Detection of blood glucose level For type 1 diabetic patient by Using non-invasive breath measurement

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Abstract- **There has been a constant demand for the development of non-invasive, sensitive glucose sensor system that offers fast and real-time electronic readout of blood glucose levels. In this article, we propose a new system for detecting blood glucose levels by estimating the concentration of acetone in the exhaled breath. A TGS822 tin oxide (SnO2) sensor has been used to detect the concentration of acetone in the exhaled air. Acetone in exhaled breath showed a correlation with the blood glucose levels. Effects of pressure, temperature and humidity have been considered. Diabetic ketoacidosis (DKA) is a potentially life-threatening metabolic complication of diabetes (Higgins, 1994). DKA is a state of relative or absolute insulin deficiency. In this system, Arduino board is used to read the sensor with sense the breath. Breath value level is log to system using wireless communication. Data collection is interfaced to web page. Ketone level is measured as the amount of breath acetone is collected when patients exhale into a mouthpiece that consists of gas sensor. The reading from Arduino is shared to the database via ESP 8266 Wi-Fi Module and can be accessed by the patients or registered doctors. This research is significant where patients can independently monitor their diabetic health and the IoT system can be alerted directly to medial officers in the hospitals.**

Keywords—ketone, personal monitoring system, acetone, exhaled breath, Internet of Things, sensor.

I. INTRODUCTION

Non-invasive diagnosis technique is becoming more prominent in diagnosing diseases due to their pain free and simple monitoring methods. Non-invasive detection of blood hemoglobin was already reported by our group in the earlier work .Lieschnegg et al. have developed a sensor to detect failures and material imperfections in total joint prosthesis based on acceleration measurement non-invasively . Diabetes can also be detected using non-invasive methods. Diabetes mellitus is a major health problem worldwide . This health condition arises from many complex metabolic disorders leading to high glucose levels in a person]. High glucose levels can lead to many health disorders such as kidney failure, blindness, heart diseases and even premature death . Frequent testing and accurate determination ofglucose levels is essential for diagnosis, effective management and treatment of diabetes mellitus. Therefore, there have been constant efforts to develop efficient and sensitive techniques for the determination of blood glucose levels. A number of invasive enzymatic and non-enzymatic methods and systems have been reported for the detection of glucose.

Conventionally, glucose level is determined from a small volume of blood sample collected by finger pricking. Though the test may not pose any risk to a healthy adult who goes for the diabetes checkup in every 2 to 3 months, but it is very painful to the diabetic patients because every time they have to prick the finger. The current invasive method is based on the enzymatic catalysis principle where a thin needle is used to prick the finger of the patient to minimize the discomfort . To avoid such painful diagnosis, extensive research has been devoted towards developing non-invasive techniques that measure blood glucose levels without taking the blood sample .Luaibi et al. used nuclear magnetic resonance technique to measure the blood glucose levels non-invasively . Apart from this, other non-invasive techniques used are electrical impedance, NIR spectroscopy, breath analysis, ultrasound and thermal spectroscopy . However, none of these methods seems to achieve the desired accuracy due to varying environmental conditions and physical movements and therefore none of them led to any accurate and safe commercial device. Further, compared to the breath analyzer other techniques appear to be expensive due to the sensor components involved.

In this work, we report a non-invasive system for the determination of blood glucose levels from the detection of the breath acetone. Acetone is one of the volatile organic compounds (VOCs) present in the exhaled breath. The acetone present in the exhaled breath is a metabolic product of the body fat-burnin]. The breakdown of excess acetyl-CoA from fatty acid metabolism in diabetic patients leads to increase in the levels of acetone in the blood. This acetone reaches lungs and exhaled or is excreted through urine. Therefore, the breath acetone levels could be a measure of the blood glucose levels of a person . The breath acetone concentration ranging from 1.7 ppm to 3.7 ppm can be detected in diabetic patients , whereas it varies between 0.3 and 0.9 ppm for healthy humans . Here we have used the TGS SnO2 particle system as acetone sensor. The resistance of this sensor varies depending on the quantity of acetone present and can be detected by potential divider circuit. Several other parameters such as the breath chamber temperature, humidity and pressure have been taken into consideration in the estimation of acetone because these parameters affect the quantity of acetone sensed by the sensor. Further, the acetone concentration in the breath chamber will not be the same for the same person every time due to different flow rates, because all humans can't blow at the same rate into the mouth piece/breath chamber.

II. LITERATURE REVIEW

Technology enhanced has enabled most system to be presented in Web based or online system. Today, the IoT has changed our lives by offering greater promise where its principles are already being applied to improve access to care, increase the quality of care and reduce the cost of care. The use of Internet for various health care related reasons from the perspective of end-users, especially patients. In the field of healthcare, collecting real-time data is vital. Thus the method of non-invasive and IoT-driven diabetes monitoring system is introduced in this paper. The amount of breath acetone is measured by using gas sensor. The data from the sensor is sent to Arduino Uno. For the real data collection and storage, the reading from Arduino is sent to local database and the patient is able to view the data via web page.

III. HARDWARE REQUIREMENT

FIGARO TGS822

The sensing element of Figaro gas sensors is a tin dioxide (SnO_2) semiconductor which has low conductivity in clean air. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration. The TGS 822 has high sensitivity to the vapors of organic solvents as well as other volatile vapors. It also has sensitivity to a variety of combustible gases such as carbon monoxide, making it a good general purpose sensor. Also available with a ceramic base which is highly resistant to severe environments as high as 200°C (model# TGS 823). Figaro TGS822 is a gas sensor having good sensitivity towards acetone

and ethanol gases. The acetone sensing application is used when the ethanol is absent in the breath. The acetone sensing relies on the changes in electrical conductivity due to the change in the sensor surface arising from the reactions between ionosorbed surface oxygen and acetone gas. In the presence of a deoxidizing gas, the surface density of the negatively charged oxygen decreases. This results in the decrease of the barrier height in the grain boundary and hence decrease of sensor resistance.

HUMIDITY AND TEMPERATURE SENSOR

Flow rate and volume of breath blow into the mouth piece can't be controlled and are different for each person. To compensate this, the effects of pressure, temperature and humidity levels have been considered for each and every person apart from the actual parameters (voltage and resistance) detected from the acetone sensor. DHT11 is a Digital Temperature and Humidity sensor from micropik. It measures humidity, ranges from 20-90% with a resolution of 1% at an accuracy of ±5 RH (Relative Humidity) and temperature from 0-50o C with a resolution of 1 at accuracy of ±2oC. The sensor is operated at 5V DC supply. DHT11 sensor sends 40bit data on a single data-line which includes 16 bit Relative Humidity (8bit integer RH data + 8bit decimal RH data), 16 bit Temperature (8bit integer temperature data + 8bit decimal temperature data) and 8bit checksum. The 40bit single data-line is connected to the microcontroller board to read the Relative Humidity and Temperatures. Each DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration. The calibration coefficients are stored as programmes in the OTP memory, which are used by the sensor's internal signal detecting process. The single-wire serial interface makes system integration quick and easy. Its small size, low power consumption and up-to-20 meter signal transmission making it the best choice for various applications, including those most demanding ones. The component is 4-pin single row pin package. It is convenient to connect and special packages can be provided according to users' request.

LCD DISPLAY

A liquid-crystal display (LCD) is a flat panel display, electronic visualdisplay, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements. A liquid crystal display or LCD draws its definition from its name itself. It is combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image.

IV. SOFTWAREREQUIREMENT

EMBEDDED C:

Embedded C is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded systems. Historically, embedded C programming requires nonstandard extensions to the C language in order to support exotic features such as fixed-point arithmetic, multiple distinct memory banks, and basic I/O operations. In 2008, the C Standards Committee extended the C language to address these issues by providing a common standard for all implementations to adhere to. It includes a number of features not available in normal C, such as, fixed-point arithmetic, named address spaces, and basic I/O hardware addressing. Embedded C uses most of the syntax and semantics of standard C, e.g., main() function, variable definition, datatype declaration, conditional statements (if, switch, case), loops (while, for), functions, arrays and strings, structures and union, bit operations, macros,etc.

INTERNET OF THINGS :
IoT is the network of physical devices, vehicles home appliances and other items embedded with electronics, sensors, software, actuators and connectivity which enables these object to connect exchange data each thing is uniquely identifiable through its embedded computing system but is able to inter-operate within the existing internet infrastructure the IoT allows object to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer based systems, and resulting improved efficiency, accuracy and economic benefit in addition to reduce human interventions. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities.

V. METHODOLOGY

The analysis of ketone level from the breath is based from the resistance of the gas sensor. FIGARO TGS 822 gas sensor is used to detect the amount of gas acetone in a person's breath. When the concentration of the acetone gas increases, the resistance of the sensor is decreased [15]. The decrease of resistance is depending on the three factors; gas concentration, humidity and temperature.

In order to get an accurate concentration of acetone gas in a person's breath, humidity and temperature sensor (DHT11) is added. This is due to the sensitivity of the electrochemical gas sensor towards other gasses other than acetone. As the reading from sensor is sent to Arduino, the data is shared to the database via Wi-Fi module ESP8266. ESP8266 gives Wi-Fi networking with TCP/IP protocol .

VI. PROPOSED SYSTEM

For analysis of glucose levels from the breath, we considered a total of four parameters from three different sensors: Voltage and resistance from acetone sensor (Figaro TGS822) and temperature & humidity from DHT11 sensor. A 215 cm3 mouth piece was designed and three sensors were placed inside the mouth piece for analysis.

Due to the presence of sensors inside the mouth piece the volume of this test chamber is taken to be approximately 200 cm3. All the three sensors data were given to the controller board (Arduino Uno) as shown in Figure 1

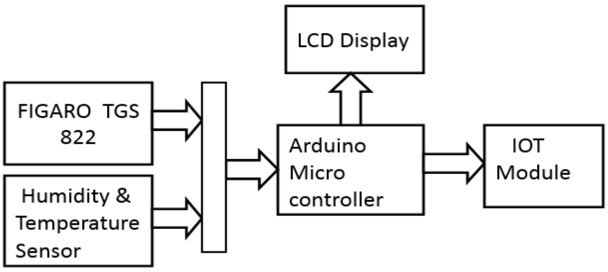

FIGURE 5.1 BLOCK DIGRAM

The invasive technique causes discomfort while going for a continuous testing and it is not suitable for children's who are affected by diabetes rarely. Many noninvasive techniques are available but those techniques have its own drawbacks. Now we propose a system not only to diagnose the diabetes mellitus and also to overcome all the limitations associated with the existing systems of diagnosis. It's also used to monitoring the temperature, humidity level in breathing which is mainly in order take prevention to avoid calibration error to get a accurate output which is necessary in healthcare sector.

VII. CONCLUSION

Based on the results, it can be concluded that the measurement of the amount of breath acetone method to determine the ketone level of diabetic patients is applicable as there is a good correlation between breath acetone levels and blood ketone levels (β-hydroxybutyrate). The real-time monitoring system for diabetes condition is able to perform with the function of Internet of Things (IoT). The effectiveness of the personal diabetes monitoring via web database has been demonstrated. The test results show that it is possible to monitor the ketone levels by measuring the amount breath acetone. The accuracy of the system can be improved by having a better algorithm in calibrating the sensor. For future works, it is possible to make a breath-based monitoring system for these types of diseases too. Besides type 1 diabetes, researchers has suggested breath tests can also be used to detect other diseases such as colorectal cancer, lung cancer, obesity, lactose intolerance and fructose intolerance [21]. Furthermore, the application of the Internet of Things can be further used by creating a mobile application for more efficient personal monitoring system. The mobile application can retrieve the data and information from the database and the user can check their health condition in a more interactive display.

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