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Detection of Diabetes from Exhaled Human Breath using Arduino

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ABSTRACT: Diabetes is one of the biggest health problems that affect millions of people across the world. Uncontrolled diabetes can increase the risk of heart attack, cancer, kidney damage, blindness and other illnesses. Human breath can be used as diagnostic sample for detecting many diseases as it contains many gases that are dissolved in the blood. Breath-based analysis stands out among the different non-invasive ways of detection as it provides more accurate predictions and offers many advantages. So we have proposed a medical system for detecting diabetes from exhaled breath. In this work, we considered concentration of acetone in the exhaled breath to analyze the diabetes. A new sensing module consisting of an array of sensors is implemented for monitoring the acetone concentration to detect the disease. By taking the acetone levels (using MQ-135 sensor) of a person of different age groups and analyzing whether a person is diabetic or non-diabetic person, for a healthy person the acetone levels are 0.9 parts per million (ppm) or less whereas for a diabetic person the acetone levels are greater than 0.9 parts per million(ppm). The study gets benefit from the well-established link between elevated acetone levels and the presence of diabetes. Acetone, a volatile organic compound (VOC), is produced during the breakdown of fatty acids in the absence of sufficient insulin. This system employs a sensitive acetone sensor integrated with an Arduino micro-controller for real-time data acquisition and processing. This study introduces a groundbreaking approach for diabetes detection based on the analysis of acetone levels in exhaled breath, facilitated by an Arduino based sensing system. The results underscore the system's potential as a noninvasive, cost-effective, and accessible tool for diabetes screening and monitoring.

KEYWORDS: Arduino Uno, MQ-135 sensor, Acquisition, Non-invasive.

I. INTRODUCTION

Diabetes is a widespread chronic disease that affects the body's ability to regulate blood glucose levels, posing significant risks to long-term health if left undiagnosed or poorly managed. Early detection and continuous monitoring are critical to minimizing complications such as cardiovascular issues, nerve damage, and kidney disease. Conventional diagnostic methods, including blood glucose tests, often rely on invasive techniques that can be inconvenient, costly, and uncomfortable for patients. This has led to the exploration of non-invasive diagnostic methods that provide a more user-friendly alternative.

One innovative solution is the analysis of exhaled human breath, which offers a non-invasive way to detect biomarkers such as acetone. Acetone levels in the breath are closely linked to blood glucose levels, making it a viable indicator for diagnosing and monitoring diabetes. By leveraging the capabilities of Arduino, a versatile and cost-effective microcontroller platform, researchers have developed compact, portable, and efficient systems to measure and analyze breath biomarkers in real-time.

The integration of Arduino with highly sensitive sensors allows for accurate detection of specific chemical compounds in exhaled air, providing immediate feedback to users. This approach not only improves patient comfort but also facilitates frequent monitoring, making it particularly beneficial for individuals in remote or resource-limited areas. Furthermore, the affordability and adaptability of Arduino-based systems make them accessible to a wide range of users, bridging the gap between advanced technology and practical healthcare solutions.

The development of breath-based diabetes detection systems signifies a breakthrough in medical diagnostics, offering a blend of precision, ease of use, and affordability. It highlights the potential of modern electronics and IoT technologies in transforming healthcare practices and empowering individuals to take proactive control of their health.

II. LITERATURE SURVEY

The paper [1] presents a significant contribution to the field of diabetes management through the development of a novel diagnostic tool. The paper addresses a critical need in diabetes care by introducing a portable, noninvasive device capable of assessing diabetes status by measuring acetone levels in exhaled breath. This innovation represents a departure from conventional glucose monitoring methods, offering patients a more convenient and potentially less intrusive means of disease management. By leveraging breath acetone as a biomarker for diabetes assessment, the device opens up new possibilities for frequent and accessible monitoring, ultimately aiming to improve patient compliance and overall health outcomes. The technology described in the paper likely employs advanced sensor technologies specifically designed to detect acetone with high sensitivity and selectivity. Such sensors may utilize nanomaterials or other innovative approaches to enhance detection capabilities while maintaining portability and ease of use. The development of a portable breath analyzer marks a significant advancement in point-of-care diagnostics, potentially revolutionizing how diabetes is managed and monitored on a day-to-day basis. This device holds promise for empowering patients to take more proactive control of their health, leading to better disease management and reduced risks of complications associated with diabetes.

The paper [4] presents a significant contribution to the field of diabetes management through the development of a novel diagnostic tool. The paper addresses a critical need in diabetes care by introducing a portable, noninvasive device capable of assessing diabetes status by measuring acetone levels in exhaled breath. This innovation represents a departure from conventional glucose monitoring methods, offering patients a more convenient and potentially less intrusive means of disease management. By leveraging breath acetone as a biomarker for diabetes assessment, the device opens up new possibilities for frequent and accessible monitoring, ultimately aiming to improve patient compliance and overall health outcomes. Hao et al.'s work provides a foundation for developing portable devices capable of detecting diabetes and possibly even monitoring its progression through breath analysis. Such devices could transform diabetes management by enabling real-time feedback on a patient's metabolic state, potentially improving compliance and facilitating more precise adjustments in therapy. The study emphasizes the need for further validation and refinement of the breath analysis technology, including enhancing the sensitivity and specificity of the sensors used to detect VOCs. It also highlights the necessity of larger scale studies to establish robust diagnostic criteria based on breath biomarker profiles, which could pave the way for clinical applications. However, the translation of these preliminary findings into practical clinical tools will require addressing several challenges. Among these are the standardization of breath collection and analysis procedures, the variability in metabolic processes among different individuals, and the environmental factors that may affect VOC concentrations. Additionally, integrating such breath analysis devices with digital health platforms could offer continuous monitoring solutions but would necessitate rigorous data security and privacy protections. Hao et al.'s study is an encouraging step toward such innovations, though extensive clinical trials and regulatory approvals remain crucial for ensuring the efficacy and safety of these potential new tools in diabetes care. The ongoing development in this area reflects a broader shift toward personalized medicine, where noninvasive diagnostics could significantly enhance patient care.

The paper [11] presents a significant advancement in the field of breath analysis for diabetes diagnosis by introducing silicon-tungsten oxide (Si:WO₃) sensors tailored for highly selective detection of acetone. Acetone is a key volatile organic compound (VOC) present in the breath of diabetic individuals due to the metabolic processes associated with the condition. By leveraging the unique properties of Si:WO₃, the researchers aimed to develop sensors capable of accurately and selectively detecting acetone, thus enabling easier and more reliable diagnosis of diabetes through breath analysis. This paper addresses a critical need in diabetes management, offering a promising avenue for noninvasive and rapid disease detection. The study likely delves into the fabrication process and characterization of Si:WO₃ sensors, emphasizing their selectivity for acetone over other interfering compounds commonly found in breath samples. These sensors may operate based on principles such as chemiresistive sensing, where changes in electrical resistance due to interactions with acetone molecules are measured and translated into concentration readings. The choice of Si:WO₃ as the sensing material is strategic, as it exhibits high surface area, sensitivity to acetone, and stability under operating conditions. Such sensors could serve as integral components in breath analysis systems designed for diabetes diagnosis, offering improved accuracy and reliability compared to conventional methods. The implications of this research extend beyond diabetes diagnosis, potentially impacting a wide range of fields where VOC detection is relevant, such as food quality control and environmental monitoring. By enabling highly selective detection of acetone, the developed Si:WO₃ sensors contribute to the advancement of sensor technologies for breath analysis, opening up opportunities for developing portable and user-friendly devices. These devices could empower individuals to monitor their health in real-time, facilitating timely interventions and personalized healthcare. Overall, Righettoni, Tricoli, and Pratsinis' paper

underscores the importance of interdisciplinary research in advancing medical diagnostics and highlights the potential of innovative sensor technologies for improving disease management and patient outcomes.

The paper [12] presents the intricate dynamics of breath acetone concentration, exploring its biological variability and the influence of various factors such as diet and altered physiological states. Acetone is a significant volatile organic compound (VOC) present in human breath, and its concentration can serve as a biomarker for metabolic processes, including those associated with diabetes. The study likely investigates the natural fluctuations in breath acetone levels within individuals over time, shedding light on the inherent variability of this biomarker. Understanding this variability is crucial for the development of accurate and reliable diagnostic tools for conditions such as diabetes, where acetone detection plays a key role. The research likely involves controlled studies to examine the effects of dietary factors and physiological changes on breath acetone concentration. By systematically altering participants' diets or inducing physiological states such as fasting or exercise, the authors likely aim to elucidate the mechanisms underlying changes in acetone production and exhalation. This comprehensive approach provides valuable insights into the complex interplay between metabolic processes, environmental factors, and breath acetone levels, offering a deeper understanding of the nuances involved in using acetone as a diagnostic marker for diabetes and other metabolic disorders. This study is likely to have implications for the development and interpretation of breath analysis techniques for medical diagnostics. By elucidating the factors influencing breath acetone concentration, the research contributes to the refinement of breath analysis methodologies, enhancing their accuracy and reliability. Moreover, the study underscores the importance of considering individual variability and external influences when interpreting breath acetone data in clinical settings. Ultimately, this paper advances our understanding of breath acetone dynamics and informs the design of more effective diagnostic tools for diseases where breath analysis plays a pivotal role in early detection and monitoring.

III. PROPOSED METHODOLOGY

We present the methodology for the detection of a Diabetes using Arduino, MQ-135 sensor, and DHT 11 sensor. The primary objective of this article is to create a painless, cost-effective and being comfortable for the patients without relying on pain-full blood piercing methods. This methodology chapter outlines the key steps involved in achieving this goal. The system operates by establishing a connection between the Arduino.

Block Diagram:

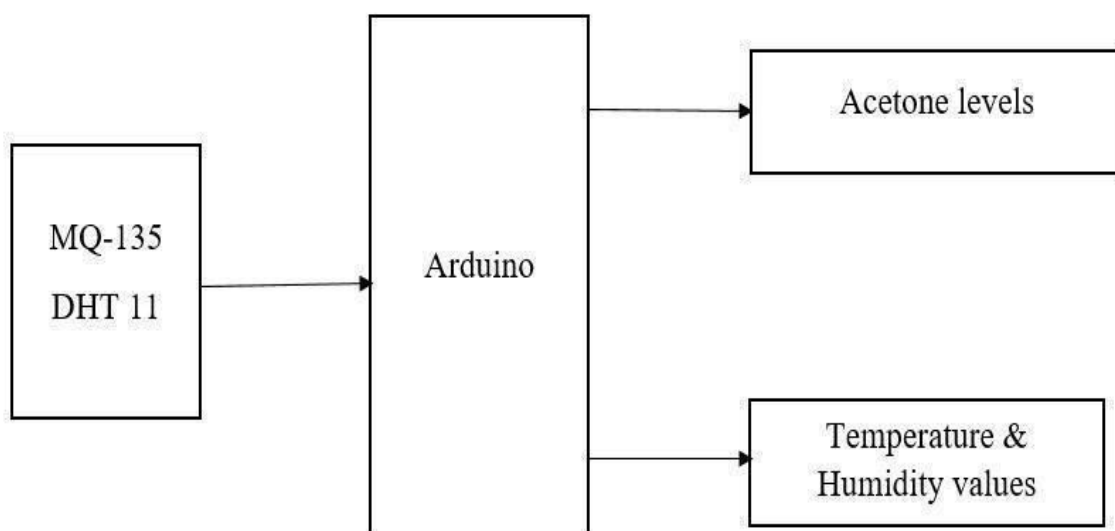


Fig.1. Block diagram of the system

The Fig 1 shows the proposed IoT-based diabetes detection system integrates multiple components, including the Arduino UNO micro-controller, the MQ-135 gas sensor, the DHT 11 temperature sensor, and patient interaction. The



patient's breath serves as the input for the system, with the patient required to blow air through their mouth onto the sensors. This interaction facilitates the collection of breath samples, which are then analyzed by the system to detect diabetes. The MQ-135 sensor is responsible for detecting acetone levels in the exhaled breath, while the DHT 11 temperature sensor measures the patient's body temperature, a factor that can influence acetone levels. By incorporating these sensors into the system, a comprehensive assessment of the patient's breath composition is achieved, enhancing the accuracy and reliability of diabetes detection. Key aspects of the circuitry include the interface between the Arduino UNO and the MQ-135 sensor, as well as the integration of the DHT 11 temperature sensor. Acetone sensors play a crucial role in diabetes detection from acetone levels in exhaled breath. The DHT11 sensor is a basic and low-cost digital temperature and humidity sensor that uses a capacitive humidity sensor and a thermistor to measure the surrounding air. The sensor provides a calibrated digital signal output of the temperature and relative humidity, making it fairly simple to use. These sensors operate based on specific gas-sensing principles, allowing them to detect and quantify acetone, a volatile organic compound that can serve as a potential biomarker for diabetes. The power supply for the sensors is provided by the Arduino UNO, with the sensor's power connected to the 5 volts output pin of the Arduino and the ground connected to the Arduino's ground pin. This setup allows for the input of sensor data, enabling the Arduino UNO to monitor and analyze the collected breath samples. The inclusion of the DHT 11 temperature sensor is crucial for accounting for temperature variations that may affect acetone levels in the patient's breath. By integrating these components into the circuitry, the system is equipped to accurately analyze breath samples and provide reliable diagnostic results. The software logic governing the operation of the system follows a sequential process, beginning with initialization. During initialization, the system initializes its components, including the sensors and the Arduino UNO. Once initialized, the Arduino UNO constantly monitors and displays the acetone levels detected by the MQ-135 sensor. If the acetone levels exceed the predetermined threshold of 0.9 ppm when the patient exhales onto the gas sensor, the system identifies the presence of diabetes. Conversely, if the acetone levels remain below the threshold, the system determines that the patient is not diabetic. This straightforward logic ensures a simple and efficient method for diabetes detection without the need for invasive procedures. The block diagram outlines the essential components and connections of the IoT-based diabetes detection system, with the Arduino UNO serving as the central processing unit. The Arduino UNO communicates with the sensors and processes the collected breath samples to determine the patient's diabetes status. The inclusion of the DHT 11 temperature sensor ensures that temperature variations are accounted for, further enhancing the accuracy of the diagnostic process. Together, these components form a cohesive system that offers a painless, comfortable, and cost-effective solution for diabetes detection. By leveraging IoT technology, the system provides a non-invasive and accessible method for diagnosing diabetes, ultimately contributing to improved healthcare outcomes and patient well-being.

CODE (Aurdino IDE)

```
int R2=1246;
#include "dht.h"
#define
ine dht_apin A3
// Analog Pin sensor is connected to A3
dht DHT; int R0; float RS; float PPM_acetone;
void setup() {
  Serial.begin(9600);
  float A0=1.6;
  R0=R2*(1-A0)/A0;
}
void loop() {
  // read the input on analog pin 0
  int sensorValue = analogRead(A0);
  float volts = sensorValue * 5; // converting to voltage:
  volts = volts / 1023;
  RS=R2*(1-volts);
  RS = RS/volts;
  // calculate acetone PPM
  PPM_acetone = 159.6 - 133.33*(RS/R0);
  Serial.println(PPM_acetone); delay(1000);
  DHT.read11(dht_apin);
  Serial.print("Current humidity = ");
```

```
Serial.print(DHT.humidity);  
Serial.print("% ");  
Serial.print("temperature = ");  
Serial.print(DHT.temperature);  
Serial.println("C ");    delay(6000);  
}
```

Explanation:

This Arduino code snippet appears to be part of a program designed to detect acetone levels in a gas sample using a gas sensor (MQ-135) and measure temperature and humidity using a DHT11 sensor. At the beginning of the code, a constant resistor value R2 is initialized to 1246. This value is likely used in sensor calculations to determine resistance values. Additionally, the code includes the library for the DHT sensor and defines a macro dht_apin to represent the analog pin A3, which is where the DHT sensor is connected. In the setup function, the serial communication is initialized with a baud rate of 9600. A local variable A0 is declared and initialized to 1.6. Then, the value of R0 is calculated using a predefined formula involving R2 and A0. This calculation likely determines a reference resistance value used in subsequent sensor calculations. Moving on to the loop function, the main execution of the program occurs here. It continuously performs a series of tasks. First, it reads the analog pin A0, which is likely connected to the MQ-135 sensor, to obtain sensor readings. These readings are then converted to voltage and used to calculate sensor resistance (RS). The formula $PPM_acetone = 159.6 - 133.33 * (RS/R0)$ calculates the acetone concentration in parts per million (PPM) based on the obtained sensor resistance value. This calculated concentration value is then printed to the serial monitor. After a delay of 1 second, the code reads temperature and humidity values from the DHT sensor connected to pin A3 (dht_apin). These values are also printed to the serial monitor. Finally, a delay of 6 seconds is introduced before the loop repeats. This code demonstrates the process of detecting acetone levels in a gas sample using an MQ-135 sensor and measuring temperature and humidity using a DHT11 sensor. It illustrates the initialization of sensor values, continuous sensor readings, and the output of calculated values to the serial monitor for monitoring and analysis purposes.

IV. RESULT

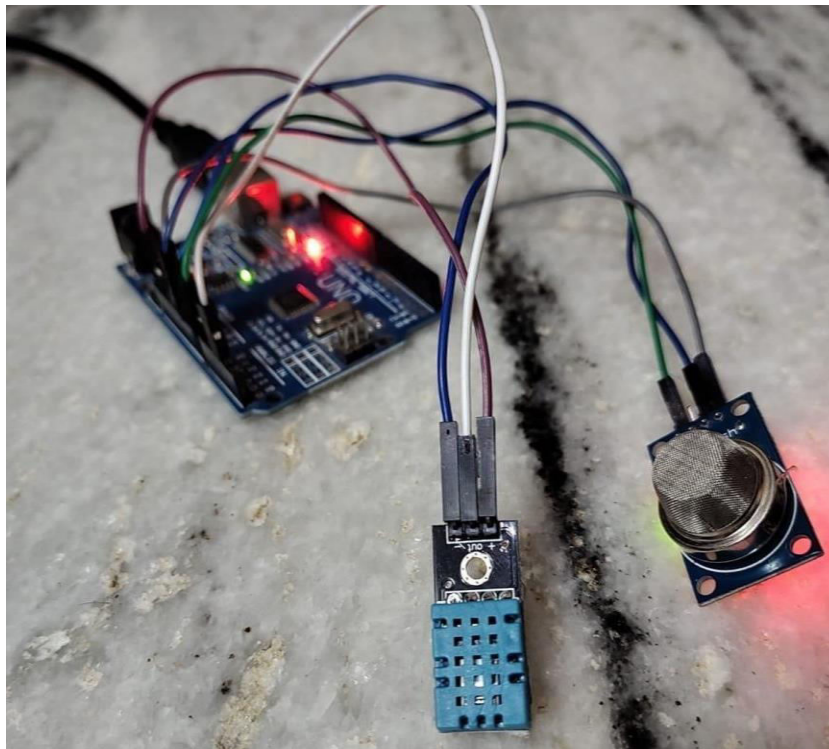


Fig 2. Prototype of the system

The code after verifying in Aurdino IDE is dumped into Aurdino UNO board for the further execution. The acetone levels of a person are collected using MQ-135 from the exhaled breadth of a person by blowing near the sensor. The person with acetone levels greater than 0.9ppm is recognized as diabetic. The temperature is measured using DHT11 sensor. The output acetone levels and temperature are displayed in the serial monitor as shown below. Figure 2 illustrates the prototype of the proposed system design.

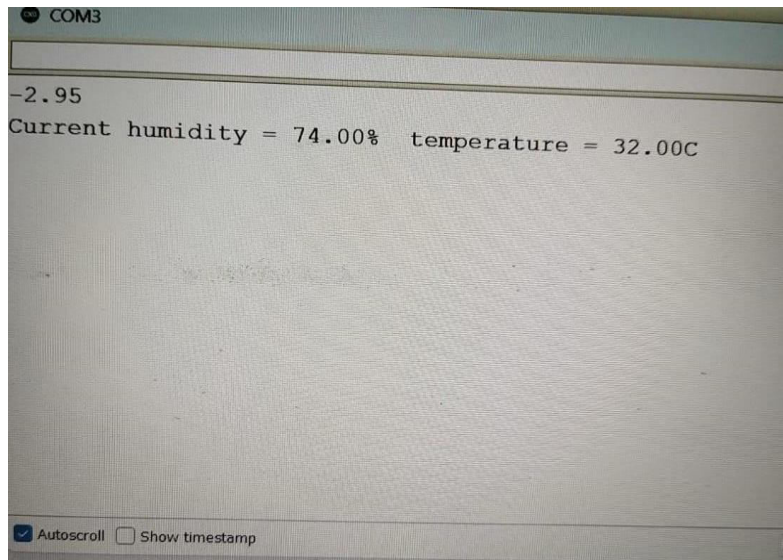


Fig 3 Output of a Non-diabetic person

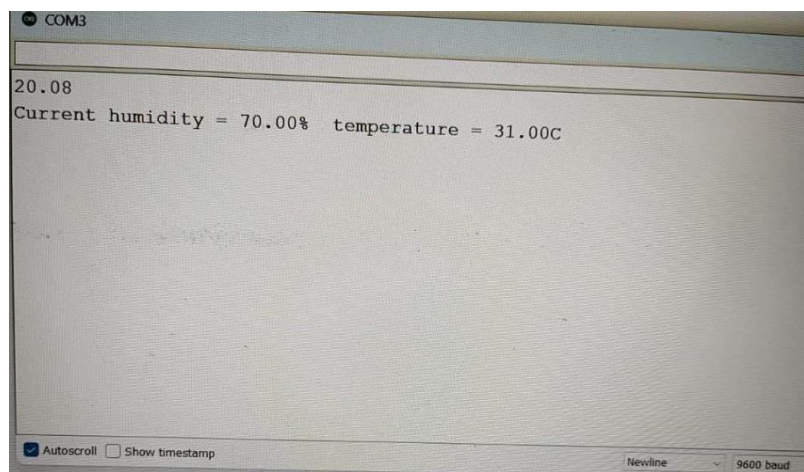


Fig 4 Output of a Diabetic person

The above figure 3 depicts the output for a non-diabetic person, while figure 4 shows the output for a diabetic person. For the person with acetone value is about -2.95 which is less than 0.9 ppm which resembles that the person is non-diabetic. In the same way, for the result of a diabetic person, the acetone levels are about 20.08 which exceeds 0.9 ppm. Sometimes the temperature plays a major in this result. If the person is having high temperature during detection then we need to again check acetone levels after the body temperature cools down.

V. CONCLUSION

In this paper, a sensing module is proposed for the non-invasive and detection of diabetes. To effectively manage diabetes and to reduce the health issues associated with diabetes, early detection of the disease is important. This article describes a breath-based diagnosis method that offers several advantages over conventional methods. The outcomes of

the proposed system are compared with the traditional blood-based diagnosis method. We observed a strong positive correlation between the two results. The statistical analysis suggests that the proposed sensing approach has the potential to be used as a non-invasive technique for detecting diabetes. On the basis of our paper, we draw the conclusion that the proposed method non-invasive method of detecting diabetes is way more comfortable and convenient than invasive method of detecting diabetes

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