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The Study on Eye Controlled Smart Wheelchair

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Abstract: ***The Eye Directive wheelchair may be a mobility-monitored device for persons with moderate/severe physical disabilities or chronic diseases also as for the elderly. There are various interfaces for wheelchair available within the market, still they continue to be under- utilized, the rationale being the power, power and mind presence required to work them. The proposed model is a possible alternative.***
In this model, we use the optical-type eye tracking system to control powered wheelchair. User's eye movements are translated to screen position using the optical type eye tracking system, with none direct contact.
When user looks at convenient angle, then computer input system will send command to the software supported the angle of rotation of pupil i.e., when user moves his eyes balls left (move left), right (move right), straight (move forward) altogether other cases wheel chair will stop.
Also, obstacle detection sensors are connected to the Arduino to supply necessary feedback for correct operation of the wheelchair and to make sure the user's safety. The motors appended to the wheelchair support differential steering which avoids clumsy motion.
Keywords: Physical disability, Pupil, Arduino, Eye Control Device, Obstacle Detection.

I. INTRODUCTION

The Wheelchair depends system employed by elderly and physical disable persons. Here introducing the planning implementation models of totally independent Eye control electric wheelchair. As per requirement of the disabilities different quite automatic systems are available in market like voice control or joystick system . Sometime for totally paralysis person could also be have very difficult to use that sort of systems. Here the attention system provides the independence to form their life easy and more convenient,
[1]. And also they save the large amount of energy or external man power. USB camera captures the image in real time and analyzes the image as input to line the commands for interface the motor driver IC through sending the commands to GPIO pins. The motor driver circuit is employed to perform the various operation like left, right, forward and stop. For the advance level of Image Processing open computer vision (OpenCV) library is employed for Face and Eye detection
[2]. and a number of other application and algorithms are wont to determine accurate pupil location detection and tracking of that. One of them is Haar cascade like features detection algorithm wont to detects single or multiple face and detection of both eye.
[3]. To detecting the precise Eye pupil and locate its center point is ultimate goal of this technique . For automatically determine Eye pupil and tracking eye pupil many computer vision library of Image processing is employed like object detection, motion detection, Image color conversion, edge detection, pattern matching etc. For eye pupil tracking there are plethora of other techniques available.
[4] [5]. But they have its own limitation. One of them ECG, EEG and EOG sensor based eye pupil detection technique is out there
[6] [7], where voltage variation based output assumed to make a decision the situation of pupil.
[8]. But for different user, different output voltage will be generating, which will result faulty location of the eye pupil. The head movement based system have limitation, when user can't ready to access the system physically.
[9] [10]. Moreover, voice activated power wheelchair which works properly, when user speak the command system works consistent with it like left, right, forward, back, stop.
But a loud environment distracts the system, and system cannot respond properly. And other infrared reflection based eye pupil detection system providing accurate detection of the attention pupil center location, also as system can track the attention movement. But the infrared radiations affected the attention and user may loss the attention visibility.
Therefore, an efficient camera captured image based eye pupil detection and tracking system is introduced. Figure 1 indicates the system architecture of the hardware system.

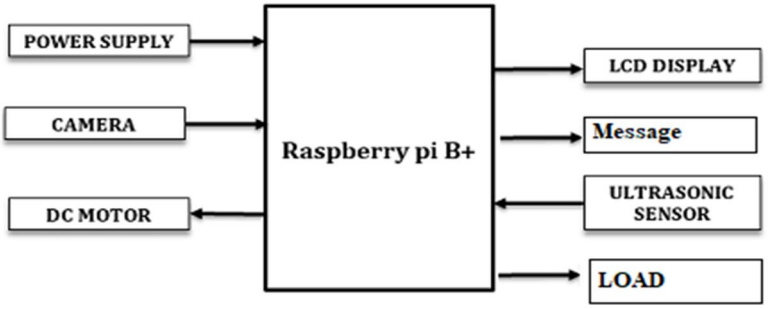

Fig. 1. System Architecture diagram

This is efficient also as cost effective system. Here real time video image capturing supported Face, Eye and Eye Pupil detection with minimum delay of your time is employed . The system includes multistage that is mainly track the Eye pupil center. This is efficient also as cost effective system. Here real time video image capturing supported Face, Eye and Eye Pupil detection with minimum delay of your time is employed .

[11]. A novel Eye tracking technique, which capture the image and detects the presents of human face. After detecting the face, it detects area of the eye location on the face detected image, and performs several operation of basic image processing like color image to grey conversion, filtering, threshold, pattern matching, noise reduction and circle detection thereon .

[12]. The Raspberry pi board is used to perform the control of the complete system operation. Digital Image processing based output signal sent to the Raspberry pi board. The Raspberry pi acquired the data and analyze it. Raspberry pi sends the control signal to motor driving circuit based on the location of eye pupil. This will decide to perform operation on motor like run the motor in clock voice direction, anti-clock voice direction and stop the motor. In a Wheelchair two individual motors are embedded on each wheel. The Ultrasonic sensor is also mounted on the wheelchair for detection of any static or mobile obstacle. If sensor gets the obstacle very on the brink of the wheelchair, it'll inform the raspberry pi and raspberry sends the signal to motor driving circuit to prevent the motor. The rest of the paper is systematized as follows. In section II discuss the system Design model. The section III describes the methodology applied for overall system and the section IV represents the implementation and system description of the proposed system, and last section of paper shows the result and conclusion of proposed implementation.

II. PROPOSED SYSTEM

System architecture is a conceptual model that defines the structure and behaviour of the system. It comprises of the system components and the relationship describing how they work together to implement the overall system.

The System architecture for the proposed system is shown below:

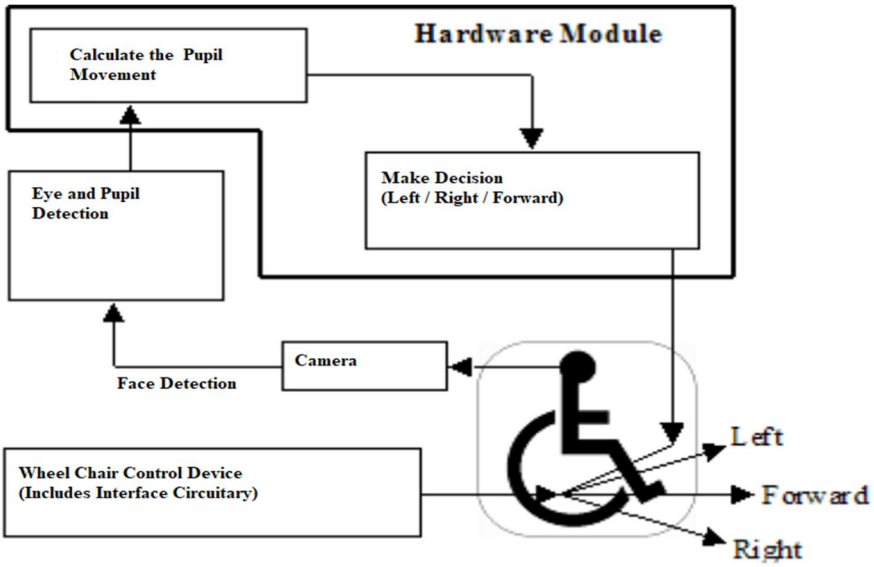

Fig 2. Proposed System Architecture

The modules in this project are shown below:

1) *Camera:* For input images of the eye of the user we make use of USB camera which takes continuous images and sends it to the next module.
2) *Eye and Pupil Detection:* This module does the image processing part. It does the Face and eye detection and extracts the features of the eye and the pupil and sends the pupil location to the hardware module.
3) *Hardware Module:* This module consists of the raspberry pi, Arduino, dc motors and other hardware parts which take the signals from the eye and pupil detection module and calculate the eye movements and perform the working of the wheelchair accordingly. The ultrasonic sensors send signals to the Arduino which stops the wheelchair when necessary and also sends message to caretaker.

We use 6 different algorithms in our project for eye detection and eyeball movement. The algorithms are :-

A. Face Detection and Eye Detection

1) For the face detection and eye detection the OpenCV library are often used directly.
2) Haar cascade algorithm is employed for both Face detection and Eye detection individually.
3) A camera detects the face of user. Once it is detected, system finds the eye location and marks the eye region using Haar cascade algorithm.
4) And the system accurately detects both the eyes based on the proper distance between each other.

The below figure shows face detection and eye detection using OpenCV Library.

Fig 2.1 Face and Eye Detection

B. BGR to Gray Conversion

1) The next operation i.e. the image color conversion is done to reduce the system delay time.
2) The Image frame size should be low, because the processor cannot process the image frames in run time if the image size is large.
3) So, by using the BGR to GRAY conversion a colored image is converted into a gray image.
4) The given figure (a) indicates the cropped color image of the Eye, figure (b) indicates the colored image to gray converted image and figure (c) shows the threshold image.

Fig 2.2 BGR Conversion

C. Features detection and Blurring Image

1) For blurring the image we use the Gaussian blur filter, which helps to detect the exact edges of specific area of the cropped image.
2) Features are the special patterns found in the image which are unique, based on it will make a pattern and make the featured detected image.
3) The figure (a) indicates the blurred image and figure (b) indicates the featured detected image

Fig 2.3 Gaussian Blur Filter

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D. Edge Detection

1) A canny Edge detection and corner Edge detection algorithm is applied for determining the soft edges of the image.
2) To set the proper threshold value it will make it easy to recognize rectangles or circle present in Image.
3) The below image indicates the edges of pupil after canny edge detection is applied.

Fig 2.4 Edge Detection

E. Hough Transform

1) Over the edge detection resulting image we use Hough circle transform method to draw a circle on eye pupil.
2) Camera captures the images continuously and according to the eye movement, a Hough circle transform detects the movements of eye pupil and draws the circles.
3) In given figure (a) indicates the features detection on image and the figure (b) indicates circle drawn eye pupil.

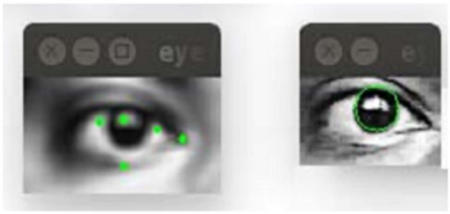

Fig 2.5 Hough Transformation

F. Eye Tracking

1) To track the Eye movements we use projection function algorithm, where the coordinates system points the location of the center point of the eye.
2) The below figure indicates the eye pupil location with respective coordinate's system graph.

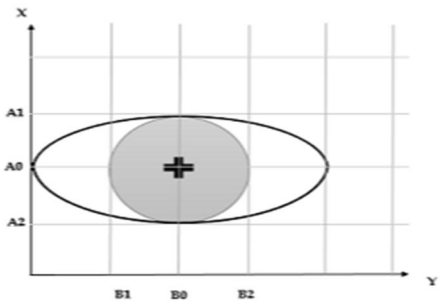

Fig 2.6 Coordinate System to point center of pupil

3) The above horizontal and vertical axis based two directional graph represents the eye movements in left or right direction.
4) It detects average point of eye pupil location.
5) The relation between the eye center and respective projection points is shown by a captured Projection function graph.
6) The directions of the eye movements are indicated by the X and Y scale points.
7) The eyeball position at the (A0, B0) point is: A0= (A1+A2) /2 and B0= (B1+B2)/ 2
8) The below figure 1 shows the Eye located in center position, figure 2 indicates the Eye pupil position located in left side of Eye and figure 3 indicates the Eye position on right side of the Eye.

Fig 2.7 Obtained eye center and detected circle

III. IMPLEMENTATION

An USB camera is mounted in front of the users face to capture images of the face and eye movements. To support the video processing gsstream properties setting required and for interfacing a camera with Raspberry pi UV4L driver is needed. The VLC video player is used for taking snapshots of the experiments and testing results. And important part is the distance between eye and camera device is fixed. It may me 10cm to 14cm.

Once the images are captured, they are taken as the input for the Raspberry Pi, here the system algorithms which are mentioned in approach are applied on the cropped image of the eye.

The low cost, credit-card sized computer known as Raspberry Pi plugs into a computer monitor or TV, and uses a typical keyboard and mouse. Here, in our system we make use of the Raspberry Pi 3 model. The Raspberry Pi 3 has inbuilt Wi-Fi and Bluetooth, but if you're employing a different model, you'll need compatible USB dongles. Along with the Pi itself, the microSD card, and power supply, you'll need a HDMI cable and an appropriate display. As with a standard computer, you'll also need a USB keyboard and mouse.

For making use of the Raspberry Pi we first need to install the Raspbian Operating System. Raspberry Pi runs on a Raspbian operating system. We use the Noobs OS installer to use Raspbian and feeding the python program into it. Noobs has a built in Raspbian OS and hence makes the program coding and uploading much easier. While putting a bootable storage device on raspberry pi board, then it can access the Raspbian OS directly without rebooting.

The python programming language is made use of for the coding. We have made use of the openCV library for performing the image processing. The openCV library for video capture is imported into the raspberry pi code, where the eye image is cropped , color inversion from BGR to gray is done, features detection and blurring image, edge detection, hough transform, eye tracking is done accordingly. This process gives the pupil bounds, corner points of eye, soft edges of eye, thresholding values and the current position of the pupil center.

A wireless Xbee module is connected onto the Raspberry Pi and another Xbee is connected to the Arduino. XBee may be a module produced by Digi International mainly use as a radio communication transceiver and receiver. XBee supports peer-to-peer also as point to multi-point network communications wirelessly with the speed of 250 k bits/s. This Xbee lets both our IoT devices i.e. the Raspberry Pi and the Arduino communicate with each other wirelessly without any hindrance.

An open-source microcontroller board known as Arduino UNO developed by Arduino.cc supported the Microchip ATmega328P microcontroller. The board is provided with sets of digital and analog input/output (I/O) pins which will be interfaced to varied expansion boards (shields) and other circuits. It are often powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. For the coding and performing the Arduino functions we used Arduino IDE. The Arduino Integrated Development Environment (IDE) may be a cross-platform application (for Windows, macOS, Linux).

It supplies a software library from the Wiring project, which provides many common input and output procedures. The ATmega328 on the Arduino/Genuino Uno comes preprogrammed with a boot loader that permits us to upload new code thereto without the utilization of an external hardware programmer. With the output signal received from the Raspberry Pi through the Xbee the Arduino calculates the eye pupil movements based on the reference point i.e. the normal eye point. The direction in which the eye is moving is calculated i.e. left, right or forward and the once the direction is determined this signal is sent to the DC motor driver which is connected to the Arduino.

In our system we make use of the L293D motor driver. L293D may be a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D may be a 16-pin IC which may control a group of two DC motors simultaneously in any direction. It means you'll control two DC motor with one L293D IC. It works on the concept of H-bridge. H-bridge may be a circuit which allows the voltage to be flown in either direction. As you recognize voltage must change its direction for having the ability to rotate the motor in clockwise or anticlockwise direction, hence H-bridge IC are ideal for driving a DC motor. In a single L293D chip there are two h-Bridge circuit inside the IC which may rotate two dc motor independently. Due its size it's considerably utilized in robotic application for controlling DC motors.

This DC motor driver in turn sends the signals received to the DC motors connected to it respectively. The DC Motors power the wheels of the wheelchair. DC motors convert electrical into mechanical energy and they consist of permanent magnets and loops of wire inside, when current is applied, the wire loops generate a magnetic field, which reacts against the surface field of the static magnets. The interaction of the fields produces the movement of the shaft/armature. Thus, electromagnetic energy becomes motion.

Here we use two DC motors for the movement of rover. A rotary electrical machines that converts DC electricity into energy is called as DC motor . The most common types believe the forces produced by magnetic fields. There are some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow partially of the motor in most of all kinds of DC motors. DC motors were the primary sort of motor widely used, as they might be powered from existing direct-current lighting power distribution systems. A DC motor's speed are often controlled over a good range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are utilized in tools, toys, and appliances.

For the obstacle detection in the pathway of the wheelchair for the safety of the user we have made use of the HC-SR04 Ultrasonic sensor. The HC-SR04 ultrasonic sensor uses sonar to work out distance to an object like bats or dolphins do. An excellent non-contact range detection with high accuracy and stable readings in an easy-to-use package, from 2cm to 400 cm or 1" to 13 feet is offered by it . From sunlight or black material like Sharp rangefinders are (although acoustically soft materials like cloth are often difficult to detect),its operation doesn't suffer. With ultrasonic transmitter and receiver module, it becomes complete.

For this module the system makes use of ultrasonic sensors attached to the front of the wheelchair and connected to the Arduino. These sensors successfully detect if there is an obstacle in the path of the wheelchair during navigation and also calculate the distance between the wheelchair and the object. They continuously send signals containing the distance to the Arduino. If the distance is less than the minimum distance threshold value then, emergency brake will be applied and the wheelchair will be stopped.

When this emergency brake occurs a message will be sent to the caretaker that an obstacle has been detected. For this purpose a Node MCU is connected to the Arduino. The code programmed in the Arduino IDE is uploaded into the Node MCU. The Node MCU in turn connects to the mobile phone of the caretaker. An open-source firmware which is known as NodeMCU , it is also the development kit that helps you to prototype or build IoT products. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is predicated on the ESP-12 module. The firmware uses the Lua scripting language. A low-cost Wi-Fi enabled microchip with full TCP/IP stack and microcontroller capability is called as the ESP8266. NodeMCU consists CPU core, faster Wi-Fi, more GPIOs, and supports Bluetooth 4.2, and low power Bluetooth.

We have used the telegram applications to send messages to the caretaker. Telegram, may be a cloud-based instant messaging and voice IP service. For Android, iOS, Windows Phone, Windows, macOS and Linux all the Telegram client apps are available. End users can communicate by sending messages and exchanging photos, videos, stickers, audio and files of any type. In this app we make use of one of its features called as BotFather. This feature is used to create new bot accounts and manage existing bot accounts. We make a personalized bot for the communication between the smart wheelchair and the caretaker. Bots are third-party applications that run inside Telegram. End users can communicate with bots by sending them messages, commands and inline requests. At the core, Telegram Bots are special accounts that don't require a further telephone number to line up.

In our proposed system the bots send the preprogrammed messages to the caretaker once the Eye directed smart wheelchair starts its operation and once there is an obstacle found in the disabled user’s pathway. This ensures that the caretaker is notified in case of an emergency or an accident and can always be prepared for the safety of the disabled user.

This is the basic implementation of the proposed system.

IV. RESULTS

A. *Result Screenshots*

The input and its corresponding images shown below are produced after using Haar cascade on input image for processing in OpenCV. The position of iris and pupil are going to be detected, and therefore the position of the image is detected and the decision for the given below input image are going to be produced as LEFT or RIGHT respectively. The obtained position is then transmitted to the Arduino which corresponding makes the wheelchair to move in left or right direction based on the received input, by controlling the rotation of the wheel. Thus making it rotate in different direction at the same time, which allows the wheelchair to steer left or right.

Fig.4.1. Screenshot of left eye movement

Fig. 4.2. Screenshot of right eye movement

The input and its corresponding images shown below are produced after using Haar cascade on input image for processing in OpenCV. The position of iris and pupil are going to be detected, and therefore the position of the image is detected and the decision for the given below input image are going to be produced as STRAIGHT or CLOSED respectively. The STRAIGHT signal corresponds to the forward movement of the wheelchair. Similarly CLOSED signal corresponds to stoppage of the wheelchair.

Fig.4.3. Screenshot of straight eye movement

Fig.4.4. Screenshot of closed eye movement

B. *Major Advantages*

1) Improves quality of life of patient.
2) Communicates with caretaker via messages.
3) Remotely controls other electrical appliances.
4) Wheelchair not only detects obstacles but also measures the distance between them, i.e. the wheelchair and the obstacle.

V. CONCLUSION

The concept of the eye controlled wheelchair is not only representing the alternative resources but more important to help physically disabled persons to make their life independent. The aim of implementing an autonomous eye controlled wheelchair is to spotlight the features of digital Image processing.

There are some real time design constants measured sort of a system takes a while(4second) to execute the system for processing the video in Real Time Environment. Therefore, the system performs the Wheelchair movement operation with some delay time. It's very hard to track the Eye pupil in dark light places, so the system works perfect on environmental light and in a room light with fluorescent mercury vapor lights, which is low in infrared.

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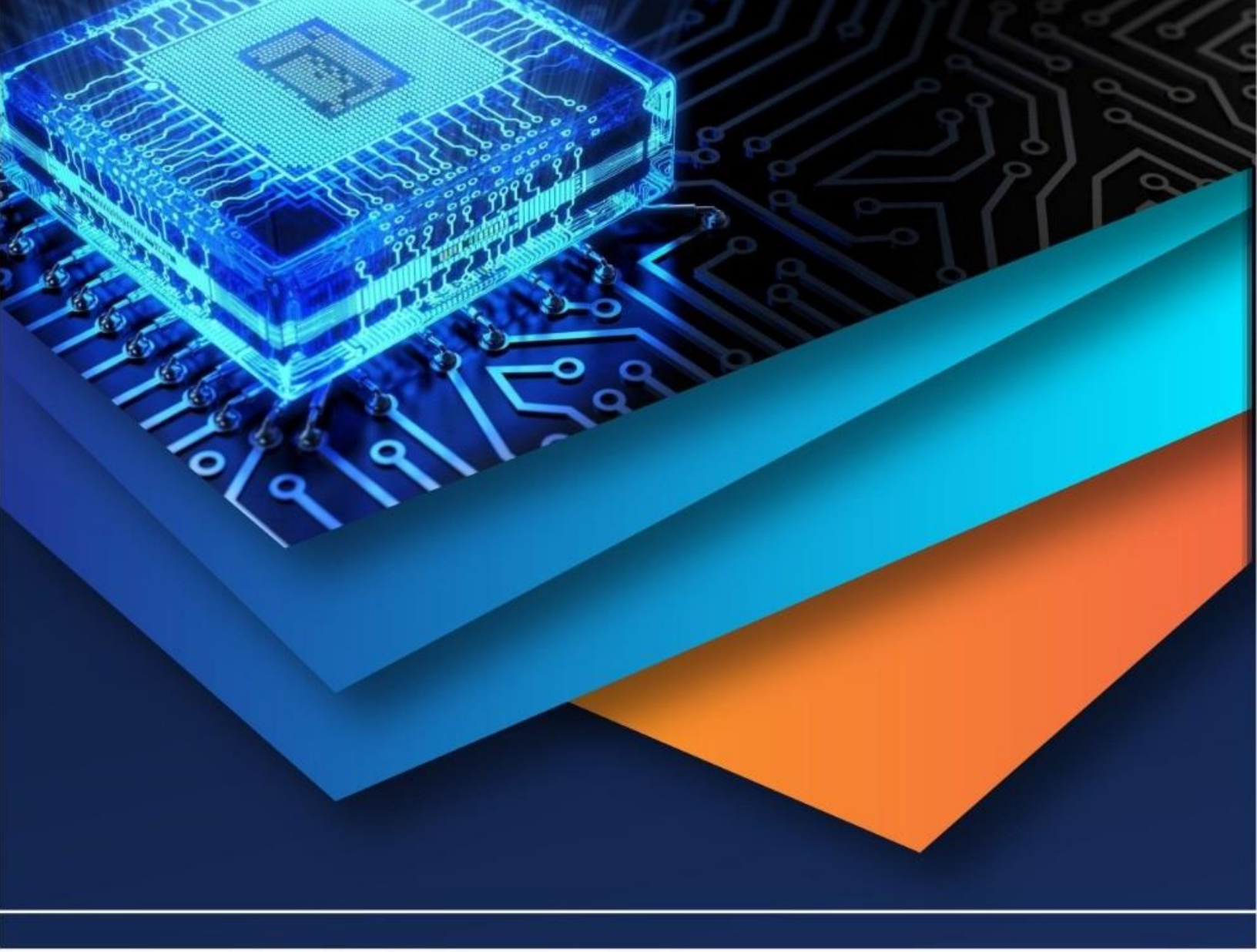

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