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Wi-Fi Pan Tilt Surveillance Camera Using ESP32

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Abstract: ***Surveillance Cameras are an integral part of today's modern security systems. There has been significant development in surveillance camera technology over the years, from fixed cameras to moving cameras, from single storage hub to remotely accessible camera using IoT (Internet of Things). This paper proposes further improvements in the field of compact remotely controlled movable cameras. This primarily focuses on increasing the compactness of the camera. Compact cameras are easier to hide, which makes them more useful as they go unnoticed to the harm causers. The proposed model can be set up easily anywhere without any expert knowledge and tools. This is a standalone model, meaning it can be set up anywhere without any other prerequisites. The only thing required is an electric source which can either be a battery or a direct supply. After powering up, it transmits the Wi-fi signals by itself. The data can also be stored on a memory card on the module itself. Only the Users connected to the password protected Wi-fi network of the module can access the video feed, control, and move the camera wirelessly on any device according to the requirement, ensuring secure feed. This has cross platform functionality, enabling it to be accessed from any platform and any device. This proposed model is also much cheaper than the current existing alternatives and can become more affordable when mass produced.***

Keywords: Security, Wireless surveillance, pan-tilt movement, cross platform operation, compact camera, IoT.

I. INTRODUCTION

It is not possible to keep a check on our homes and business places when we are away [1-2]. Monitoring altering information or behavior is what is meant by surveillance when it comes to protecting or influencing people. Electronic tools can be used for this [3]. The electronic machinery used in this project is an ESP 32 camera module. In public spaces around the world, surveillance cameras are being placed at an increasing rate. A surveillance camera is a piece of security equipment that documents human activity, such as those used to identify, stop, or investigate criminal activity or public safety threats. It safeguards the populace from danger and aids with criminal investigations [3]. Fixed surveillance cameras are conventional cameras that have been used since the birth of digital security systems. But being fixed, they pose a limitation wherein even the cameras having the widest angle can only capture a limited area. The conventional security systems are labor-intensive and have limited capabilities. [8]. To overcome this problem, cameras with pan and tilt ability came into existence. These kinds of cameras were not only capturing the video feed but also were able to rotate in X and Y axis, according to user and provide footage of the desired area whenever required.

The designed pan-tilt surveillance camera can be used to monitor any place where a conventional camera is used. It can be moved up and down as well as left and right as required by the user. On any platform, continuous monitoring is possible via a web browser. Security today is of utmost importance; hence surveillance is crucial. In this study, we proposed a portable camera that can move in any direction to record video.

The ESP 32 camera module is used as a surveillance camera. The web browser can be used to modify the view. The IP address generated by the ESP-32's Wi-Fi module can be used in any web browser to do live feeding. A webcam is built inside the system itself to record the movies. This lowers the price and complexity. The suggested mechanism is capable of semicircle motion. As a result, the system's cost is significantly reduced given that it uses a single web camera to cover a larger region. Traditional CCTV cameras have relatively limited application options because they are stationary, fixed, and only cover a very restricted region.

A. Role of Surveillance Cameras in Public Areas

Higher authorities use video evidence to identify criminals in crimes that occur in public places. If a person learned that there are surveillance cameras in the public area, he might decide against engaging in illicit conduct [3]. Monitoring is the process of keeping an eye on how information or behavioral patterns develop. gives one a feeling of security.

B. Importance of Surveillance Cameras at Workplace

Video surveillance in the workplace safeguards both the business and the employees. Putting in place a monitoring system both within and outside the company makes it easier to apprehend thieves who steal or damage company property. They will use the video footage to identify the perpetrator and further their investigation. [9].

C. Problems with Surveillance Systems

The surveillance system present today is costly as well as stationary. It records a specific area in its field of view. To capture another area, it needs to be adjusted to a different position. It can't record a wide range of area. Our designed system can overcome these issues and prove helpful in surveillance.

II. METHODOLOGY/EXPERIMENTAL

A. Synthesis/Algorithm/Design/Method)

The components are assembled including the ESP 32 cam module on pan tilt assembly.

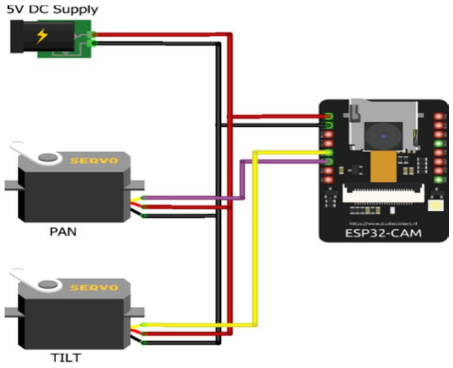

Fig. Circuit Diagram For making Connections.

- Camera control code is uploaded in ESP 32 using Arduino.
- ESP 32 module is attached on pan tilt assembly and power source is connected.
- The Wi-Fi is connected to the mobile and the camera control interface is accessed using the IP address.
- The camera starts working and can be controlled as required.

B. Components

1) ESP32 Module: This is the heart and brain of the whole project. It controls the servo motors, establishes connection between the control device and the camera system through Wi-Fi, and transmits camera feed.

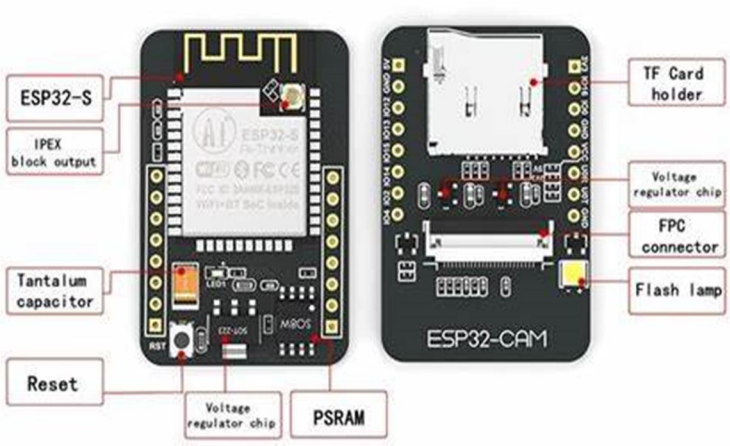

Fig. ESP-32 module

Module Model	ESP32-CAM
Package	DIP-16
Size	27*40.5*4.5 mm
SPI Flash	Default 32Mbit
RAM	520KB SRAM +4M PSRAM
Bluetooth	Bluetooth 4.2 BR/EDR and BLE standards
Wi-Fi	802.11 b/g/n/
Support interface	UART/SPI/I2C/PWM
Support TF card	Maximum support 4G
IO port	9
UART Baudrate	Default 115200 bps
Image Output Format	JPEG(OV2640 support only), BMP, GRAYSCALE
Spectrum Range	2412 ~2484MHz
Antenna	Onboard PCB antenna, gain 2dBi
Transmit Power	802.11b: 17±2 dBm (@11Mbps) 802.11g: 14±2 dBm (@54Mbps) 802.11n: 13±2 dBm (@MCS7)
Receiving Sensitivity	CCK, 1 Mbps: -90dBm CCK, 11 Mbps: -85dBm 6 Mbps (1/2 BPSK): -88dBm 54 Mbps (3/4 64-QAM): -70dBm MCS7 (65 Mbps, 72.2 Mbps): -67dBm
Power Dissipation	Deep-sleep: 6mA@5V Moderm-sleep: 20mA@5V Light-sleep: 6.7mA@5V
Security	WPA/WPA2/WPA2-Enterprise/WPS
Power Supply Range	5V
Operating Temperature	-20 °C ~ 85 °C
Storage Environment	-40 °C ~ 90 °C, < 90%RH
Weight	10g

[10]

2) *Arduino UNO:* Since ESP32 doesn't have any direct USB port, Arduino UNO is used for making and uploading code to the ESP32 cam module.

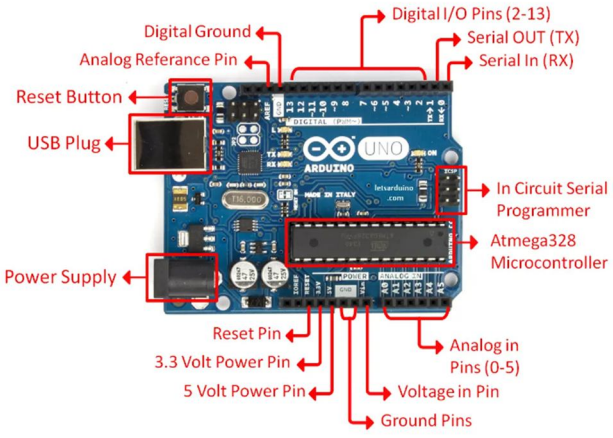

Fig. Arduino Uno

The following table has the specifications of Arduino Uno:

Microcontroller	ATmega328P – 8 bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB
Frequency (Clock Speed)	16 MHz

[11]

3) *Pan-Tilt servo assembly:* This is the skeleton of the whole model. It is a custom 3D printed component which accommodates the ESP32 Cam module and the servo motors together to make the whole model function.

Fig. Pan-Tilt Servo Assembly

4) *Servo Motors:* They are responsible for moving the whole assembly according to the instructions given. There are two motors in the whole assembly, one is responsible for the pan motion and the other is for the tilt motion. Both are controlled and coordinated by the ESP32 Cam module collectively.

Fig. Servo Motors

III. UNDERSTANDING WORKFLOW

The pan and tilt servo motors are assembled on the and connected to the ESP32 module.
ESP32 alone is sufficient in handling all the requests, including controlling of servos, receiving, and transmitting signals through Wi-fi for controlling of model, capturing, and transmitting real time camera feed.
After the code is uploaded to the ESP32, it will start transmitting a secure Wi-Fi connection signal which can only be accessed through password.
After connecting to the Wi-Fi network, user can access the device specific IP address through any device irrespective of any platform, directly through the browser.
The user will be able to observe the video feed and control the servos' pan and tilt motion after accessing the IP address.
For controlling and surveillance at night, the ESP32 module also has night vision capability which includes the built in flash, which can also be controlled in real time from the same screen that appears after accessing the IP Address.
The process of installation of the whole model is simple and the interface of the browser page is kept extremely user friendly.

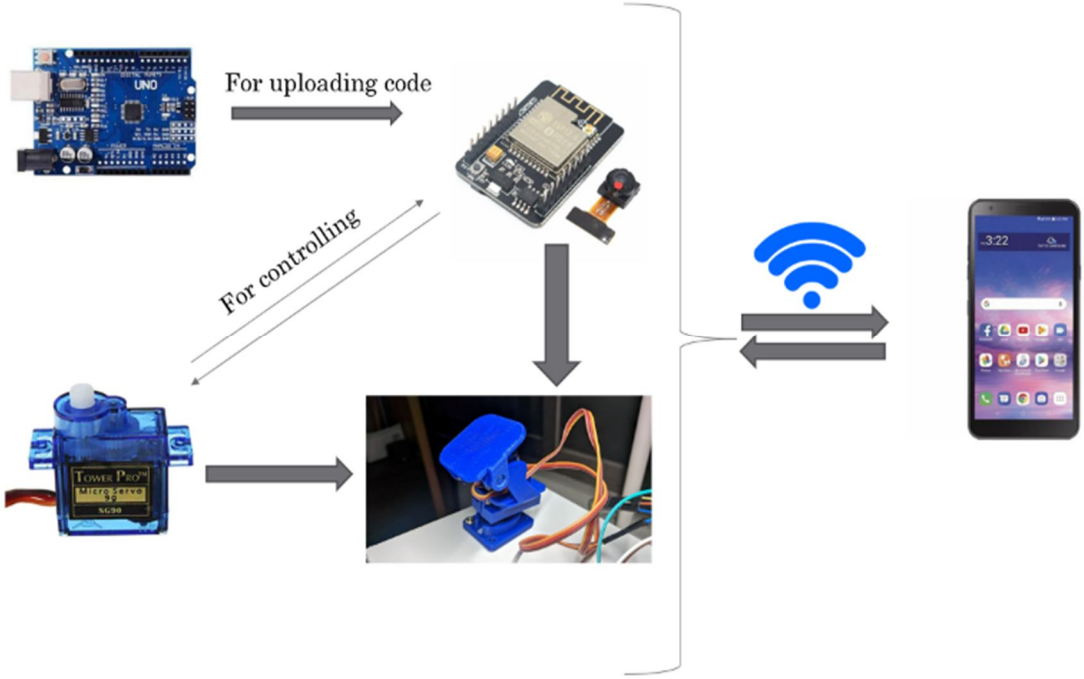

Fig. Working Flow of the Model

Camera Resolution = (Pixel Size Magnification) * 2.3
where 2.3 compensates for the Nyquist limit

IV. RESULTS AND DISCUSSIONS

A. *Results*

The Wi-Fi controlled pan-tilt camera system developed in this research paper was tested and evaluated for its performance. The following results were obtained:

1) *Wireless Communication:* The system was able to establish a wireless connection between the smartphone and the pan-tilt camera system using the ESP32 Wi-Fi module [4]. The communication between the two devices was found to be stable and reliable.
   Frame Size = Resolution * Colour Depth (Chrominance/Luminance information)
   Bit Rate = Frame Size * Frame Rate (fps)

2) *Movement Control:* The system was able to control the movement of the camera's pan-tilt mechanism using the smartphone. The movement was found to be accurate and responsive, with minimal lag or delay [5].
   The field of view (FOV) can be calculated using the following formula:
   W (horizontal width) = (distance) * 3.2 mm / (Lens Focal Length)
   where 3.2 mm is the horizontal size of 1/4″ CCTV sensor (4.8 mm for 1/3″ sensor).

3) *Real-time Monitoring:* The system provided real-time monitoring of the monitoring area, with the camera's video feed displayed on the smartphone. The video quality was found to be adequate for monitoring purposes.
   Camera Resolution = (Pixel Size Magnification) * 2.3
   where 2.3 compensates for the Nyquist limit

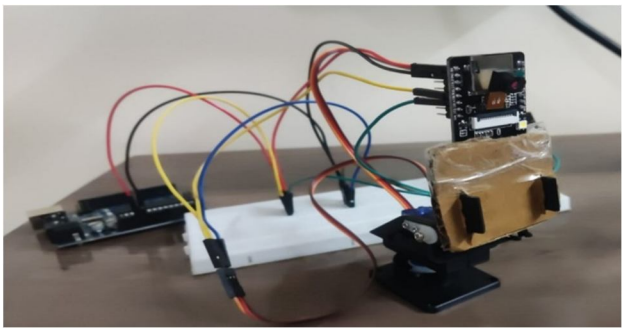

Fig. Proposed Model

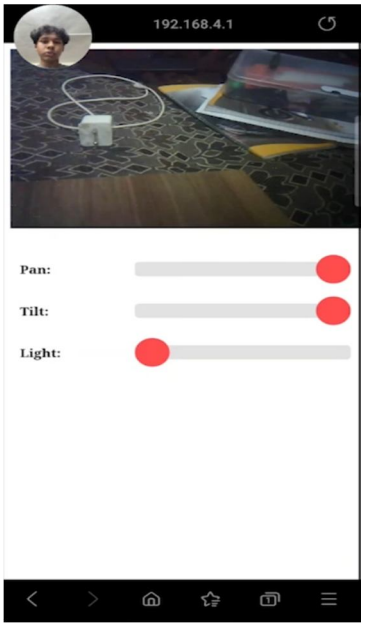

Fig. User Interface from a mobile device

B. Discussion

The Wi-Fi controlled pan-tilt camera system developed in this research paper provides a convenient and user-friendly interface for remotely controlling a pan-tilt camera system over a wireless network.

One of the strengths of the system is its mobility and ease of installation, as it does not require any wired connections. This makes it suitable for temporary monitoring applications, such as event monitoring.

One of the limitations of the system is the camera's resolution and field of view, which are limited by the camera used in this project.

Overall, the Wi-Fi controlled pan-tilt camera system developed in this research paper provides a solid foundation for future developments and improvements in the field of wireless monitoring systems.

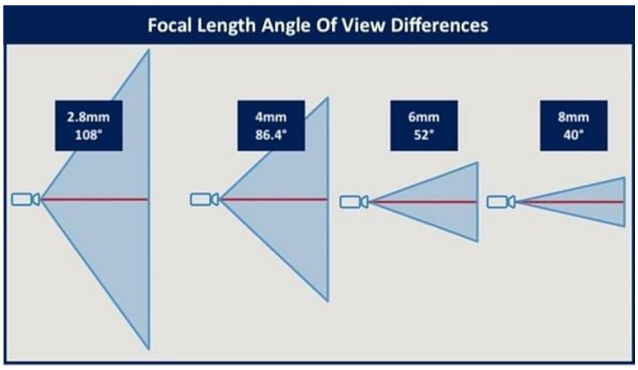

Fig. Conventional Fixed Cameras Range Capability

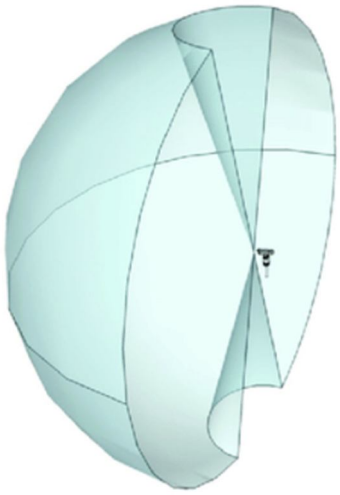

Fig. Pan Tilt Camera Range Capability

V. FUTURE SCOPE

The Wi-Fi Controlled Pan-Tilt Surveillance Camera has huge benefits in the commercial and scientific world.

Some of the major future scopes are -

1) Improvement in automation: By using artificial intelligence and machine learning this assembly is used to track or detect the motion of the objects like a person or vehicle.
2) Virtual reality: Wi-fi controlled pan-tilt surveillance cameras can be used to develop immersive virtual reality environments by using cameras of 360 degrees field off view.
3) Integration with smart home devices: This assembly will help to develop the security cameras working in automated manner.
4) And many more like improving the security, improving the video quality and low-light performance.

VI. CONCLUSION

In conclusion, the Wi-Fi-controlled pan-tilt camera is a valuable surveillance tool that provides users with enhanced control and convenience. The camera's ability to be remotely controlled using a Wi-Fi connection, combined with its pan and tilt capabilities and motion detection features, make it a popular choice for both personal and professional use. While the camera has its limitations, its various features and benefits make it an excellent investment for those who are looking to enhance their security and monitoring capabilities.

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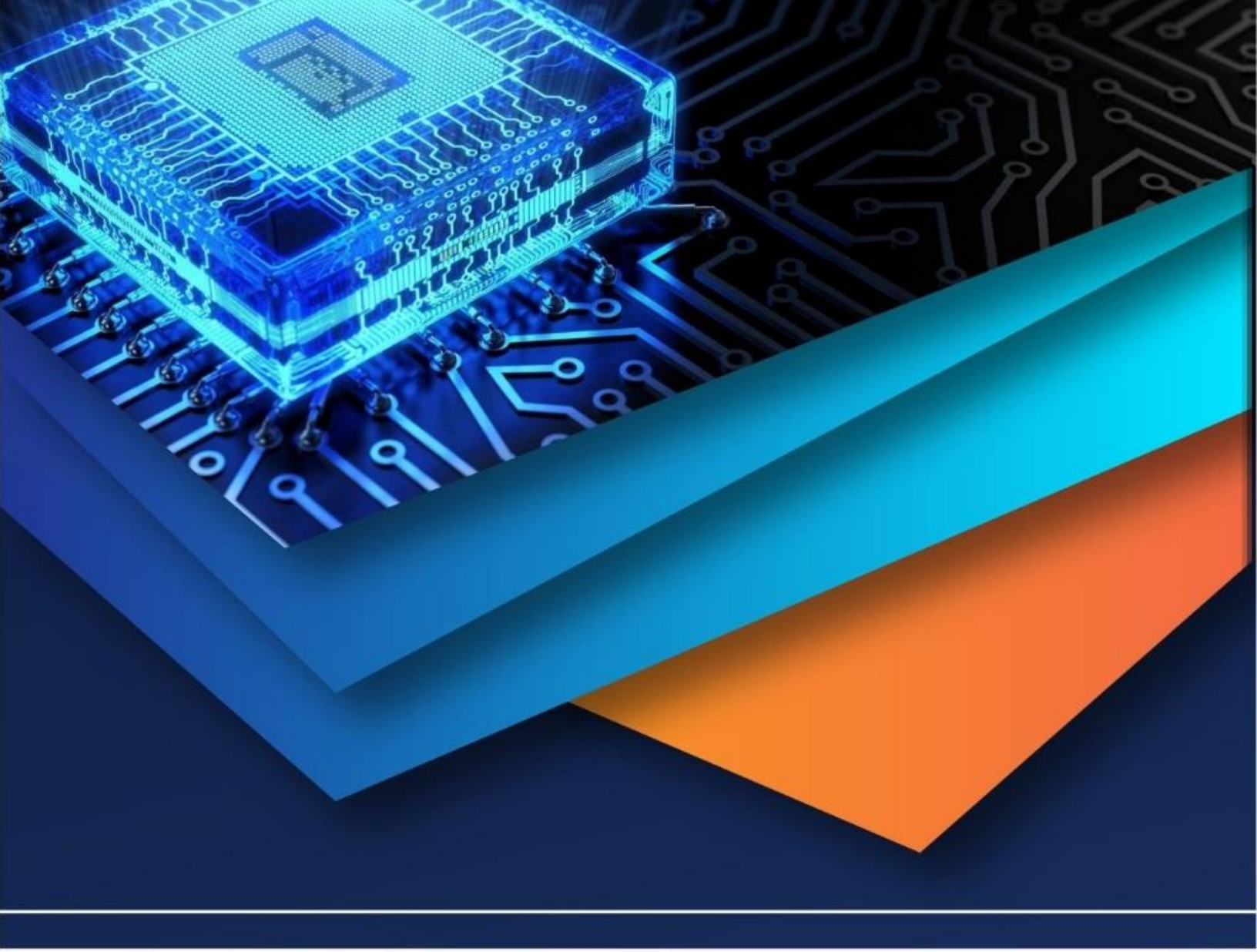

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