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Development of IoT Based System for Early Detection of Asthma

Malik Sameen Ahmed[1*], Chaudhry Muhammad Rehan[1], Abbas Laiba[1], Jameel Atiqa[1], and Zia Arifullah [2]
[1]Department of Biomedical Engineering, University of Engineering & Technology Lahore (Narowal Campus), Narowal, Punjab, Pakistan.
[2]Department of Biology, Faculty of Science, Nangarhar University, Nangarhar, Afghanistan.
*Corresponding author: sameen.ahmed@uet.edu.pk

ABSTRACT

When airborne dust enters the respiratory system, it causes inflammation and constriction of the airways, making asthmatics' breathing more difficult. Inhaling dust particles, which frequently contain allergens, greatly exacerbates respiratory problems and raises the possibility of asthma episodes. The project intends to deliver individualised alerts based on dust density levels in real-time asthma monitoring, recognising a need in the market for affordable IoT solutions. Using an ESP8266 microcontroller and GP2Y1010AU0F dust sensor, the system provides timely alerts and continuous monitoring to improve asthma management. The process entails using Blynk for real-time data visualisation and analysis and connecting the dust sensor with the ESP8266 microcontroller. The results highlight the system's effectiveness in providing preventive asthma care by demonstrating the successful implementation of Blynk notifications caused by increasing dust density. In conclusion, this Internet of Things-based approach has the potential to enhance patient care through tailored asthma monitoring. Some of the limitations are the wide range of sensor accuracy, the dependence on IoT infrastructure, and the emphasis on dust as the main asthma trigger.

Keywords: Asthma, Dust Pollution, Internet of Things, Wearable Device, Remote Monitoring

INTRODUCTION

Chronic Chronic asthma is a disease that gets worse over time as a result of a number of risk factors, such as environmental factors and the patient's bio-signals. Globally, it affects 7% of people on average (Khasha et al., 2018). Despite the complex web of worldwide health issues, bronchial asthma is a ubiquitous problem that affects people of all ages (Keglowich & Borger, 2015). Asthma impedes breathing and is characterized by constricting and inflaming airways along with thick mucus formation. Coughing and a characteristic whistling sound during exhale are common symptoms (Jeffery, 2001). With millions of people suffering from this chronic illness globally, there is an urgent need for novel remedies (Alharbi et al., 2021).

Since dust is a strong trigger for respiratory distress, it is extremely important for asthma patients to have dust in the air (D'Amato et al., 2015). Dust particles frequently contain bacteria and mites, which are allergens that can irritate an asthmatic's respiratory tract when inhaled (Miller, 2018). This increased susceptibility to dust can worsen breathing problems and increase the likelihood of asthma episodes (Hsu et al., 2011). For people with asthma, knowing and keeping an eye on the amount of dust in the air becomes essential since it allows them to take preventative action (Abbasi, 2007). Patients who are aware of increased dust concentrations can take steps to limit their exposure, which can help lower the chance of an asthma attack and enhance their respiratory health in general (Taştan & Gökozan, 2019).

This article examines a novel Internet of Things (IoT)-based solution that offers a promising path for better care and a higher quality of life by anticipating the possibility of asthma attacks and promptly alerting patients to them. The GP2Y1010AU0F dust sensor's sophisticated light-scattering technology is used in the process to actively sample air particles (Thompson, 2021). The system, which is integrated with the ESP8266 microcontroller, analyses data in real time and uses a threshold-based method to send out notifications when dust concentrations rise above predetermined thresholds. This allows asthmatics to receive prompt notifications and minimize health risks by enabling them to take preventive measures in response to elevated dust levels (Ellwood *et al.*, 2016). Variations in sensor accuracy, reliance on reliable IoT infrastructure, and the project's limited focus on dust as the main asthma cause present difficulties (Baqer *et al.*, 2022). Crucial issues to take into account are user compliance, environmental factors, and the requirement for ongoing medical guidance.

Concerns about privacy, the financial impact, and accessibility challenges also point out areas that need to be improved (Yang *et al.,* 2021).

MATERIALS AND METHODS

ESP8266 Node MCU

The ESP8266 NodeMCU module is a highly versatile microcontroller unit (MCU) designed for Internet of Things (IoT) applications. Initially independent of AVR processors, it now incorporates Arduino MCU compatibility to enhance flexibility. Engineered to minimize component and shield requirements, it aligns with the Arduino Uno board manager and SAM core.

Dust Sensor

The GP2Y1010AU0F Dust Sensor, shown in Figure 1, is a compact optical sensor designed for detecting airborne dust particles through light scattering. Utilizing an infrared LED and a phototransistor, it provides an analog voltage output proportional to dust concentration. Widely employed in air quality monitoring, it offers real-time assessment of dust levels, contributing to applications aimed at maintaining clean and healthy indoor environments.

Figure 1. Schematics of methodology of the device.

Voltage Regulator 7805

The 7805 Voltage Regulator, a member of the 78xx series, is a fixed linear voltage regulator widely employed in electronics to maintain a stable output voltage, typically +5 volts. Operating with an input voltage range of 7V to 35V and a current rating of 1A, its pinout consists of input (Pin 1), ground (Pin 2), and regulated output (Pin 3). Despite its prevalence, the 7805 has efficiency challenges, leading to heat generation, a concern mitigated by either using a heat sink or limiting the input voltage.

Circuitry Connections

We have built a circuit for our asthma monitoring project using essential parts like the ESP8266 (NodeMCU), an OLED display (Adafruit SSD1306), a dust sensor (GP2Y1010AU0F), and integrated Blynk for remote monitoring. After that, we connected its VCC and GND pins appropriately to power it using a 5V source. We were able to control the dust sensor's LED by connecting its LED power pin (D2) to the D2 pin of the NodeMCU. We connected the dust sensor's analogue output pin (A0) to the A0 pin of the NodeMCU in order to collect analogue data from it. We created an I2C connection for the OLED display by joining its SDA and SCL signals to the matching pins on the NodeMCU (SDA to D2, SCL to D1). The OLED display's VCC and GND pins were linked to ground and a 5V power supply, respectively.

The ESP8266 (NodeMCU) was set up to connect to a Wi-Fi network using the SSID and password that were supplied in the code in order to access the Blynk platform. It was possible to integrate Blynk and communicate with the Blynk server. The code included the Blynk login token, which allowed for remote system control and monitoring via the Blynk app. The device's breadboard circuitry, which integrates its physical form, is depicted in Figure 3. This graphic depicts the painstaking assembly process and highlights the interconnected network that powers our Internet of Things asthma monitoring system. Presenting the ultimate achievement: Figure 3 reveals our fully realized asthma monitoring device in its final prototype. This image captures the culmination of design, effort, and innovation—a compact and user-friendly solution dedicated to assisting those with asthma. The visual testament showcases the journey from initial ideas to a tangible, functional reality, highlighting the practicality and impact of our work.

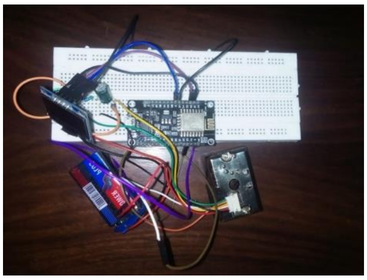
a)  b) 

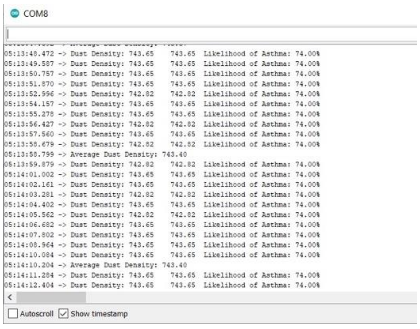
Figure 3. a) Breadboard Circuit Architecture b) Final Prototype

To transform the analogue output from the dust sensor into a useful indicator of air quality, the dust density computation process entails multiple phases. The sensor provides the analogue output, which is first represented by the letter Vo. The 0–1023 analogue values are then converted to a range of 0–5V using a conversion formula (CalcVoltage) to convert this analogue value into voltage. The voltage value is then subjected to a linear equation that is particular to the calibration of the sensor. The dust density is then computed using the equation that follows. This formula, which can only be obtained by calibration, is essential for estimating dust density in micrograms per cubic metre ($\mu g/m^3$). As a measurable indicator of air quality, the resulting DustDensity value shows the concentration of dust particles in the atmosphere.

RESULTS AND DISCUSSION

The measure dust density values are shown on the serial monitor. The provided screenshot, labeled as Figure 4 (a), presents a real-time snapshot of the serial monitor readings from our IoT-based asthma monitoring system. The display showcases a continuous stream of values, updating every second, encompassing crucial metrics such as dust density, asthma likelihood percentage, and average dust density. Simultaneously, the asthma likelihood percentage, derived from the dust density readings, provides an estimate of the probability of an asthma episode based on the system's predefined thresholds. The dynamic nature of these values becomes apparent in the continuous updates, reflecting the system's responsiveness to fluctuating environmental conditions.

The incorporation of Blynk notifications into our system has shown to be an essential element, successfully warning asthmatics when the dust density exceeds the critical value. The blynk notification appears in Figure 4 (b) when the dust density above 700. Real time values of dust density have shown on blynk and these real time values are also plotted on blynk as shown in Figure 4 (c). As a preventative step, this real-time alerting tool enables everyone, including us, to should act right away, moving to a cleaner environment or using inhalers as a preventative precaution.

a) 

b) 

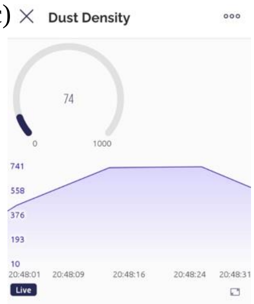
c) 

Figure 4. a) Values on Serial Monitor b) Blynk notification c) Blynk App Design

The system's adaptability and user-centric design are improved by its capacity to create individualized notifications depending on individual susceptibility. A graphic representation of the dynamics of air quality can be obtained by looking at the plotted data of dust density readings over time shown in Figure 5(a). While extended periods of high density imply a chronically difficult environment for asthma patients, sudden jumps in dust density may indicate short-term exposure to excessive pollution levels. Personalized asthma care is our goal, and this visual input empowers users—including us—to make informed decisions about their surroundings and activities. The percentage chance of developing asthma is plotted over time in Figure 5(b) Figure 12.

Monitoring changes in this index offers ongoing information about how environmental factors affect an individual's vulnerability to asthma. Peaks in the likelihood % highlight the clear relationship between asthma risk and environmental factors when they are connected with times of high dust density.

a) b)

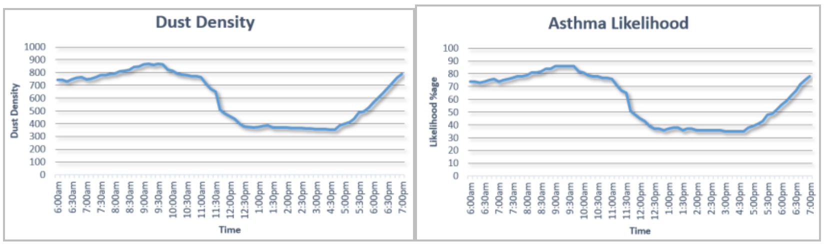


Figure 5. a) Dust density vs time plot b) Asthma likelihood vs time plot

CONCLUSION

In conclusion, our study presents an Internet of Things (IoT)-based asthma monitoring system that combines real-time data display on the Blynk app, an ESP8266 microcontroller, and a GP2Y1010AU0F dust sensor. When dust density exceeds a key threshold, the system successfully sends out Blynk messages, giving asthma patients timely notice for preventive healthcare. The customized alarms, which are based on each person's susceptibility, highlight the system's user-centric design. Plots visually display dust density. Even while our approach shows promise, it's vital to recognise its limitations, which include fluctuations in sensor accuracy and its emphasis on dust as the main cause of asthma attacks. Real-world application considerations also include user compliance and the requirement for continuous medical guidance. In the future, studies may examine more environmental factors for improved prediction abilities and deal with issues like accessibility, affordability, and privacy. Essentially, our Internet of Things (IoT)-based asthma monitoring system is a useful tool for personalized healthcare because of its real-time alerts, continuous monitoring capabilities, and visual representations. By using technology to help people take control of their asthma, we help achieve the larger objective of enhancing the lives of those with long-term respiratory diseases.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Conflict of Interest Funding: No funding was required for this research.

Authors Contributions: SAM conceptualized, AZ methodology, LP original draft preparation, review and editing AJ project hardware, MRC supervision.

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