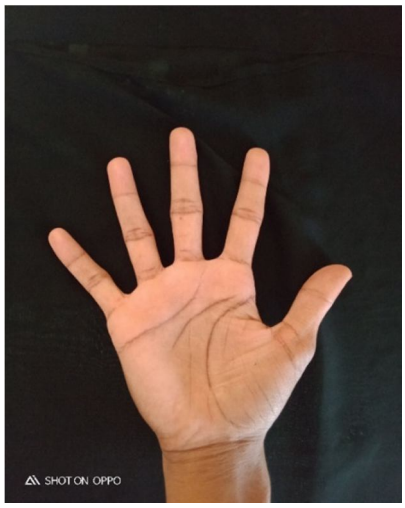

Fig 5. Gesture for Mouse Scroll Up

Fig 6. Gesture for Mouse Left Click

VI. APPLICATION

This project can reduce the dependancy on hardware device, mouse. Since it removes the burdens of the device, it brings the user and the system closer.

A. Major Applications

1) User might use this project to control Robots without the need of extra devices.
2) Digital artists can use this project to draw 2D and 3D objects and images
3) Old people and patients might find this project very useful to control electrical appliances and other gadgets around them
4) People who use sign language (dumb people) for communication can use this project to communicate with the people who don't know sign language.

VII. CONCLUSION

Clearly, this project is aimed to control a PC without the need of a mouse. The basic operations such as Clicking, Scrolling, Pointing can be performed using simple hand gestures and a real-time camera. The system works by detecting the gesture and executing the appropiate mouse operation Analyzing results, it can be concluded that if we provide sufficient light, high definition camera, the algorithms can work more efficiently. Then our system should be more reliable. In future, we may try to add more features of mouse such as changing the size of windows, Pressing and dragging icons on the screen etc.

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VIII. ACKNOWLEDGEMENT

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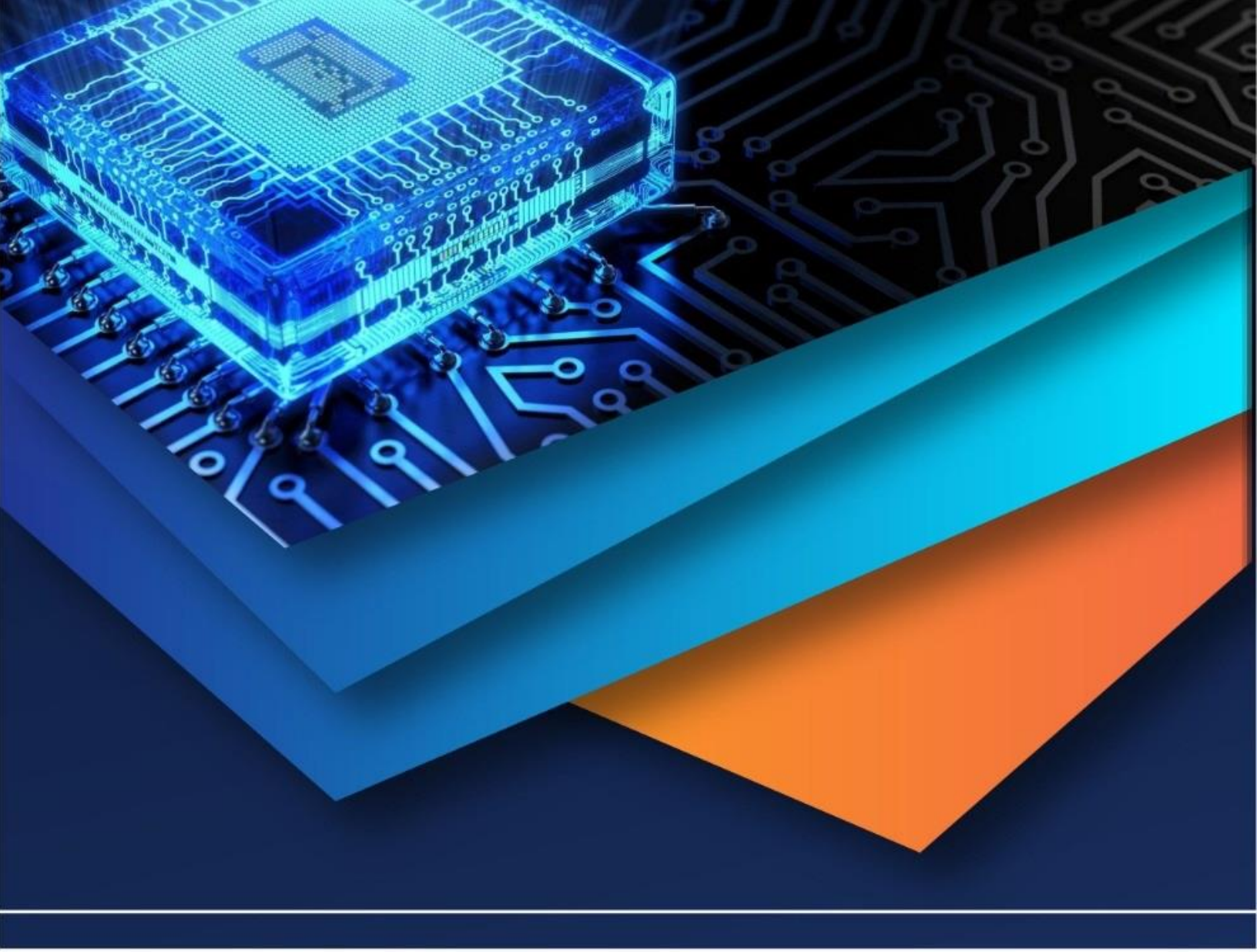

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