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Real-Time Sewage Manhole Monitoring System

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Abstract: ***Monitoring the sewage system is vital to maintain the cleanliness of the city. Because of the inconsistency of the sewerage system drains are clogged. Clogged sewers are the primary reasons for flooding and pollution in the sewer system. They might be involved in an accident if the workers do not know what is going on at the sewer hole. The manhole has been used as a point of contact for the sewer system. If a blockage is not cleared, water from the sewers flows through the manholes. As long as the blockage is not addressed, the water from the sewer flows through the manholes, raising the tempers of pedestrians and vehicle drivers. It's also dangerous to have tilted manhole covers, which can lead to accidents. To overcome these problems, the system is equipped with a wireless sensor. The proposed model includes a system to monitor water levels, atmospheric temperature, and pressure inside the manhole, to check whether the manhole lid is open or damaged, and to determine the level of harmful gases. It will send a WhatsApp alert to the connected mobile devices of authorized persons remotely located at work where levels are higher than a threshold. With the help of live video streaming, blockages can be monitored if they are encountered. The core of this system is an IoT-based, low-power portable device installed under the manhole cover. The system will benefit the public in addition to lowering the risk of accidental death for people who manually clean sewers.***

Keywords: Manhole, Sensors, Arduino UNO, Node MCU(micro-controller unit), ESP32-CAM, Whatsapp alert.

I. INTRODUCTION

A vital piece of any seepage framework is the passages into it with regard to cleaning, clearing, and review. Metropolitan urban communities have embraced the underground seepage framework and the' s city company should look after its neatness. On the off chance that the sewage upkeep isn't legitimate,groundwater gets tainted causing irresistible sicknesses. Blockages in channels during rainstorm season messes up the daily practice of general society. Subsequently, there ought to be an office in the city's enterprise, that cautions the authorities about blockages in sewers, their careful area, and furthermore if the sewer vent cover is open consequently.

Underground waste comprises of sewage framework, gas pipeline organization, water pipelines, and sewer vents. Temperature sensors are utilized to screen electric electrical cables that are introduced underground[2]. An integral part of any drainage system is the access points into it when it comes to cleaning, clearing, and inspection. Metropolitan cities have adopted underground drainage systems and the city's municipal corporation must maintain its cleanliness. If the sewage maintenance is not proper, groundwater gets contaminated causing infectious diseases. Blockages in drains during monsoon season cause problems in the routine of the public.

Hence, there should be a facility in the city's corporation, which alerts the officials about blockages in sewers, and their exact location. It mainly acknowledges the field of alerting the people about gas explosion, and increase in the water level and temperature level[1] It uses IoT to make the drainage monitoring system in a highly automotive environment by using sensors for detecting and sending alerts through WhatsApp to the authorities. So, the main focus of this project is to provide a system that monitors water level, atmospheric temperature, and toxic gases.

If drainage gets blocked and sewage water overflows, the manhole lid opens, it is sensed by the sensors, and this data is sent to authorized persons remotely located at work. Maintenance of manholes manually is tedious and dangerous due to the poor environmental conditions inside.

It is, therefore dangerous to go inside the manholes for inspection of their current state[2].To solve all the problems related to underground sanitation, a remote alarm system is necessary for transmitting data collected by the sensors set inside the manhole to the managing station, his includes components such as a controller, memory, transceiver, and battery to supply power[1]. Many variables such as humidity, temperature and generation of live videos were not considered.Using the latest design, the drawbacks of the current system will be addressed. In addition to the gas sensors, the humidity, and temperature sensors can aid in assessing the overall environment of the sewage. While assisting sewage employees to check blockage, there will be live video streaming[3].

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II. RELATED WORKS

A. *Respiratory Health Problems of Sewage Workers[4]*

It studies the presence of noxious gases of sewage and parts of it. Study shows that gases like H2S, NH3, NO2, SO2, and HCHO are the primary gases present in high amounts which lead to several respiratory problems in sewage workers working in Primary settling tanks, Screening tanks, Aeration tanks and Mechanical de-watering of the sludge. Workers face general manifestations to acute respiratory manifestations which include problems like Headache, Dizziness, Fatigue, Dry cough, Chest tightness, Acute bronchitis etc. However, no solution has been proposed or implemented to tackle this issue.

B. *IoT Sewage Gas Monitoring and Alert System Sewage regions Arduino Uno, Methane Gas Sensor[5]*

This has proposed a system to measure the ppm levels of gases only. Although, their system does not take into account that temperature and humidity also play a major role in wellness of sewage workers on duty. Detection of blockages in advance is another necessity which has not been addressed in this system.

C. *Sewage Level Maintenance Using IoT[6]*

The system design includes a sensor that detects sewage level, a controller to order, a communication network that records complaints about continuous rise in sewage level, and if any, blockages. To record the data a database must be maintained. The system generates warning signals prior to overflow by means of complaints to the specified departments via mail and SMS.

D. *Automated Internet of Things For Underground Drainage and Manhole Monitoring Systems For Metropolitan Cities[7]*

This paper describes a Underground Drainage and Manhole Monitoring System (UDMS) adapting and design feature for IoT applications. The proposed model provides a framework for monitoring inside a manhole the water level and atmospheric temperature and pressure and for testing whether a manhole lid is open. It also controls electrical power lines installed underground. UDMS can remotely track the current state of the manholes in real time.

E. *Underground Drainage Monitoring System Using IoT[8]*

Development and implementation of a network that regulates sewer conditions and provides a means to maintain and control the underground infrastructure using methodical approaches. The model proposed consists of a wide range of complex components which require routine maintenance and observation. The current system lacks a specified network for the simultaneous management of multiple types of sensors. In such a scenario the risk of failure is possible.

III. PROPOSED METHODOLOGY

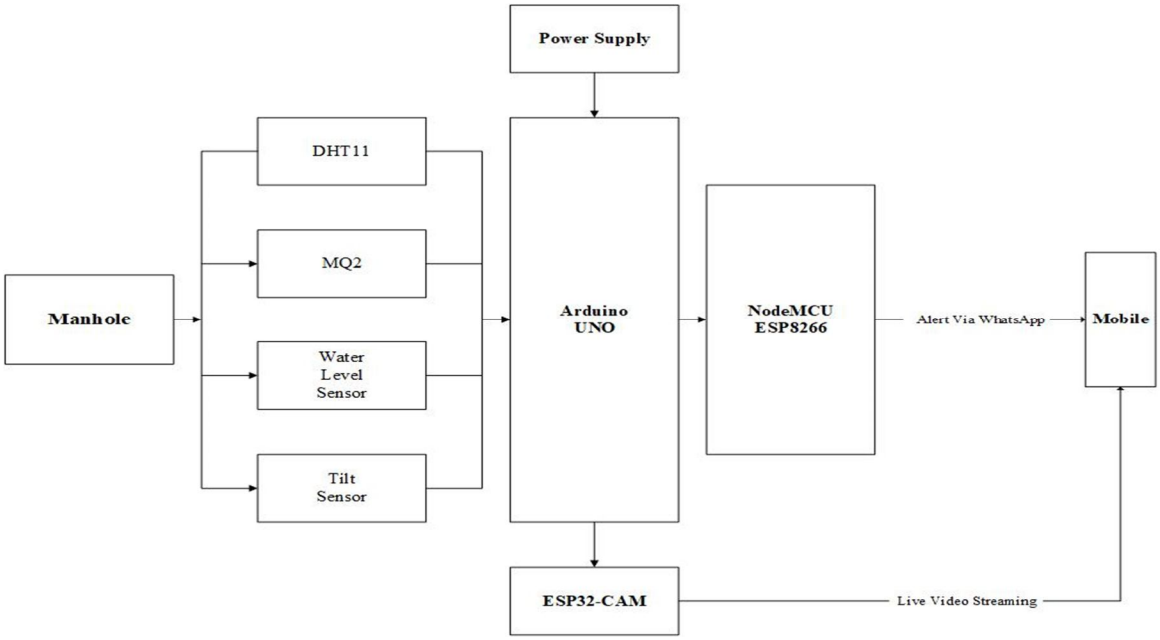

Figure 1 Proposed System Architecture

Fig 1 shows the real-time sewage manhole monitoring system is designed to keep track of important information inside the manhole to ensure safety and efficient management. It uses various sensors like the DHT11 (for temperature and humidity), water level sensor, MQ2 gas sensor (to detect harmful gases), and a tilt sensor (to check for unauthorized access). These sensors collect data, which is then processed by an Arduino Uno, acting as the brain of the system. The NodeMCU facilitates data transmission to a cloud platform or web server, allowing remote monitoring from anywhere. Additionally, the system has an ESP32-CAM equipped with a camera to provide live video streaming from inside the manhole. In case of any critical event, the system sends alerts through WhatsApp using the callmebot API. This setup ensures that authorities or relevant personnel are quickly notified of any issues, and the stored data helps in tracking historical patterns and making informed decisions about sewage management.

A. MQ2 Gas Sensor

The MQ2 gas sensor is a widely used gas sensor module that can detect a variety of flammable gases, smoke, and harmful gases in the air. It is commonly used in gas leak detection systems, fire alarms, smoke detectors, and air quality monitoring applications. The MQ2 sensor can detect gases such as methane, propane, butane, LPG, smoke, alcohol, hydrogen, and other volatile organic compounds (VOCs).

Figure 2 MQ2 Gas Sensor

Specifications:
Operating voltage- 5V
Load resistance - 20KΩ
Heater resistance - 33Ω ± 5%
Heating consumption - <800mw
Sensing Resistance - 10 KΩ – 60 KΩ
Concentration Range - 200 – 10000ppm
Preheat Time - Over 24 hours

B. DHT11 Sensor

The DHT11 sensor is a basic and popular digital temperature and humidity sensor module used in various electronics projects and applications. It provides a simple and affordable solution for measuring temperature and relative humidity in the air.

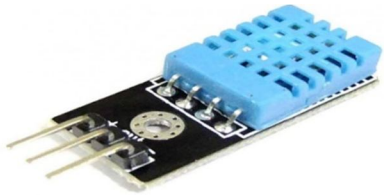

Figure 3 DHT11 Sensor

Specifications:
Temperature Range: 0°C to 50°C (32°F to 122°F)
Temperature Accuracy: ±2°C
Humidity Range: 20% to 90% Relative Humidity (RH)
Humidity Accuracy: ±5% RH
Operating Voltage: 3. 3V to 5. 5V DC
Output: Digital data in 40-bit binary format
Response Time: 2 seconds for temperature and humidity readings
Sampling Rate: 1 reading per second
Dimensions: Approximately 15. 5mm x 12mm x 5. 5mm (L x W x H)

C. Water Level Sensor

Water Level sensors detect the level of water and other fluids and fluidized solids, including slurries, granular materials, and powders that exhibit an upper free surface. Substances that flow become essentially horizontal in their containers (or other physical boundaries) because of gravity whereas most bulk solids pile at an angle of repose to a peak. The substance to be measured can be inside a container or can be in its natural form (e. g., a river or a lake). The level measurement can be either continuous or point values. Continuous-level sensors measure the level within a specified range and determine the exact amount of substance in a certain place, while point-level sensors only indicate whether the substance is above or below the sensing point. Generally, the latter detects levels that are excessively high or low.

Figure 4 Water level sensor(Robodo SEN18)

D. Tilt Sensor

A tilt sensor, also known as a tilt switch or inclinometer, is a simple electronic device that can detect changes in orientation or tilt. It works by changing its state when the sensor is tilted beyond a certain angle threshold. Tilt sensors are commonly used in various applications to trigger actions or events based on changes in orientation.

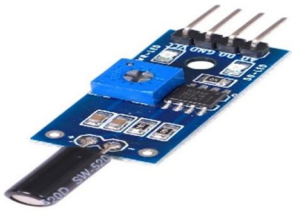

Figure 5 Tilt sensor

E. Arduino Uno

The Arduino Uno is a widely used microcontroller board based on the ATmega328P microcontroller. It is the most popular board in the Arduino family and is often used in various electronics projects and prototyping.

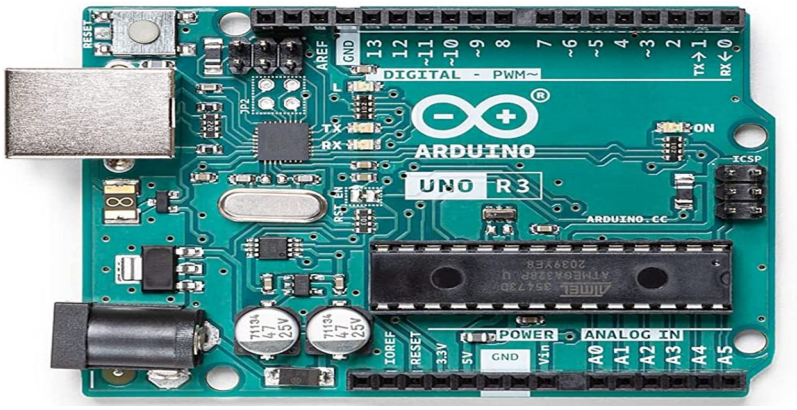

Figure 6 Arduino UNO

The major components of the Arduino UNO board are the following:

1) Microcontroller: ATmega328P running at 16MHz (with an external crystal oscillator).
2) Digital I/O Pins: 14 digital input/output pins, which can be configured as either inputs or outputs.
3) Analog Input Pins: 6 analog input pins, marked as A0 to A5.
4) PWM (Pulse Width Modulation) Pins: 6 of the digital pins can be used for PWM output.

5) UART (Universal Asynchronous Receiver/Transmitter): Allows serial communication with other devices like a computer or other microcontrollers.
6) I2C (Inter-Integrated Circuit) and SPI (Serial Peripheral Interface) Interfaces: For communication with other devices like sensors, displays, or other microcontrollers.
7) USB Interface: Used for programming the board and serial communication with a computer.
8) Reset Button: To restart the program execution or reset the board.
9) Power Jack: To supply external power to the board (typically 7-12V DC).
10) Operating Voltage: 5V (can be powered from USB or external power supply).

a) Specifications

Flash Memory:32KB (of which 0. 5KB is used for the bootloader).
SRAM:2KB
EEPROM:1KB

b) Programming

The Arduino Uno can be programmed using the Arduino IDE (Integrated Development Environment) using the C/C++-based Arduino programming language. It is straightforward to use, even for beginners, and has a vast community and libraries of pre-written code to support various sensors, modules, and functionalities.

F. NodeMCU- ESP8266

NodeMCU ESP8266 is an open-source development board based on the ESP8266 Wi-Fi chip. The ESP8266 is a popular and cost-effective Wi-Fi module that enables microcontrollers to connect to Wi-Fi networks and communicate with other devices or servers over the internet. NodeMCU provides an easy-to-use platform for programming and interacting with the ESP8266, making it a popular choice for IoT (Internet of Things) projects is a small and affordable electronic board that allows you to connect things (like sensors and actuators) to the internet wirelessly You can program NodeMCU to do various tasks using either the Lua scripting language or the Arduino programming language, which is quite popular and easy to learn.

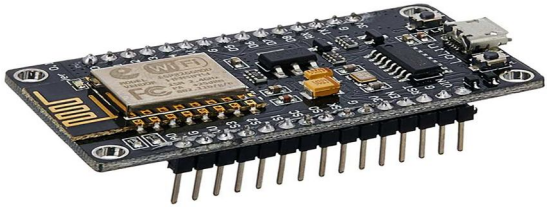

Figure 7 NodeMCU- ESP8266

G. ESP32-CAM

The ESP32-CAM is a popular development board based on the ESP32 microcontroller and features a camera module. It's designed for projects that require image and video capabilities in addition to Wi-Fi and Bluetooth connectivity.

Figure 8 ESP32-CAM

IV. IMPLEMENTATION

Connect the sensors (DHT11, Water Level, MQ2 Gas, Tilt) to the Arduino Uno. Power all the sensors using the power supply. Set up the NodeMCU to receive data from the Arduino Uno. Program the Arduino Uno to read data from the sensors periodically. Send the sensor data from the Arduino Uno to the NodeMCU via serial communication.

Configure the NodeMCU to check the sensor data for abnormal readings. If any sensor data exceeds safe thresholds, trigger a WhatsApp alert using the callmebot API. Connect the ESP32-CAM to the NodeMCU for live video streaming. Capture live video using the ESP32-CAM and transmit it to the NodeMCU. Incorporate the live video stream in the WhatsApp alert, if needed. House all components in a suitable enclosure, ensuring protection from the environment. Install the system in the sewage manhole, positioning sensors correctly. Implement power management to prolong battery life if using batteries. Regularly maintain the system and check for any issues.

Figure 8 Flow Diagram

V. EXPERIMENTAL PROCEDURE FOR SETUP AND TESTING

Gather the following components: DHT11 Sensor (temperature and humidity), Water Level Sensor, MQ2 Gas Sensor (detects harmful gases), Tilt Sensor (monitors manhole cover status), Arduino Uno, Power Supply, NodeMCU (for local network communication), ESP32-CAM (for live video streaming), and WhatsApp Alert API (for notifications).

A. Sensor Interfacing

Connect the DHT11 sensor, Water Level Sensor, MQ2 Gas Sensor, and Tilt Sensor to the Arduino Uno using appropriate connections.Program the Arduino Uno to read data from these sensors at regular intervals.

B. Data Transmission

Connect the NodeMCU ESP8266 to the Arduino Uno using serial communication (TX and RX pins). Program the NodeMCU to receive sensor data from the Arduino Uno. Use Wi-Fi connectivity on the NodeMCU to connect to your local Wi-Fi network.

C. Live Video Streaming

Set up the ESP32-CAM to capture live video footage from the manhole. Stream the video using the ESP32-CAM's Wi-Fi capabilities.

D. WhatsApp Alert Integration

Create a WhatsApp account for the manhole monitoring system.Sign up for the "callmebot" API service, which allows sending WhatsApp messages programmatically.

E. Alert Triggering

Set up a threshold value for each sensor, based on which an alert should be triggered (e.g., temperature too high, water level too low, gas concentration too high,etc.Continuously monitor the sensor data received on the NodeMCU, comparing it to the predefined threshold values. When any sensor value exceeds the threshold, trigger an alert message using the "callmebot" API, including relevant sensor data and a link to the live video stream.

F. Smartphone Setup

Install WhatsApp on the smartphone that will receive the alerts. Make sure the smartphone is connected to the internet.

G. Test and Monitor

Deploy the complete system near the manhole, ensuring all components are adequately protected from environmental factors. Test the system thoroughly by simulating different scenarios and checking if alerts are sent correctly. Monitor the system's performance regularly to ensure it functions as expected.

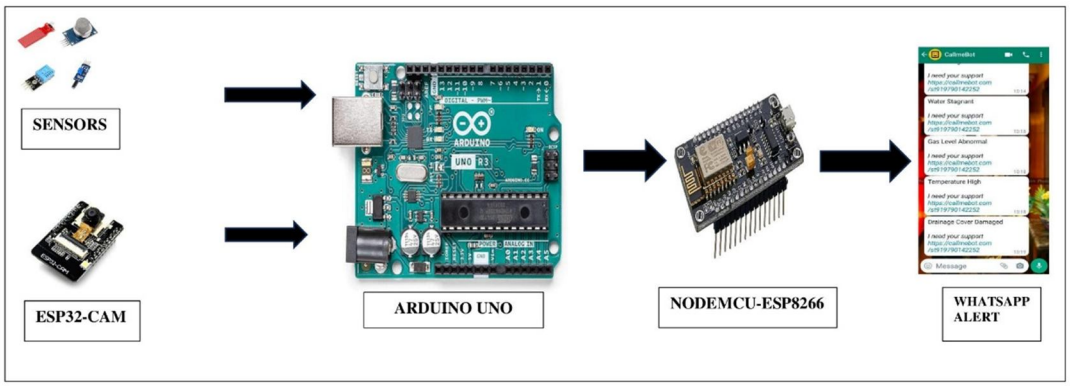

Figure 9 Workflow diagram

VI. RESULTS

A. WhatsApp Alert

When the real-time sewage manhole monitoring system detects any abnormal conditions, such as high gas levels, water overflow, or unusual tilting of the manhole cover, it triggers a WhatsApp alert. The alert message sent to the specified WhatsApp number, enabling the concerned authorities or maintenance personnel to receive real-time updates about the manhole's condition and take immediate action.

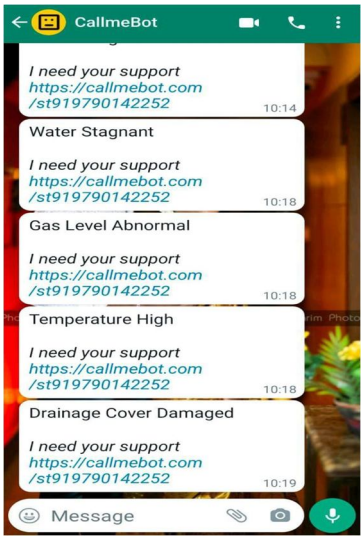

Figure 10 WhatsApp Alert

B. Live Video Stream

In addition to the WhatsApp alert, the real-time sewage manhole monitoring system also offers a live video stream. By visiting a specific web address from any device connected to the same Wi-Fi network, authorized personnel can access the live video feed from the ESP32-CAM. The live video stream allows them to visually inspect the manhole in real-time. They can observe the actual condition inside the manhole, check for blockages, flooding, or any other potential hazards. This visual feedback assists in making informed decisions and determining the necessary actions promptly.

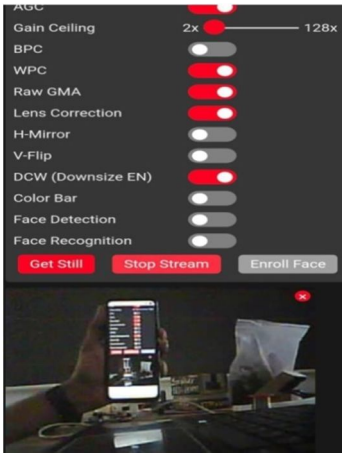

Figure 11 Live Video Streaming

VII. CONCLUSION

Underground monitoring is a difficult task. This project suggests many strategies for monitoring and maintaining an underground drainage system. It describes numerous applications. Various applications such as subsurface drainage and real-time manhole identification are explained. Various parameters such as temperature, toxic gases, flow, and water level are monitored and updated via the Internet of Things. This enables the person in charge to take the necessary measures. In this way, unnecessary trips to the manholes are saved and can be carried out only when needed. In addition, the real-time update on the Internet helps maintain the regularity of wastewater control, avoiding hazards. The combination of the WhatsApp alert and live video stream empowers the maintenance team or responsible authorities to respond proactively to any emergencies, swiftly address issues, and ensure the safety and proper functioning of the sewage system.

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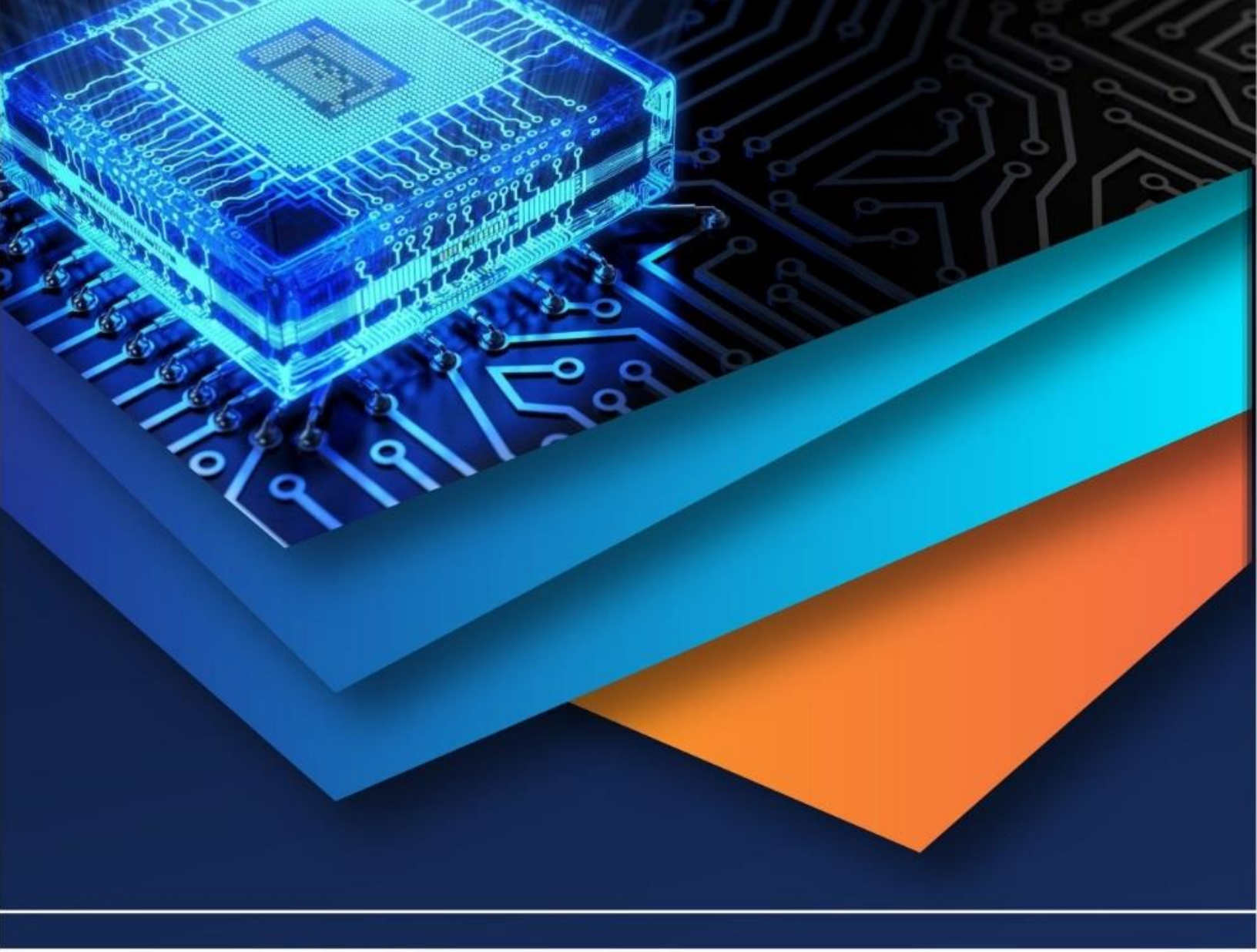

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