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Compact Health Care System

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Abstract
The never-ending list of diseases is growing each day. It has become important for us to monitor our health condition regularly as it not only helps us to prevent diseases but also detect diseases which do not have any visible symptoms. One such main disease is diabetes which is a real test for the current century. It is a disease which is non-infectious and non-transmissible and is a major contributor to stroke, kidney disease, vision loss, vascular disease and heart disease. It's a rapidly-growing condition, approximately 500 million people around the world, including Fifty million Indians, are diabetes victims. The conventional method of measuring blood glucose is uncomfortable and painful as individuals need to poke their finger to draw blood regularly for calculating glucose concentration. Non-invasive blood glucose measurement can diminish this pain and also reduce the cost of measurement as non-invasive glucometer does not need fresh testing strips for each test. In the proposed project, we have designed a system that can measure the blood glucose level with the help of NIR spectroscopy. A NIR Led is used to pass IR radiations into the finger, the intensity of this radiation depends on glucose concentration in the blood. The IR light passes through the finger, after amplification and filtering we get output voltage signals. Using regression analysis, the unknown glucose value is determined from the unknown voltage level. It then communicates the detected blood glucose level into the smartphone through the wireless channel for output monitoring. Along with this infrared temperature monitoring unit and heart rate monitoring units have also been employed to help achieve the monitoring of different health parameters in the same system.

Keywords: *Health monitoring, Diabetes, Non-invasive glucometer, Regression analysis, ESP32, Body temperature, Heart rate.*

1. INTRODUCTION

The food we eat contains several essential nutrients such as proteins, fats, vitamins, carbohydrates and minerals. During digestion, a carbohydrate which is a macronutrient is broken down into glucose, for this glucose to enter body cells we require a hormone known as insulin which is secreted by the pancreas. Diabetes is a health condition which occurs when the pancreas cannot secrete insulin leading to abnormal blood sugar levels. Diabetes is categorized as type 1, type 2 and gestational. Type 1 is an autoimmune response where the patient's body destroys its insulin-producing cells known as islets of Langerhans. This type is not because of the patient's diet or lifestyle and has no cure. The patient needs to administer insulin dose via syringe or pump regularly. Type 2 diabetes occurs comparatively at an older age and is because of an unhealthy diet, lack of physical activity and lifestyle changes. Depending on the level of blood sugar, they can keep this under control by using medications or by administering insulin doses. Gestational diabetes occurs in pregnant women and causes complications to both mother and child. This usually is cured after pregnancy, but women who had gestational diabetes are at greater risk of developing type 2 diabetes. Diabetes can lead to serious outcomes such as a heart attack, blindness, kidney failure and stroke and should be monitored and treated accordingly. According to reports by the World Health Organization and International Diabetes Federation, 463 million people in the world are diabetic patients, which are 1 in 11 people. 1 in 2 adults with diabetes are undiagnosed (223 million). [1] To combat diabetes along with healthy food (low carb levels), proper exercise, losing weight one needs to properly monitor blood glucose levels regularly. Determining one's sugar level is known as-Self Monitoring of Blood Glucose (SMBG). It is important to perform structured self-testing of blood glucose as it would help them achieve better glycemic control, detect and prevent hypoglycemia and hyperglycemia, analyze and understand body response to

exercise, blood sugar variation after meals and diabetic drugs. Testing of blood sugar alone is not enough to bring glycemic levels to a normal range. Along with it, one also needs to document the results so they can test what is working for them and what is not. With diabetes, structure leads to success and the first step towards improvement is measuring the blood sugar levels. One of the most common techniques used in medicine to determine if an individual is affected by some disease is to measure that person's body temperature. Fever is an immediate response of the body if it is infected by the external pathogen. So measuring body temperature can tell a lot about a person's health condition. Heart rate is a common parameter used to determine a person's heart function as it can help determine cardiac output and stroke volume. Thus in this project, we propose a system which can determine three parameters which are body temperature, heart rate, blood glucose level and also displays it in a mobile interface.

2. LITERATURE SURVEY

In this paper [5] they have built a cheap wearable system for monitoring blood glucose non-invasively. The paper is based on the theory that change in blood volume in arteries leads to a change in blood glucose levels. They have opted for Vis-Nir spectroscopic technique in the wrist region as it provides better resolution. They have placed IR Led and photodiode on the same side making it diffused reflectance-based design for determining output. Several output spectra have been obtained by performing in-vivo experiments on 12 patients and resultant values are documented. In paper[2] the glucose level of the blood is determined using a diffused reflectance method. They have designed a system that takes measurements from the finger using 940nm IR led and detector pair placed opposite to each other. The output data is filtered using a notch filter, processed and analyzed using Arduino microcontroller. The final signal is displayed using an LCD module. The paper [3] they have studied the different available glucose measurement techniques such as invasive, non-invasive and minimally invasive options. In paper [4] they have reviewed the various continuous glucose monitoring techniques. They have discussed the purposes, problems, accuracy and outcomes of systems based on continuous glucose monitoring systems. In paper [6] Near-infrared (NIR) technique is used for designing blood glucose monitoring unit. At first 940 nm wavelength optical signal in the IR region of the electromagnetic spectrum is passed through the arm, the earlobe and the finger using a NIR led. Arduino Uno microcontroller then processes the signal and produces the output. It is then sent to a web server via GSM module, simultaneously the patient also gets SMS notification along with appropriate medical advice regarding blood glucose levels.

3. HARDWARE DESIGN

The proposed system of determining blood glucose level non-invasively can be elucidated with the help of the following block diagram:

- The NIR region of electromagnetic spectrum can be in turn divided into three regions-region 1(800-1200nm), region 2(1200-1800nm) and region 3(1800-2500nm)[14]. Led of 940nm wavelength has been selected as OPT101 Photodiode has an absorption peak in this region and this wavelength does not interfere with absorption peaks of water(1450nm, 1787nm), protein(2174nm,2288nm) and fat(2299nm, 2342nm)[15, [16]. The led is placed opposite to the photodiode in an enclosure with a minimum possible gap between the two exactly enough to place a finger to maximize the accuracy of the system.

- OPT101 monolithic photodiode has been chosen as a suitable photodiode for this project. It is a lightweight and low-cost module with a built-in trans-impedance amplifier. This eliminates the need for additional amplification circuitry. It is sensitive to a wide range of electromagnetic spectrum with the absorption peak being at the infrared region. Thus it should be enclosed completely to prevent other wavelengths from interfering in the output.

- The following 50hz notch filter was integrated into the module to eliminate noise due to power line:

  To determine R, C values:

$$F=(1/4\pi RC)$$
$$F=50\ Hz$$
Let C=0.1uf
$$50=1/(4(3.14)(R)(0.1*10-6))$$
$$R=1/(50)(4)(3.14)(10-7)$$
$$R=15.923KOhm$$
$$R=16KOhm$$

- Mlx90614 sensor has opted for temperature sensing. It is a non-contact IR temperature sensor. It is a small size, a low-cost sensor which is easy to integrate with any module. It has an accuracy of 0.5°C thus making it highly suitable for body temperature measurements. It has an ambient temperature range of (-40-125) °C and objects temperature range of (-70-380) °C. It works using I2C communication protocol and thus uses minimum wiring in the circuit.

- Max30100 sensor has been chosen as the ideal option for heart rate sensing as it is a low-cost sensor which can also be used for pulse oximetry measurements. It uses a combination of 2 LEDs and a photodetector. It has an operating voltage range of 1.8-3.3v thus providing better battery performance to the entire system. For it to operate properly in a system having input voltage greater than 1.8v, the onboard SMD resistors have to be unsoldered and external pull-ups of 4.7v needs to be used in sda,scl and int pins for it to operate properly.

- ESP32 has been chosen as a microcontroller for this system as it is low cost and low power system. It has inbuilt Wi-Fi and Bluetooth connectivity with 30 GPIO pins. It supports a wide range of communication protocols like I2C, SPI, UART thus making it suitable for this project. It can be interfaced and coded using Arduino IDE so it is easy to program and attach peripherals. For all of the above benefits and as a system can be made compact if this microcontroller is employed this has been chosen for our design.

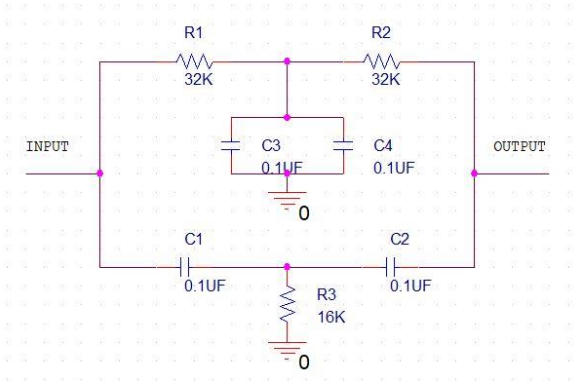

Fig. 1. Notch Filter Circuit diagram

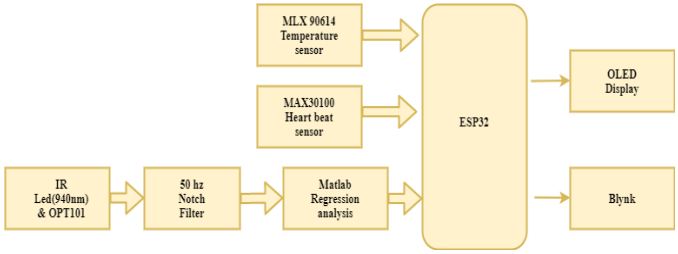

Fig. 2. Block diagram of the proposed system

The proposed system measures and determines the blood glucose level with the help of regression analysis. Body temperature is measured using non-contact MLX90614. Heart rate is determined using MAX30100 sensor. All parameters can be monitored using a single unit. The determined level is then wirelessly communicated to a mobile interface. The user can then monitor the user-friendly representation of the glucose level, the temperature and heart rate in the output device.

4. ADVANTAGES

- Non-invasive in nature and requires no pricking or injections, pain-free
- A cost-effective system which does not require multiple strips for measurement
- No biomedical waste is generated
- Portable and environment-friendly
- Real-time data is available in both web and mobile platform
- Probability of human error is reduced
- Self-diabetes management is easier
- Documentation of data is automated thus requires less human effort
- Biotelemetry is easier for medical analysis of data

CONCLUSION

In this paper, we have designed a health care system that can non invasively monitor blood sugar using the near-infrared technique, body temperature and heart rate. As the system is simple it can inturn also be developed into a wearable device. This prototype is developed using ESP32 microcontroller, thus making this a unique cost-effective device.

REFERENCES

[1] IDF, https://idf.org/aboutdiabetes/what-is-diabetes/facts-figures.html
[2] Mohammed Shahriar Arefin, Adnan Hossain Khan, and Rabiul Islam, " Non-invasive Blood Glucose Determination using Near-Infrared LED in Diffused Reflectance Method" in 10th International Conference on Electrical and Computer Engineering 20-22 December 2018, Dhaka, Bangladesh
[3] David C.Klonoff "Continuous Glucose Monitoring Roadmap for 21st-century diabetes therapy" in DIABETES CARE, VOLUME 28, NUMBER 5, MAY 2005
[4] Raju Poddar, Joseph Thomas Andrews, Pratyoosh Shukla, Pratima Sen "Non-invasive Glucose Monitoring Techniques: A review of current trends " in arXiv:0810.5755v1 [physics.med-ph] 31 Oct 2008
[5] Vega Pradana Rachim, Wan-Young Chung "Wearable-band Type Visible-Near Infrared Optical Biosensor for Non-invasive Blood Glucose Monitoring" in Sensors and amp; Actuators: B. Chemical (2019), https://doi.org/10.1016/j.snb.2019.01.121
[6] Md. Mahbub Alam, Swapnil Saha, Proshib Saha, Fernaz Narin Nur, Nazmun Nessa Moon, Asif Karim and Sami Azam " D-CARE: A Non-invasive Glucose Measuring Technique for Monitoring Diabetes Patients " in Uddin M., Bansal J. (eds) Proceedings of International Joint Conference on Computational Intelligence. Algorithms for Intelligent Systems. Springer, Singapore
[7]M. S. Asekar, "Development of Portable Non-Invasive Blood Glucose Measuring Device Using NIR Spectroscopy," 2018 Second International Conference on Intelligent Computing and Control Systems (ICICCS), Madurai, India, 2018, pp. 572-575.
[8] C. Sreenivas and S. Laha, "Compact Continuous Non-Invasive Blood Glucose Monitoring using Bluetooth," *2019 IEEE Biomedical Circuits and Systems Conference (BioCAS)*, Nara, Japan, 2019, pp. 1-4.

[9] B. Sargunam and S. Anusha, "IoT Based Mobile Medical Application for Smart Insulin Regulation," *2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT)*, Coimbatore, India, 2019, pp. 1-5.
[10] Saina Sunny, S.Swapna Kumar "Optical Based Non-Invasive Glucometer with IoT" in *2018 International Conference on Power, Signals, Control and Computation (EPSCICON)*, Thrissur, 2018, pp. 1-3.
[11]K. T. Sithara Surendran and T. Sasikala, "Sensor system based Non-Invasive System to Measure Glucose Level in Human Body," 2019 3rd International Conference on Computing Methodologies and Communication (ICCMC), Erode, India, 2019, pp. 203-207.
[12]K. Lawand, M. Parihar and S. N. Patil, "Design and development of infrared LED based non-invasive blood glucometer," 2015 Annual IEEE India Conference (INDICON), New Delhi, 2015, pp. 1-6.
[13]B. L. Priya, S. Jayalakshmy, R. Bhuvaneshwar and J. K. Kumar, "Non – Invasive Blood Glucose Monitoring based on Visible LASER Light," 2018 3rd International Conference on Communication and Electronics Systems (ICCES), Coimbatore, India, 2018, pp. 938-941.
[14]Ozaki Y. Near-infrared spectroscopy--its versatility in analytical chemistry. Analytical Sciences: the International Journal of the Japan Society for Analytical Chemistry. 2012;28(6):545-563. DOI: 10.2116/analsci.28.545.
[15]Omar S Khalil, Spectroscopic and Clinical Aspects of Noninvasive Glucose Measurements, *Clinical Chemistry*, Volume 45, Issue 2, 1 February 1999, Pages 165–177
[16] D Ramesh, D Jose, Keerthana, V Kishnaveni, Detection of pulmonary nodules using thresholding and fractal analysis, Computational Vision and Bio Inspired Computing, Pages, 937-946, 2018