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IoT-Based Integrated Environmental and Health Monitoring System for Asthma Patient Management

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Abstract - In the current fast-paced world, respiratory illnesses like asthma have become increasingly common due to rising pollution and changing environmental conditions. This project demonstrates a real-time asthma monitoring and alert system based on Internet of Things (IoT) approaches. It automatically detects environmental and physiological parameters to assess the potential risk of asthma attacks in an individual. A compact embedded system is developed using a combination of sensors to monitor temperature, humidity, air quality, and pulse rate, which are typically associated with asthma triggers. The system is implemented using Arduino-compatible hardware and ESP8266, supported by sensors like MQ-2, DHT11, and pulse sensors for continuous data acquisition. It takes input from real-time environmental conditions and health data, performing processing and cloud transmission for live monitoring. The results are displayed on an Android application through Firebase, providing the user with alerts and preventive suggestions. Development and testing were conducted in a controlled environment using Arduino IDE and Android Studio. The results demonstrate the efficiency of the system in detecting asthma risk levels, useful for early warning, patient self-care, and remote monitoring. Future work can include integration of machine learning models for intelligent asthma prediction and support for wearable device compatibility.

Key Words: Asthma Monitoring, Air Quality Detection, Real-Time Health Tracking, Internet of Things (IoT), Embedded System, Environmental Sensing, Pulse Rate Analysis, Android-Based Application, Wireless Data Transmission, Cloud Integration with Firebase

1. INTRODUCTION

The growing prevalence of asthma, a chronic respiratory disease affecting individuals of all ages, has intensified the need for effective and accessible healthcare solutions. In today's fast-paced world, where environmental factors like air pollution and allergens significantly contribute to asthma attacks, proactive and remote patient monitoring is crucial. In response to this healthcare challenge, we present our IoT-Based Asthma Monitoring System — an innovative solution designed to monitor key physiological and environmental parameters, offering users and healthcare providers real-time data and insights to manage asthma more effectively and safely.

1.1 Real-Time Health and Environmental Sensing

At the heart of our system is a network of smart sensors integrated with microcontrollers, designed to track vital health metrics such as body temperature, heart rate, and SpO_2 levels, along with environmental factors like dust concentration, air quality, humidity, and ambient temperature. These parameters are essential in understanding asthma triggers. The system continuously collects and transmits this data in real time, helping users avoid potentially dangerous exposure and enabling medical professionals to assess conditions without delay.

1.2 Data Visualization and Analysis

The collected sensor data is processed and visualized through intuitive charts and graphs. Leveraging powerful libraries such as Python's Pandas and Matplotlib, we deliver comprehensive dashboards that represent trends, fluctuations, and alerts. Whether tracking changes in air quality or observing a patient's heart rate variation during high-risk hours, these visualizations help both users and doctors make informed decisions regarding preventive or emergency care.

1.3 Personalized Asthma Management Recommendations

Based on the interpreted sensor readings, our system offers personalized advice to manage and mitigate asthma symptoms. This may include alerts for taking medication, guidance to stay indoors during high-pollution periods, or prompts for breathing exercises and hydration. These recommendations are tailored to each user's real-time conditions and medical history, ensuring a truly customized approach to asthma care.

1.4 Remote Monitoring and Emergency Alerts

The system supports remote data access for doctors and caregivers through a secure cloud interface. It can be programmed to issue instant alerts via SMS, email, or app notifications if readings exceed safe thresholds — such as high CO_2 levels or abnormal heart rate. This allows for immediate intervention, even before symptoms escalate, potentially saving lives.

2. Body of Paper

Recent advancements in the Internet of Things (IoT) have enabled the development of real-time health monitoring systems that can assist in managing chronic diseases like asthma. This section elaborates on the core concepts, prior work, technical framework, and methodology supporting the proposed asthma monitoring system

Table -1: literature survey

AUTHOR	ALGORITHM / TECHNIQUE	METHODOLOGY	REMARKS / PROBLEM	MERITS
Shambhavi Kharbanda, Reetu Jain (RBL15, 2023)	Arduino-based Embedded System	Used DHT11 and PMS7003 sensors to monitor temperature, humidity, and dust levels. Alerts through buzzer and LED, data shown on LCD.	Lacks physiological health monitoring. Focus is solely on environmental triggers.	Real-time monitoring, cost-effective, portable with 3D-printed casing, easy to use.
Safayat Reza Anan et al. (JHE, 2021 – Retracted)	IoT + Telemedicine (ESP8266, Firebase, Django)	Combined multiple sensors (SpO_2, heart rate, ECG, temperature, humidity, gas) with an Android app and web interface. Supports video call with doctors.	Retracted due to manipulation, ethical concerns, and reliability issues.	Rich feature set, real-time cloud sync, supports remote consultation, data visualization on mobile/web.
Niranjana S., Hareshaa S.K., Irene Z. Basker, Dr. Jose Anand (IJECE, 2020)	Android App + IoT (NodeMCU + Firebase)	Monitors air quality, temperature, humidity, pulse rate using sensors. Uses AST (Asthma Symptom Test) in app. Sends alerts and logs data to cloud with GPS location.	Lacks advanced physiological monitoring and direct doctor integration.	Simple interface, self-care focused, cloud-connected with real-time alerts, integrates location-based assessment.

2.1 Problem Statement

While the proposed IoT-based asthma monitoring system presents a promising approach to improving real-time health and environmental tracking, it faces certain limitations in terms of scalability, adaptability, and clinical robustness. First, many existing models rely on basic threshold-based alerts for environmental parameters such as air quality and humidity, which may not capture the nuanced interaction between physiological data (e.g., heart rate) and environmental triggers that contribute to asthma attacks. This simplistic data fusion method lacks intelligent processing and does not utilize the full potential of multi-modal sensor input.

Second, although Arduino-based platforms offer ease of development and cost efficiency, they often struggle with processing higher-resolution data or supporting advanced features such as predictive analytics or trend detection without offloading to external systems. This limitation reduces the system's real-time adaptability and decision-making capabilities, especially when attempting to forecast asthma events based on subtle changes over time.

Finally, issues such as sensor drift, external interference, noise in signal acquisition, and the computational overhead of continuously monitoring multiple parameters may affect long-term reliability and usability. These limitations highlight the need for a more intelligent, adaptive, and interpretable system architecture that goes beyond data collection to deliver precise, context-aware insights for asthma management.

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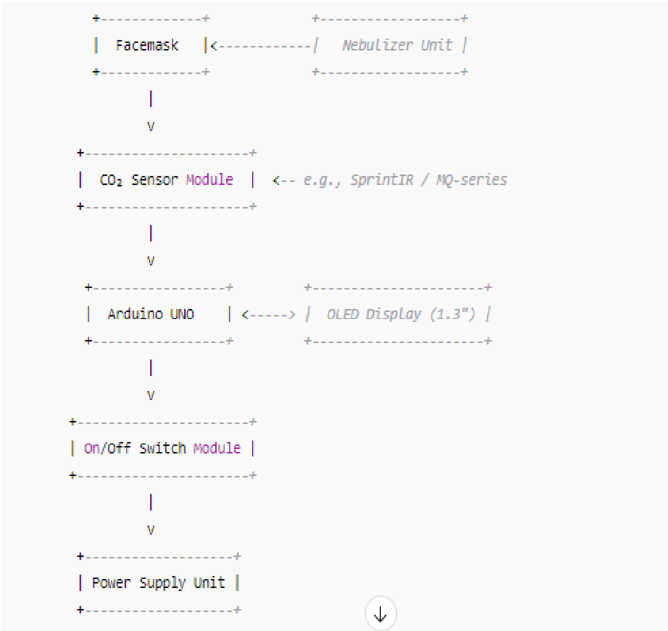
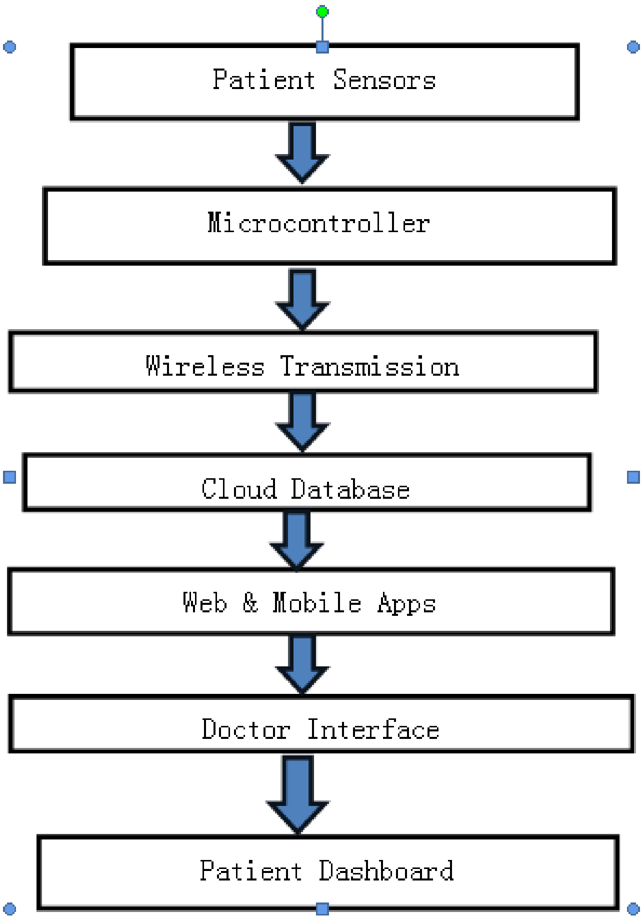
2.1 Existing block diagram:



2.2 proposed block diagram



2.4 Practical Setup

The practical implementation of the IoT-based asthma monitoring system involves integrating both hardware and software components for real-time data acquisition and visualization. The core hardware setup includes an Arduino Uno microcontroller connected to multiple sensors, namely the DHT11 for temperature and humidity, MQ135 for air quality, MLX90614 for non-contact body temperature, and a pulse sensor for heart rate monitoring. These components are mounted on a breadboard using jumper wires and powered via USB from a laptop or desktop computer. An optional buzzer or LED can be included to provide immediate audible or visual alerts when sensor values cross dangerous thresholds.

The system is designed to run efficiently in a standard indoor setting with a stable power supply and proper sensor placement. The air quality sensor should be exposed to ambient air, while physiological sensors should be positioned appropriately for accurate readings. Data monitoring is typically carried out through a Python terminal or visual interface, and users can terminate the monitoring session by closing the script or using an assigned key interrupt. This setup enables a cost-effective, portable, and real-time asthma monitoring environment that can assist patients in managing their respiratory health proactively.

Input

Dataset Name: Real-Time Sensor Data for Asthma Monitoring (Custom Collected Dataset)
The dataset used in this project is based on real-time sensor readings collected through a custom-built IoT setup for asthma monitoring. The input data consists of environmental and physiological parameters recorded using various sensors connected to an Arduino Uno microcontroller. These include air quality data from the MQ135 sensor, temperature and humidity readings from the DHT11, body temperature from the MLX90614 infrared sensor, and heart rate data from the pulse sensor.

Each recorded entry in the dataset represents a timestamped set of values across the mentioned sensors, forming a structured array of multi-modal health and environmental indicators. The data is collected continuously and streamed through serial communication to a Python-based interface, where it is either visualized or stored in CSV format for further processing. Each sample includes labels such as sensor type, time of capture, and corresponding values, enabling easy tracking of condition trends over time.

This real-time dataset is essential for implementing threshold-based alert systems and visual analytics to detect asthma-related risks. While not sourced from a public benchmark like FER-2013, this dataset is highly relevant due to its personalization, real-world applicability, and integration of both external (environmental) and internal (physiological) factors. It provides the foundation for building intelligent monitoring solutions aimed at improving asthma management and timely intervention.

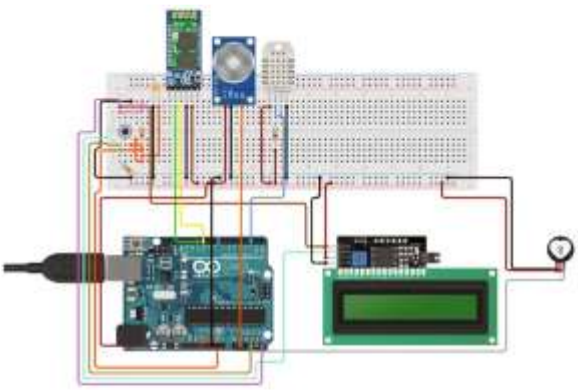
2.5 Implementation

The implementation of the IoT-Based Asthma Monitoring System follows a streamlined development flow combining both hardware and software components. The process begins with the installation of necessary tools, including the Arduino IDE for microcontroller programming and Python through the Anaconda distribution for data processing and visualization.

Visual Studio Code and Jupyter Notebook are used to facilitate development and interactive analysis.

To maintain consistency in package versions and avoid conflicts, a Python virtual environment is set up using either venv or Anaconda. Once the environment is ready, essential Python libraries such as pyserial, matplotlib, pandas, and numpy are installed. These dependencies support serial communication, real-time data visualization, structured data handling, and numerical computation. Optional libraries such as plotly or tkinter may be added for enhanced visualization or user interface design.

The hardware is assembled by connecting the DHT11, MQ135, MLX90614, and Pulse Sensor to the Arduino Uno on a breadboard. The Arduino is programmed via the Arduino IDE to initialize sensors and transmit data via serial communication using the Serial.begin() function. On the software side, Python scripts capture the incoming sensor data using the PySerial library. This raw data is preprocessed to convert analog values into meaningful units such as parts per million for air quality, degrees Celsius for temperature, or beats per minute for heart rate. Normalization and rolling average techniques are applied to smooth fluctuations and reduce noise.



2.6 Reslult:

3. CONCLUSIONS

This project has demonstrated a functional and practical design of a real-time asthma monitoring system based on IoT platforms and environmental-health data integration. The objective was a development process that required building a sensor-driven system using the Arduino microcontroller platform, capable of monitoring both physiological parameters—such as heart rate and body temperature—and environmental factors including humidity, temperature, and air quality. The system utilizes sensors like DHT11, MQ135, MLX90614, and a pulse sensor to gather data, which is transmitted through Bluetooth or WiFi and visualized using Python-based tools for analysis. The development environments used include Arduino IDE and Jupyter Notebook, enabling both system programming and real-time data visualization, making it easier to interpret and validate the collected data.

The project has successfully achieved its intended goal of detecting asthma-related risks by combining real-time environmental and health data. It also lays the foundation for more advanced systems that can support remote patient monitoring, emergency alerts, and data-driven decision-making in healthcare. The system can be further improved by integrating cloud storage, GPS-based environmental tracking, or mobile applications to enhance accessibility and usability. Overall, the project offers a meaningful intersection of IoT technology and respiratory healthcare, providing a valuable solution for proactive asthma management and overall well-being.

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I would like to express my heartfelt appreciation to all those who contributed toward my research project titled **"IoT-Based Integrated Environmental and Health Monitoring System for Asthma Patient Management."** This project has been a valuable and enlightening learning experience and would not have been possible without the continuous support, encouragement, and guidance from several individuals.

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I would also like to extend my gratitude to the **Institute of Aeronautical Engineering** for providing access to the necessary resources, infrastructure, and a research-friendly environment. The availability of platforms such as Arduino IDE, Python, and supporting hardware like sensors and microcontrollers enabled the practical realization of the proposed system.

I am thankful to my fellow undergraduate peers for their collaborative spirit, insightful discussions, and moral support throughout this journey. Lastly, I sincerely thank my family and

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