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DETECTION OF KETOSIS USING NON-INVASIVE METHOD

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ABSTRACT

In recent years, lifestyle related illness have become more pronounced as social problems and with obesity as a root cause of number of illness, there has been growing demand for technology that enable easy and quick checking of the state of fat burning in the body. Responding to this we have prototyped a design of handy and non-invasive instrument for the measurement of acetone in the human breath, which is useful for ketosis monitoring & control. This instrument's purpose is to detect amount of acetone in human breath. It utilizes electrochemical sensors to detect acetone in human breath. By measuring the amount of breath acetone gas present in a person's breath, it should be possible to determine whether or not a person is in a state called ketosis. Ketosis is, very simplified, when the body runs on fat rather than carbohydrates. Currently, the only way to monitor your ketone levels are either to take a blood based test or a urine based test. The device we proposed in this article is portable, fast and easy to operate. Results of this instrument can be used to offer diet support programs tailored to individual user's metabolism, exercise tolerance and so forth. We hope this system could contribute a step towards a practical system that could be used for diabetes screening.

Keywords: Ketosis monitoring, Arudino, Acetone level, Nano powders, Gas sensors

1. INTRODUCTION

Accounting for the greater part of national medical expenditure, general medical costs have been steadily increasing in recent years. About one-third of these costs are due to lifestyle-related illnesses. Lifestyle-related illnesses are diseases such as cancer, heart disease and cerebrovascular disease whose pathogenesis has a close relationship with an individual's lifestyle including diet, exercise, smoking and drinking and so forth. Thus, altering an individual's lifestyle can act as preventive care to prevent the onset of disease, or retard its advance.

For preventive care to be successful, simple and easy-to-use devices that enable users to check and confirm the state of their health in detail on a daily basis, and advisory services tailored to the health conditions of the individuals must be provided.

Nearly 10 lakh Indians die due to Diabetes every year, So the detection of Ketosis helps to control diabetes. Present methods are inconvenient and painful. Constant monitoring of the blood glucose level can be easily achieved through a non-invasive and portable ketosis detector.

The purpose of this prototype model is to find out whether the user is in Ketosis state or not. Ketosis state is identified by measuring the quantum of the acetone level present in the exhaled air of a person. Acetones are generated in human body when our body burns fat. (Normally, our body gets energy from body sugar, when its level falls, followed by the start of the process of the burning of the fat). Burning fat condition is possible when the user in hunger state or when the person does some exercise.

Assume one's mind feels as if one is in a hungry state. But the acetone is low when measured, indicating the presence of sugar level sufficient for conversion into energy, with really no need to have food or do any exercise. Consuming food unknowingly may result in over-weight and any exercise done at this stage helps only in the burning of the body sugar but not fat. Alternatively, acetone level when measured is found to be high and the need to burn out fat forthwith. Hence doing exercise or taking food at this stage helps to reduce weight or to avoid over weight.

Additionally, when we compare the acetone level of body before and after doing exercise, and we notice is no change in the acetone levels, the indication is low level of the exercise load or duration of exercise as small.

In practical human life scenario, identifying ketosis state is done by taking blood samples (Invasive method). Hence, our prototype model, on the basis of the identification of ketosis, helps indicating the appropriate meal time or exercise duration for effective burning of body fat and eliminating obesity related problems.

Section 1 deals with the background, problem statement and objective of the paper. Section 2 deals with the literature review of the various technical papers used for our research work. Section 3 includes the project block diagram, circuit diagram and the flow chart of the software program. Chapter 4 explains the features of Hardware Components used in this project such as Arduino UNO, DHT 11 temperature and humidity sensor, TGS 822 sensor and LCD display. Chapter 5 explains the features of the software- Arduino IDE. Chapter 6 includes results and observation. Chapter 7 provides the conclusion of the project.

2. LITERATURE SURVEY

This literature review explores some basic knowledge about the most commonly existing techniques for the detection of ketosis using non-invasive method and ways to improve the presently existing techniques to make it more cost effective and efficient.

The work in [1] "Breath Acetone Analyzer to Achieve Biochip Mobile Terminal", explains ways to achieve a bio-chip mobile terminal that will enable health management and diagnosis through bio-chemical analysis of biological samples that can be collected easily. In recent years life-style related illnesses have become more pronounced as social problems, and with obesity as a root cause of a number of illnesses, there has been a growing demand for technologies that enable quick and easy checking of the state of fat burning in the body. It explains about the issues with breath acetone measurement, overview of the prototype, calibration of the measurement curve and service development.

The research work by Keyan and David Zhang on [2] "Blood Glucose Prediction by Breath Analysis System with Feature Selection and Model Fusion", explains the concentration of acetone in breath is correlated with the subject's blood glucose level (BGL). Therefore, noninvasive BGL monitoring of diabetics can be achieved by the analysis of components in breath. In this paper, a breath analysis device with 10 gas sensors is designed to measure breath samples. Transient features are extracted from the signals of the sensors. Sequential forward selection is applied on the features to find the most informative ones. In order to reduce the interference brought by the inter-subject variance of breath acetone, global and local BGL prediction models are built and fused. The two models are based on different training strategies and have different advantages. Experiments were conducted using 203 breath samples from 36 diabetic subjects. Results show that the accuracy of the proposed feature is better than other similar features and the model fusion strategy is effective. The mean absolute error and mean relative absolute error of the system are 2.07 mmol/L and 20.69%, respectively.

The work in [3] explains a noninvasive breath analysis system for diabetes diagnosis is proposed in this paper. It utilizes commercial chemical sensors to detect acetone in human breath. The device is portable, fast and easy to operate. Experiments with real breath samples from both inpatient and outpatient diabetics validated the accuracy of this system. An optimal sensor array for diabetes diagnosis is decided according to the classification accuracy. We hope this system could contribute a step toward a practical system that could be used for diabetes screening.

In [4] explains the various non invasive methods of detection, breath analysis presents an easier, more accurate and viable method in providing comprehensive clinical care for the disease and also examines the concentration of acetone levels in breath for monitoring blood glucose levels and thus predicting diabetes. The analysis uses the support vector mechanism to classify the response to healthy and diabetic samples. For the analysis ten subject samples of acetone levels are taken into consideration and are classified according to three labels which are healthy, type 1 diabetic and type 2 diabetic.

In [5] explains the design of a handy and noninvasive measurement of acetone in the human breath, which is useful for ketosis monitoring and control, by means of MOS sensors is reported. For this aim, highly sensitive resistive sensors in thick film configuration, fabricated depositing sensing layers of In_2O_3 and Pt-In_2O_3 nano powders by screen-printing, have been developed. The devices were calibrated using standard gases in the laboratory, showing high sensitivity and a linear response in the range of acetone concentration investigated (1–100 ppm). The results obtained indicate that MOS sensors based on Pt- In_2O_3 nano powders are promising as fast and quantifiable means of determining acetone in the breath, posing the advantages of real time measurements and low costs devices for the control of ketogenic diets.

3. IMPLEMENTATION

This section explains about the basic implementation and functioning of the project in detail which covers block diagram, connection diagram, description of major components and their part in the research work.

The simplified block diagram of the project is shown in figure 1 which contains TGS 822, DHT 11, Arduino UNO and LCD display.

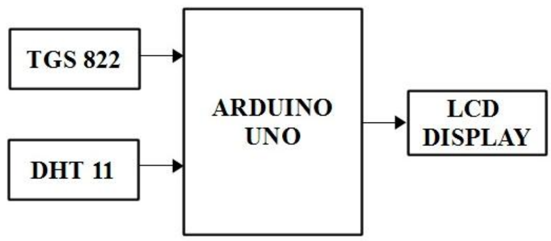

Fig.1 Block diagram

3.1 TGS 822- ELECTROCHEMICAL GAS SENSOR

This sensor works like a resistor, the higher the gas concentration is, the lower the resistance gets. It has 6 pins, the two middle pins are the power to the internal heater and the other is the resistor connections. There are two pairs of resistors connectors called “A” and ”B”, but they are essentially the same so I just soldered them together. It is very important that the power provided to the internal heater is exactly 5 Volts. We used an LM7805L voltage regulator to provide the power for both the TGS822 and the DHT11 sensor.

The TGS822 is connected to the Arduino on analog pin 0 in parallel with a 10k resistor to create a voltage divider circuit.

3.2 DHT11 – DIGITAL TEMPERATURE AND HUMIDITY SENSOR

We added the DHT11 sensor because the characteristics of the gas sensor changes depending on temperature and humidity. Since a person’s breath is both humid and warm, it was necessary to factor that in when trying to determine the gas concentration. We moved the temperature and humidity sensor to sit as far away from the gas sensor as possible.

The DHT11 is not very fast, especially when it comes to humidity. It can take about 2-3 minutes before the humidity reaches its max value. This presents a bit of a problem when it comes to scaling the reading from the gas sensor, depending of humidity from the DHT11. The gas sensor reaches its max value just seconds after you finished blowing into it. So if you read the DHT11 at the same time as the gas sensor reaches its max value, the humidity value will be to low because the DHT11 is slow.

The DHT11 sensor is connected to digital input pin 10.

4. RESULTS AND OBSERVATION

In this chapter we explain about the step by step procedure which must be followed for the acetone measurement and the results obtained for various subjects are discussed. The working model of the proposed prototype model is shown in figure 2.

After supplying power to the Arduino we should wait for sensor to get warm up, the warm up time required for TGS 822 is approximately 5 to 10 minutes. The display during warm-up is shown in figure 3.

The notations are

H- Relative Humidity in %

T- Temperature in ℃

Max- Maximum resistance value in Ω

Min- Minimum resistance value in Ω

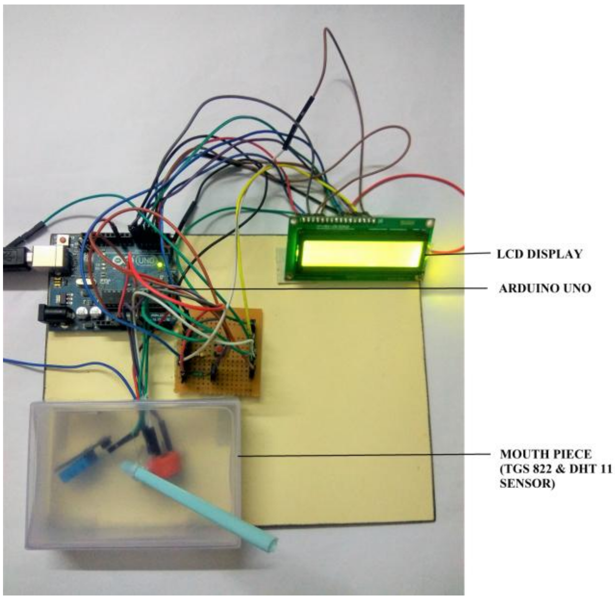

Fig. 2 Working model

Fig. 3 Warm-up

The sensor stability is achieved when a condition is satisfied, which is the difference between the maximum resistance value and minimum resistance value should be less than 5 for 20 seconds. If it does not satisfy the above condition then time again starts from 1 second and if it satisfies the above condition then we have to blow into the mouthpiece.

After we blow into the mouthpiece, the Arduino ta kes three samples in 5 milliseconds gap and check whether the values are same and changes the corresponding resistance value of sensor into ppm which is in turn converted into mmol/l and displayed. The display is shown in figure 4.

The notations are

R- Scaled resistance value in Ω

Now- Current acetone concentration in mmol/l

Max- Maximum acetone concentration recorded in mmol/l

Fig. 4 Final observation

Table 1 Subject sample values

SUBJECT NO.	AGE	ACETONE CONCENTRATION IN MMOL/L	
		BEFORE FASTING	AFTER FASTING
1	19	1.67	0.78
2	21	1.78	0.66
3	22	1.61	0.84
4	19	1.82	1.22
5	20	24.26	12.34
6	24	1.72	1.11
7	21	2.56	1.34
8	26	1.46	0.52
9	27	2.11	0.98
10	30	2.33	1.16
11	32	1.98	0.75
12	33	2.16	1.09
13	37	1.85	1.12
14	41	2.34	0.87
15	42	10.45	4.42
16	44	1.73	0.43
17	47	2.22	1.11
18	49	1.78	0.74
19	51	2.60	1.35
20	56	3.22	1.66

Here the resistance value is scaled according to the temperature and humidity. Here the temperature and humidity are hardcoded to approximate value because of the reaction time difference between the sensors. Finally the acetone concentration is displayed in mmol/l which helps us to find whether a person is in ketosis state or not.

Several subjects of different age groups were allowed to blow into the mouthpiece before and after fasting and their acetone concentrations are noted which is given in the table 1

From the above measurement values we can set the threshold of acetone level as 1.5 mmol/l. Below threshold the person is considered normal and there is no necessity to intake ketogenic food. Above the threshold value indicates lack of sugar in our body so we have to consider eating ketogenic diet.

5. CONCLUSION

The display shows the concentration of acetone in mmol/l. From the result we can infer whether a person is in ketosis state or not, which helps the person to keep his body fit in turn to control diabetes. Further the proposed work can be extended and the future works are discussed below

- Construction of battery powered device
- Replacement of Arduino UNO with Micro Controller
- Miniaturization of the circuit
- Fine tuning of the scaling function matching invasive method results
- Increasing accuracy by adding bio-metric sensor

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