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Air-Pollution Monitoring using IoT

Shashwat Negi
School of Computer Science and Engineering, B. Tech in Computer Science, VIT-Vellore, Vellore, India

Abstract: ***The level of pollution has increased due to a lot of factors like the increase in population, commercial vehicles, industrialization and stubble burning which has caused harmful effects on human wellbeing by directly affecting health of population exposed to it. The worst affected by this are the individuals, like traffic police officers, who are required to stay outside breathing the toxic gases and bearing the strong heat to maintain a constant traffic flow and order in society. Studies and surveys show that they suffer from respiratory diseases, photo sensitivity, skin infections, nausea, high blood pressure and many other problems.***

This research paper presents an innovative way to monitor real-time air quality and collect data to provide insights to local authorities. The 'Air Pollution Monitoring System' using Internet of Things will monitor the air quality over a web server using cloud technology and will trigger a alarm when the air quality goes beyond a certain level, meaning there are dangerous amount of harmful gases present in the air like CO2, CO, particulate matter, alcohol, benzene and NH3.Governments and citizens are looking for scientific intellect to challenge the common threat of pollution in its many procedures. Currently mobile apps are capable of accomplishing functions like reporting status of air quality, air quality forecasts, air quality monitoring in a particular area, and risks highlighting. But these applications do not provide the user with data of a local area, where the user is currently located, which will be more beneficial for an individual.

Index Terms: Internet of Things (IOT), Data Analytics, NodeMCU, ESP8266, ThingSpeak Cloud

I. INTRODUCTION

One of the basic requirements of human health and well- being is clean air. However, the World Health Organization (WHO) estimates that around 1.4 billion urban residents worldwide are living in areas with air pollution above recommended air quality guidelines, and reports that air pollution kills about 7 million people a year.

Chronic exposure to air pollution increases the risk of cardiovascular and respiratory mortality and morbidity, while acute short-term inhalation of pollutants can induce changes in lung function and the cardiovascular system exacerbating existing conditions such as asthma and ischemic heart disease. Monitoring and controlling air pollution is high on the public consciousness in both developing and developed countries.

Several governments operate air quality monitoring stations and publish the data. These stations are generally outfitted with several high-quality monitoring devices that can measure a wide range of air pollutants (such as CO, NOx, SO2, ozone, particulate matter, etc.).

However, the high costs of installing and maintaining these sites limits their number.

Existing monitoring systems are highly immobile and are incapable of identifying the source of pollution. Therefore, improved monitoring systems is needed.

To overcome the problems of existing systems, we will develop an economical and portable air pollution monitoring system that can provide on-demand monitoring of concerned area like traffic congested areas. An IoT kit was prepared using gas sensors, Arduino IDE (Integrated Development Environment), Wi-Fi module and Thinkspeak cloud service. This kit can be placed physically in various cities to monitoring air pollution. The gas sensors gather data from air and forwards the data to the Arduino IDE. The Arduino IDE transmits the data to the cloud via the Wi-Fi module for analysis and notification.

II. METHODOLOGY

The paper discusses methods to notify local authorities or traffic policemen about the air quality of a particular area. The paper proposes a smart city product will can raise public awareness about the ever-increasing pollution.

NodeMCU having an added advantage to the Arduino Uno is the Wi-Fi Capability can be used to connect to the internet. Conducting research and experiments to threshold value is determined beyond which the air quality is unhealthy. The proposed system follows in the below Fig 1 workflow.

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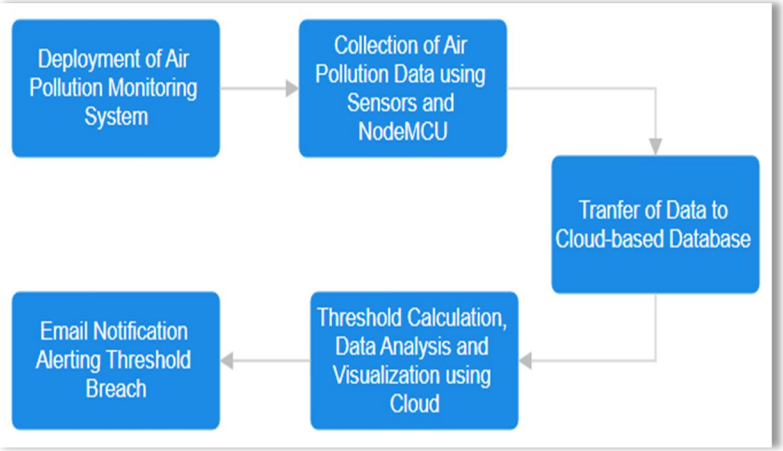

Figure 1. Proposed Workflow

System collects and collates air pollution data obtained from personal sensing units, and the greater spatial density of data thus obtained from many users in turn gives each user more accurate estimates of their pollution exposure.
System determines the threshold and alerts to the user on breach.
Using equation for AQI:

$$\mathbf{Ip = [IHi – ILo / BPHi – BPLo] (Cp – BPLo) + ILo}$$

Where Cp = truncated concentration of pollutant p
BPHi = concentration breakpoint upper limit
BPLo = concentration breakpoint lower limit
IHi = AQI value corresponding to BPHi
ILo = AQI value corresponding to BPLo
The AQI is calculated after 16 hours of data collection for 3 different pollutants (CO, NH3 and NO2)

III. LITERATURE SURVEY

In the paper [1] authors give us insight on methods of bringing the air pollution level back to the bottom. The paper discusses a novel method of purifying air using distilled water without the use of any synthetic material or chemical substance.
Some previous works like Smart environment monitoring system [2] on vehicles was introduced in 2015. The paper proposed a system consisting of sensors that acquired data from cameras as well as from Light Detection and Recognition (LIDAR) instruments.
The data collected, analyzed and merged to determine the degree of air pollution and fog. The authors of the paper [3] had utilized machine learning algorithms to build an accurate forecasting model for concentration of ground -level ozone(O3), nitrogen dioxide (NO2) and sulfur dioxide (S02).
The paper [4] proposes a novel multi-pollutant monitoring wearable using low-cost gas sensors. The device acts as a personalized heath advice and assistance application providing user with real-time air pollution sensing.
The paper [5] investigated the key issues of a real-time pollution monitoring system, including the sensers, Internet of Things communication protocols, and acquisition and transmission of data while ensuring data security and consistency. The paper addresses the IOT security challenges within the communication channels between IoT gateway and the cloud infrastructure.
By reviewing the current research, which has done thoroughly, we can say that air pollution has increased by an alarming rate. If it is not stopped immediately the whole world is going to face the filthy and extreme weather in the future. There are more forms of pollutions for instance water pollution, noise pollution, plastic pollution, soil contamination but from the studies we can say that air pollution is the most alarming issue, and this should be acted upon for the sake of saving the world.

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IV. COMPONENTS USED

A. *Hardware*

1) *NodeMCU :* NodeMCU is an open-source LUA basedfirmware developed for ESP8266 Wi-Fi chip. By utilizing functionality of ESP8266 chip, NodeMCU firmware comes with ESP8266 Development board/kit that offers a low-cost, compact, and easy-to-program solution for adding Wi-Fi connectivity to various projects.

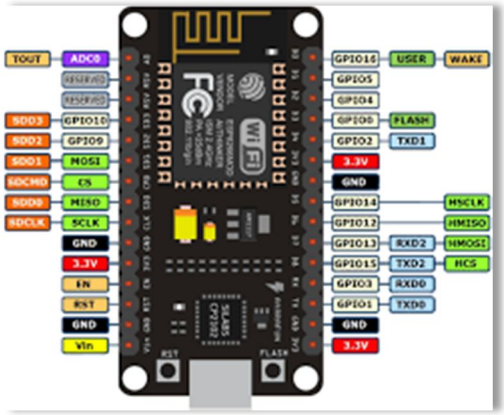

Figure 2. NodeMCU Circuit Diagram

2) *MQ-135 Gas Sensor:* The MQ-135 Gas sensors are used in air quality control equipment's and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, CO2. The MQ-135 sensor module comes with a Digital Pin which makes this sensor to operate even without a microcontroller and that comesin handy when trying to detect one particular gas.

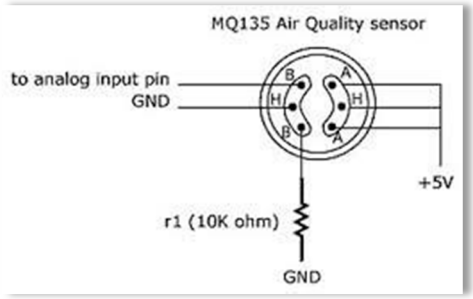

Figure 3. MQ-135 sensor

3) *DHT 11:* The DHT11 is a commonly used Temperature and humidity sensor. The sensor comes with a dedicated NTC to measure temperature and an 8-bit microcontroller to output the values oftemperature and humidity as serial data. The sensor is also factory calibrated and hence easy to interface with other microcontrollers.

4) *MQ3 Sensor:* The Grove - Gas Sensor (MQ3) module is useful for gas leakagedetection (in home and industry). It is suitable for detecting Alcohol, Benzene, CH4, Hexane, LPG, CO. Due to its high sensitivity and fast response time, measurements can be taken as soon as possible. The sensitivity of the sensor can be adjusted by using the potentiometer.

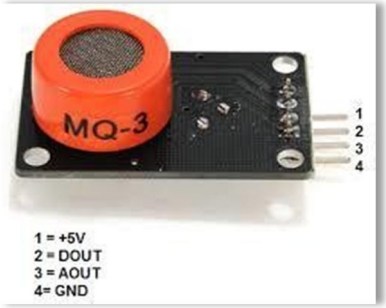

Figure 4. MQ-3 Sensor

5) *LED:* A light-emitting diode (LED) is a semiconductor light source that emits light when current flows throughit. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of thelight (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor.

B. Software

1) *Arduino IDE:* The Arduino board is connected to a computer via USB, where it connects with the Arduino development environment (IDE). The user writes the Arduino code in the IDE, then uploads it to the microcontroller which executes the code, interacting with inputs and outputs such as sensors, motors, and lights.
2) *Thing-Speak*: Thing-Speak is an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. Thing-Speak allows user to perform online analysis and processing of the data as it comes in.
3) *Blynk App:* Blynk is an IoT platform builder for mobile applications to control Arduino, Raspberry Pi and NodeMCU over the Internet. It's a simple and powerful platform for deploying and managing connected electronic devices at any scale.

V. PROPOSED ALGORITHM

The algorithm for the air pollution monitoring system involves three main phases:

1) *Phase 1:* Detection of the concentration of air pollutants in interest via sensors. Sensor measures the key pollutants such as CO, NO2, NH3 and Temperature and humidity.
2) *Phase 2:* Connect to internet via the esp8266 module and transfer the data to cloud database. Conducting research determine the conditions for unhealthy air quality and alerting the user.
3) *Phase 3:* User-friendly and portable interface – a web application, which the user can use to know the pollution level in their area. Utilize third-party software like Blynk app, for instant result and email-based notification possible.

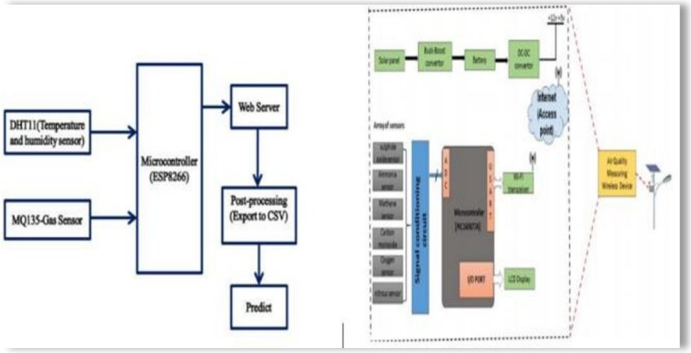

Figure 5 High Level Architecture

A. Threshold Value

The AQI is an index for reporting daily air quality. It tells youhow clean or unhealthy your air is, and what associated healtheffects might be a concern. The AQI focuses on health affects you may experience within a few hours or days after breathingunhealthy air. The higher the AQI value, the greater the level of air pollutionand the greater the health concern. For example, an AQI valueof 50 represents good air quality with little or no potential to affect public health, while an AQI value over 300 represents air quality so hazardous that everyone may experience seriouseffects.

Air Quality Index (AQI) Values	Levels of Health Concern	Colors
When the AQI is in this range:	*...air quality conditions are:*	*...as symbolized by this color:*
0 - 50	Good	Green
51 - 100	Moderate	Yellow
101 - 150	Unhealthy for Sensitive Groups	Orange
151 - 200	Unhealthy	Red
201 - 300	Very Unhealthy	Purple
301 - 500	Hazardous	Maroon

Figure 6. AQI Classification

The AQI is calculated and reported by monitoring record concentrations of the major pollutants at more than a thousandlocations across the country. These raw measurements are converted into a separate AQI value for each pollutant (ground-level ozone, particle pollution, carbon monoxide, andsulfur dioxide) using standard formulas developed by EPA.

VI. EXISTING METHODS

The existing monitoring and sensing system receive, store thedata, preprocess, and convert the data into useful information. Using the sensors such as MQ7 (CO detector), MQ9, MQ135(Air Quality detector), MQ3(Alcohol and Smoke detector) and Arduino Uno. But the information cannot be monitored by a person far away from the sensor.

Wi-Fi module ESP 8266 which gives the system access to the internet. Being very cheap it makes the project more powerful. It can be used to send the data to the cloud like ThinkSpeak onwhich the user can perform various analytics.

VII. IMPLEMENTATION

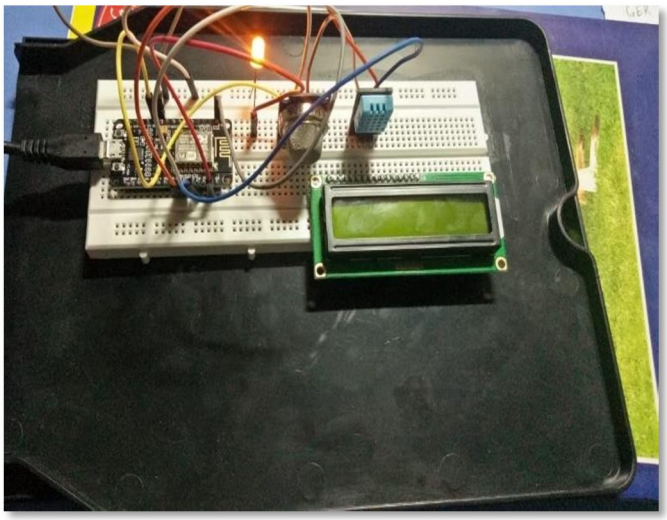

Figure 7. Hardware Connection

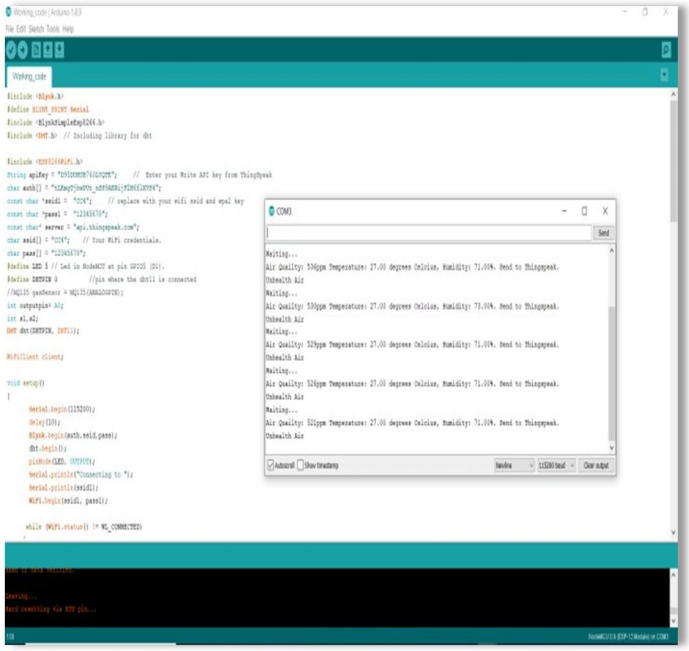

Figure 8 Serial Monitor

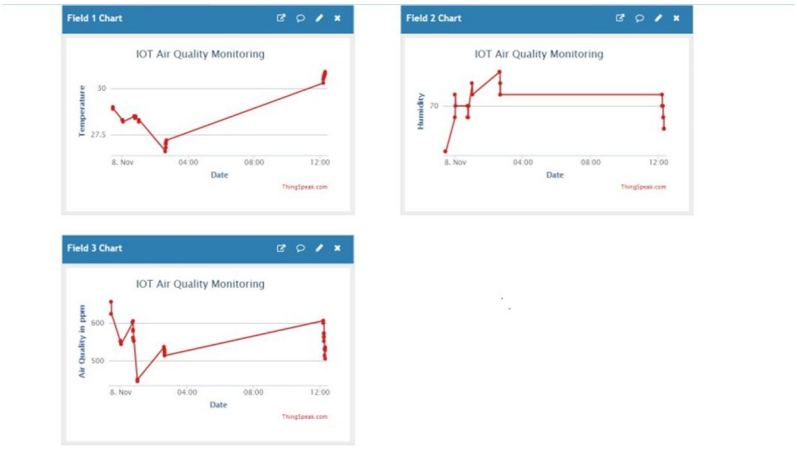

Figure 9 Data Visualization

The Field 1 measures the change in temperature against time.
The Field 2 measures the change in CO pollutant concentration against time.
The Field 3 measures the change in Air Quality Index (AQI) value against time.
All the three parameters are taken into consideration to determine the overall quality of air.

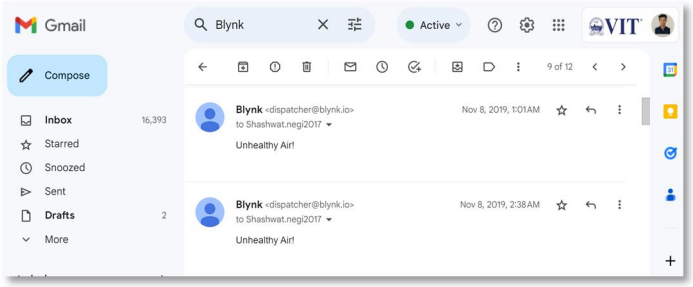

Figure 10 Email Notification on Threshold Breach

VIII. CONCLUSION

This research proposed a smart air pollution monitoring system that constantly keeps track of air quality in an area and displays the air quality measured on an LCD screen. It also sends data measured to the 'ThingSpeak' cloud platform. The system provides insights and helps to create awareness of the quality of air that one breathes daily. This monitoring device can deliver real-time measurements of air quality.

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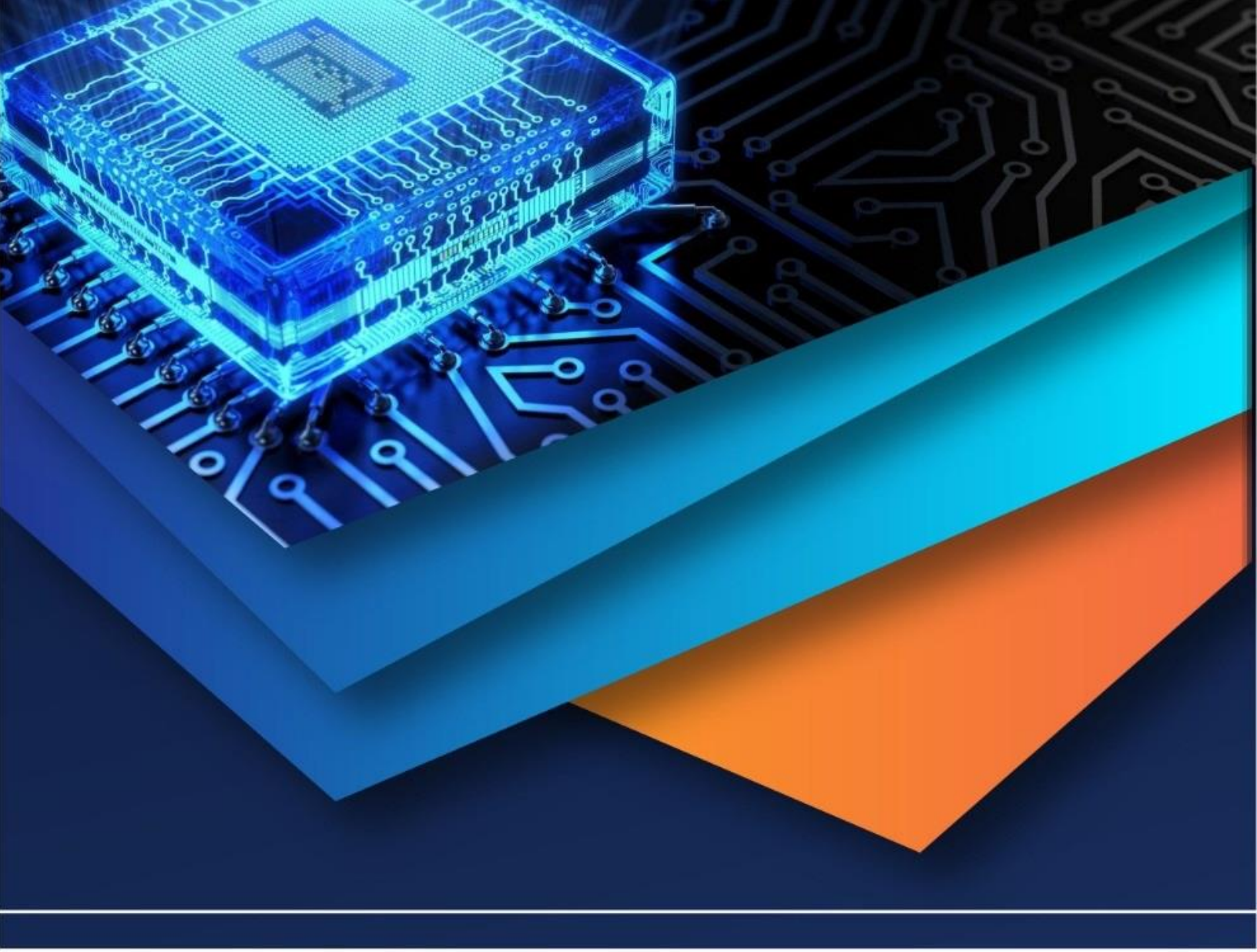
AUTHOR PROFILE

Shashwat Negi completed his Bachelor of Technology, from the School of Computer Science & Engineering, VIT, Vellore. His primary areas of research include IoT, Machine Learning, Data Science and Analytics.



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