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Review onNon-Invasive Blood Glucose Level Monitoring Using IoT

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ABSTRACT*: Frequent Finger pricking is a challenging problem in obtaining sugar level of the patients. It is routinely carried out in differenthospitals, research institutes, laboratories, etc…. Blood plays an important roleinobtaining the sugar levelof the patients. This paper reviews the literature based onnon-invasiveblood glucose monitoring using IoT. The objective is to study different methodologies of non-invasive methodand identifyfutureresearchdirections.*

KEYWORDS: *Finger pricking, Blood, Non-Invasive.*

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I. INTRODUCTION

Diabetes is one of the most challenging disease in 21st century healthy field due to number of patients increasing now a days. Early detection of diabetes is very important in now a days.Finger prickingisaverycommontaskperformedinhospitals for obtaining the sugar level.Frequently the sugar test need to be done for 5 to 10 times a day for the person affected with hypoglycemia, hyperglycemia, type 1 and type 2, diabetics patients. This result in development of massive scarring/callous formation and loss of sensibility/perception hindrance to patients.

This paper reviews, the noninvasive glucose sensor is employed to detect the quantity of sugar levels in the body. Also presents the microcontroller to preprocess the sensor data and preprocessed data is updated to IOT. The creation of a non-invasive and reliable system for diabetic patients who are required to use this invasive procedure are going to be sigh of relief. Furthermore, microcontrollercontrol the insulin infusion system attached to the user. When the quantity of glucose detected above, the traditional level turned on automatically and insulin was admitted into the vein of the patient.

Pricking the finger tip several times per day for many years/decades is not only annoying to the patient but also has certain consequences: (1) development of massive scarring/callous formation and (2) loss of sensibility/ perception hindrance. The pain associated with finger pricking is most probably the main reason (besides the costs) why patients refrain from SMBG. In turn, such a reduced measurement frequency has a negative impact on metabolic control. The pain might also induce a negative perception against diabetes and its therapy in general. Keep in mind how difficult it is to convince children to measure BG levels several times a day. This induces a lot of trouble in families with diabetic children. Most likely it is more the finger pricking that is the negative symbol for diabetes than the (more or less pain free) subcutaneous injection of insulin. It might not be a nice comment; however, if diabetologists/scientists would have to prick their fingers several times a day, this probably would change their attitude about finger pricking somewhat.

Scientists and physicians have been documenting the condition now known as diabetes for thousands of years. From the origins of its discovery to the dramatic breakthroughs in its treatment, many brilliant minds have played a part in the fascinating history of diabetes. The first known mention of diabetes symptoms was in 1552 B.C., when Hesy-Ra, an Egyptian physician, documented frequent urination as a symptom of a mysterious disease that also caused emaciation. Also around this time, ancient healers noted that ants seemed to be attracted to the urine of people who had this disease.

In 150 AD, the Greek physician Arateus described what we now call diabetes as "the melting down of flesh and limbs into urine." From then on, physicians began to gain a better understanding about diabetes. Centuries later, people known as "water tasters" diagnosed diabetes by tasting the urine of people suspected to have it. If urine tasted sweet, diabetes was diagnosed. To acknowledge this feature, in 1675 the word "mellitus," meaning honey, was added to the name "diabetes," meaning siphon.

A glucometer is a small, portable device that lets you check your blood sugars (glucose levels) at home. Your healthcare provider will show you how to use a glucometer. First, you'll put a test strip in the device. Then you'll prick your finger to get a small drop of blood that you can put on the strip so it can be analyzed by the glucometer. Also called glucose meters, these devices can tell you in seconds if your blood sugar is too low, too high, or on target. No matter what type of diabetes you have, a glucometer can give you valuable information.

Non-invasive blood glucose monitoring, as its name implies, refers to the detection of human blood glucose without causing damage to human tissues. There are lots of methods for non-invasive blood glucose detection, which can be generally divided into optical methods, microwave methods and electrochemical methods. Optical methods include near-infrared reflectance spectroscopy (NIRS), polarized optical rotation, Raman spectroscopy, fluorescence, optical coherence tomography (OCT) and so on.

In addition to glucose in human blood, there are also considerable amounts of glucose in other biofluids (such as saliva, tears, sweat, and ISF). Utilizing the coherent correlation between biofluids and blood glucose value, the electrochemical method usually measures the glucose content in body fluids first and obtains the blood glucose value indirectly after the calibration of the algorithm or data model.

The range of glucose in ISF is the closest to the range of blood glucose in both healthy and diabetic, which provides a theoretical basis for the development of an ISF glucose sensor. However, a large number of research works have shown that there is a time-lag phenomenon between the ISF glucose and blood glucose, that is, ISF reflects the change of blood glucose level with a certain delay, which ranges from about 4–10 min. Transdermal biofluid extraction generally adopts reverse iontophoresis (RI) technology, which can achieve the purpose of rapid extraction of ISF.

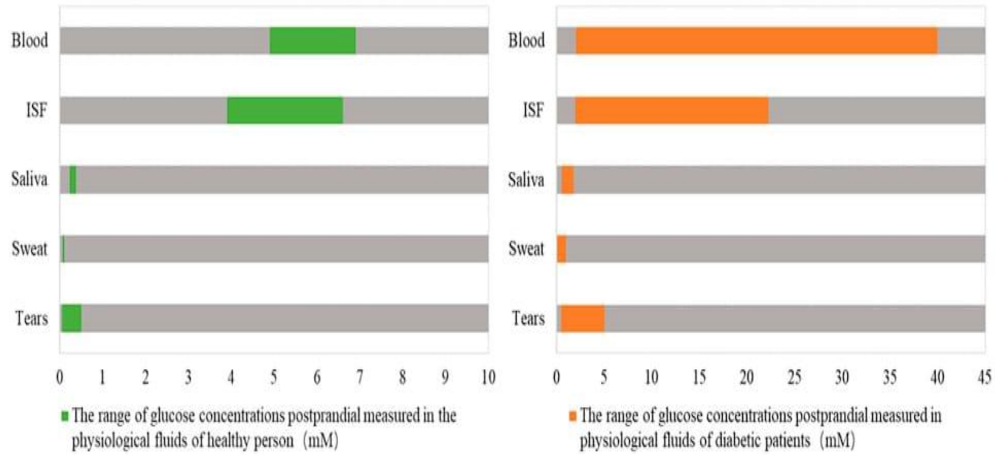

FIG.I. Range of glucose concentration

II. FRAMEWORK

ThegeneralmethodforNon-invasive sugar testingfollowsthefollowingframework:

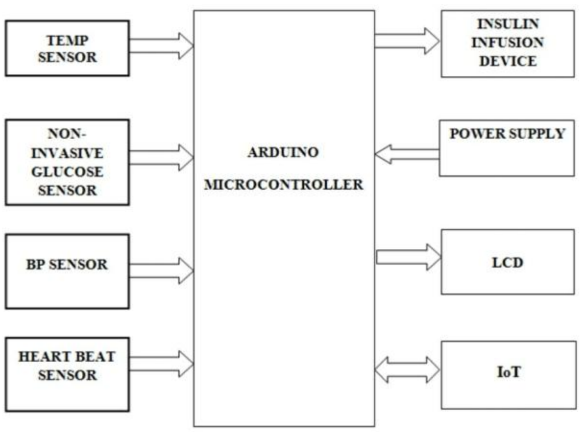

FIG.II. GeneralizedFrameworkforNon-invasive blood glucose meter

1. Arduino:Arduino consists of both a physically programmable circuit board and a bit of programming integrated in our device, used to import the actual board's computer code. It gets data from sensor and procedure on it.

2. Heart beat sensor:Heart beat sensor chips away at an extremely essential guideline of optoelectronics. Everything necessary to gauge of optoelectronics. Everything necessary to gauge you pulse is a couple of LED and LDR and a microcontroller. IR drive emanates energy from the inflator and absorbs the infrared light from the air. The pulse sensor is attached to the Arduino. There are three pins to the pulse reader. Attach 5V and the pulse sensor ground pin to Arduino's 5V and field, and the signal pin to Arduino's A0.

3. Temperature sensor:The LM35 is one kind of Temperature sensor commonly used, Which can be want to measure temperature with an electrical o/p close to air. It can measure temperature by comparing and thermistor all the more efficiently.It sensor provides a high yield voltage relative to thermocouples, and may not need a raise in voltage.The LM35 has a yield voltage that fits the temperature in Celsius. The criterion size is .01v/c.

4. Force sensor:This is a force-sensitive resistor with a round sensing region of 0.5" diameter. This FSR can adjust the resistance based on applied pressure. This FSR will sense the force applied anywhere within the range of 100g-10kg. It will act as a BP measure sensor.

III. LITERATUREREVIEW

1. Liu Tang, Shwu Jen Chang, Ching-Jung Chen, Jen-Tsai Liu introduced the method Blood Glucose Monitoring through Saliva, The International Diabetes Federation estimates 382 million people worldwide had diabetes in 2013, and the number is forecasted to reach 592 million by 2035 (a 55% increase). There were 5.1 million diabetes-related deaths globally in 2013, equaling to one death every 6 s, an 11% increase over 2011. Early diagnosis, on-time treatment and continuous management are vital to patients' life quality and to avoid complications such as circulatory problems, kidney failure, heart disease, stroke, and blindness. Current practices for diabetes management rely on monitoring blood glucose levels. In our study, the fasting salivary glucose levels of two healthy young individuals were found to be between 0.6 and 1.2 mg/dL and it was consistent with the results reported by other groups using different salivary glucose sensing methods. The peak salivary glucose concentrations after subjects taking regular meals or 75 g glucose tolerance beverage could reach 1.1 mg/dL and 2.8 mg/dL respectively. However, even higher levels of fasting salivary glucose of non-diabetic subjects (ranging 3–12 mg/dL) were also reported. The studies were done in Iran and India with different age groups being compared. The reason of their much higher fasting salivary glucose levels is most likely due to their carbohydrate-rich dietary pattern of the Iran and Indian population. Thus, we believe subjects' age, living regions, and life styles including their dietary patterns play important roles in their glucose tolerance levels.

2. MasoudBaghelani, Zahra Abbasi, MojganDaneshmand, PeterE.Light presented the method of Blood Glucose monitoring using a chip less printable sensor based on split ring microwave resonators, The World Health Organization estimates that there are > 500 M people worldwide who have diabetes1. Diabetes is primarily characterized by poorly controlled blood glucose concentrations that, if allowed to remain chronically high (hyperglycaemia), result in the development of serious and life-threatening diseases such as stroke, heart attack, heart failure, kidney failure, adult blindness and amputation2. Moreover, many patients also experience episodes of very low blood glucose (hypoglycaemia) that can rapidly lead to coma and death3. The most common glucose-sensing technology in use today are finger-prick based glucose strips, although this requires sampling many times per day and the continual purchase of the consumable once-use strips.According to conductivity increasing of the samples, the amplitude of the notch frequency is increased. For this experiment, a shaved mice skin with about 300 μm thickness wrapped inside a sealed plastic bag is used between the sensor and the liquid. Hence, the sample is located in further distance from the sensor. As illustrated in Fig. 8, the sensitivity of the sensor is decreased with the same justification as Fig. 2 as the result of increasing the distance between ISF sample and the sensor. However, the sensitivity of the system to changes in glucose concentration is still superior to other non-invasive technologies published to date.

3. ZhanxiaoGeng, Fei Tang, Yadong Ding, Shuzhe Li, Xiaohao Wang published the method of Glucose Monitoring Using a Multisensor-Based Glucometer and Time Series Analysis, As a global chronic disease, diabetes is associated with high morbidity1 and cannot be fully cured with current technology2. Within the years before onset, diabetes manifests as impaired glucose tolerance (IGT). People with IGT comprise an even

larger group than those with diabetes and suffer a significantly increased risk of cardiovascular disease (CVD) compared with people with normal glucose3. Testing the postprandial glucose profile is an important method of evaluating glucose tolerance4. Researchers have shown that a delayed peak time of postprandial glucose indicates degraded cellular function and worse glucose tolerance5,6. Continuous glucose monitoring can promote the timely detection of IGT and thus, the adjustment of lifestyle to prevent or delay the progression to diabetes4,5,7,8,9,10.To compare the estimation results of the single-feature model and multi-feature fusion, the results of each estimation were investigated separately. We compared the estimation result of multi-feature fusion and the best estimation result of single-feature models. For each volunteer, each group of experimental data was used for modelling, while the remaining groups of data were used for estimation. Therefore, there were three groups of modelling and six groups of estimations for each volunteer. There were 54 estimations in total for nine volunteers. When using single-feature model, the optimal feature obtained from different experiments differed.

4. Maria Valero, Priyanka Pola, Liang Zhao introduced the method of Glucose measuring by laser technology based on near-infrared spectroscopy. Diabetes is the biggest health challenge of the 21st century. It is the major cause of blindness, obesity, ageing population, heart disease, stroke, amputations and renal failure in the world. Diabetes affects the bodies ability to produce or utilize insulin, a hormone that is needed to properly process blood glucose. As a result, diabetics must regulate their own blood sugar levels through diet and insulin injections. The key point in the regulation of blood sugar is the accurate measurement of the blood sugar level.To obtain the calibration model between reals GCB readings and PPG voltages readings, regression analysis was done in MATLAB. Figure 10 shows a regression analysis example of a subject which indicates that voltage PPG reading increases with the increase of real BGC. The regression coefficients were calculated from (8) and (9) and were substituted in (7) for the prediction of non-invasive glucose concentration. When the system was fully calibrated, the validation data sets for each subject were used to test the performance of the measurement model. The measurements presented in Table 1, this table shows some of the benchmarking test results between commercially invasive glucometer and our proposed non-invasive NIR sensor. The comparison between the predicted values and the real values of blood glucose concentration.

5. Shyqyrihaxha, Jaspreetjhoja presented the method of Optical Based Non-invasive Glucose Monitoring Sensor Prototype, Diabetes is also known as Diabetes Mellitus (DM). It is a medical condition which occurs when the body is unable to regulate blood sugar levels. There are two types of Diabetes: type-1 and type-2. Diabetes type-1 is a condition when the body is unable to produce any insulin which is used to regulate the blood sugar levels. Insulin is an essential for human body to convert glucose into energy [2]. Diabetes type-2 occurs when the body is not making enough insulin or is making insulin which is repelled by the body [3]. This usually occurs in people 40+ years of age. Diabetes type-2 is spreading worldwide more rapidly than type-1. This research successfully demonstrated the relationship between the sensor output voltage and the glucose concentration, where the sensor output voltage increases as the glucose concentration increases, which have been verified and demonstrated by in-vitro experiments. The proposed non-invasive glucose monitoring system has low manufacturing and maintenance cost and showed good accuracy in vitro. The demonstrated results of the proposed non-invasive glucose sensor prototype show a very promising future for the implementation of NIR technology in biomedical field especially in optical spectroscopy for real-time and continuous non-invasive glucose monitoring. Our proposed NIR spectroscopy experiment demonstrates a great potential for non-invasive continuous monitoring of the glucose levels in the human body.

6. Amay J. Bandodkar, WenzhaoJia published the method of Tattoo-Based Noninvasive Glucose Monitoring.We present a proof-of-concept demonstration of an all-printed temporary tattoo-based glucose sensor for noninvasive glycemic monitoring. The sensor represents the first example of an easy-to-wear flexible tattoo-based epidermal diagnostic device combining reverse iontophoretic extraction of interstitial glucose and an enzyme-based amperometric biosensor. In-vitro studies reveal the tattoo sensor's linear response toward physiologically relevant glucose levels with negligible interferences from common coexisting electroactive species.This preliminary investigation indicates that the tattoo-based iontophoresis-sensor platform holds considerable promise for efficient diabetes management and can be extended toward noninvasive monitoring of other physiologically relevant analytes present in the interstitial fluid.the tattoo-based iontophoretic-biosensing system was evaluated toward noninvasive glucose monitoring in human subjects and was validated by simultaneous blood fingerstick measurements using a commercial glucose meter. The specificity of the tattoo GOx sensor was validated by applying it simultaneously with an enzyme-free tattoo sensor (no GOx control) on human subjects. The requirement of performing reverse iontophoresis prior to detection was demonstrated by analyzing the sensor response with and without active extraction of glucose ISF toward the sensor surface.

7. Sathiyanarayanan, Sivagnanam.R, Smrithisri.V.K, Dr.V.Thulasi Bai presented the method of Smart Phone based Non-Invasive glucose monitoring, a model which can be cost effective and non-obtrusive prototype utilizing NIR spectroscopy methodology. Also, Mobile application is utilized to show the Glucose esteem and to store the estimated data for future records. Through which the client can distinguish the glucose level to keep up the regiment regimen at opportune time. It includes a sensor for noninvasive blood glucose and bilirubin measurement using near-infrared spectroscopy and optical method, respectively, communicating with a smartphone.It was observed that by increasing the glucose concentration, the output voltage of the sensor increases in transmittance mode and decreases in reflectance mode. Moreover, it was observed that by increasing the bilirubin concentration, the output voltage of sensor decreases in transmittance mode and increases in reflectance mode. In the collected data there was good correlations between voltage and concentration and their relationship were approximately linear. Therefore, it is possible to use noninvasive methods to predict the glucose or bilirubin concentration. In vivo experiments for glucose were carried out with 19 persons in training phase, and five persons were used for testing the model. The glucose behavior model was built into the mobile application. The average glucose concentrations from the transmittance and reflectance mode were obtained. The average percentage error was 8.27 and root mean square error was 18.52 mg/dL.

8. David C. Klonoff, Kevin T. Naguyen published the method of Non invasive optical glucose monitoring, Our study aimed to describe a pilot test to test the accuracy of a noninvasive glucose monitoring prototype that uses laser technology based on near-infrared spectroscopy.Our system is based on Raspberry Pi, a portable camera (Raspberry Pi camera), and a visible light laser. The Raspberry Pi camera captures a set of images when a visible light laser passes through skin tissue. The glucose concentration is estimated by an artificial neural network model using the absorption and scattering of light in the skin tissue. This prototype was developed using TensorFlow, Keres, and Python code. A pilot study was run with 8 volunteers that used the prototype on their fingers and ears. Blood glucose values obtained by the prototype were compared with commercially available glucometers to estimate accuracy.When using images from the finger, the accuracy of the prototype is 79%. Taken from the ear, the accuracy is attenuated to 62%. Though the current data set is limited, these results are encouraging. However, three main limitations need to be addressed in future studies of the prototype: (1) increase the size of the database to improve the robustness of the artificial neural network model; (2) analyze the impact of external factors such as skin color, skin thickness, and ambient temperature in the current prototype; and (3) improve the prototype enclosure to make it suitable for easy finger and ear placement.Our pilot study demonstrates that blood glucose concentration can be estimated using a small hardware prototype that uses infrared images of human tissue. Although more studies need to be conducted to overcome limitations, this pilot study shows that an affordable device can be used to avoid the use of blood and multiple finger pricks for blood glucose monitoring in the diabetic population.

9. Andrea tur, Alberto maran introduced the method of Monitoring using HTA Methodology, Various health technology assessment (HTA) agencies review new medical devices worldwide, and their recommendations can be useful in guiding clinical decision making. However, different agencies use different processes and methodologies, resulting in variation in recommendations.The objectives were to review full HTAs for a new technology for diabetes management, flash glucose monitoring (FGM), with the aim of summarizing similarities/differences in processes, methodologies, and recommendations from the perspective of everyday clinical practice.Four full HTAs were identified (Canary Islands, France, Catalunya, and Norway); one issued a conditional recommendation for patients with type 1 diabetes mellitus (T1DM) with controlled glycatedhemoglobin (HbA1c) (Spain; Canary Islands), one issued a broader recommendation for patients with T1DM and T2DM (France), and two reported that there was insufficient evidence to support a recommendation (Spain [Catalunya] and Norway). The most comprehensive and stringent of the available HTAs were those in the Canary Islands and Norway, which included systematic literature reviews (SLRs), consultation with patient groups and clinicians, GRADE evidence quality assessments, and full economic models. Comprehensive HTAs either did not recommend FGM (Norway) or restricted the recommendation to a small subpopulation of the overall diabetes population (Canary Islands).HTAs represent a valuable additional resource for clinicians to consider alongside clinical evidence, guidelines, and consensus papers; however, interpreting recommendations requires an understanding of the processes behind these recommendations. In this review, comprehensive HTAs either recommended for a selected subpopulation based on RCT evidence or found insufficient evidence for a recommendation.

10. Asmat Nawaz, Morten Jacobsen presented the method of Glucose monitoring through skin. Continuous glucose monitoring (CGM) devices help you manage Type 1 or Type 2 diabetes with fewer fingerstick tests. A sensor just under your skin measures your glucose levels 24 hours a day. A transmitter sends results to a wearable device or cell phone. It takes time to learn how to use CGM, but it can help you more

easily manage your health.Tracking blood glucose levels tells you how much insulin your body needs and when. Blood sugar levels that go up and down a lot can damage your body in different ways. Very high (hyperglycaemia) or low (hypoglycaemia) blood sugar levels can be serious, and even life-threatening when not treated quickly.Many things (like the foods you eat, sports you play and your lifestyle) can affect your blood sugar levels. But diabetes affects everyone differently. How a food or activity affects one person's glucose levels is often different from how that same thing affects someone else.You place a small sensor just under your skin, usually on your belly or arm. An applicator makes this part quick and easy to do. Adhesive tape holds the sensor in place.The sensor measures glucose levels in the fluid under your skin. Most CGM devices take readings every five minutes, all day and night. You'll need to change the sensor regularly based on the device. For most devices, you change sensors at home every 7 to 14 days. For some long-term implantable CGM devices, your healthcare provider will change the sensor in a procedure in their office a handful of times (or less) each year.All CGM systems use a transmitter to wirelessly send the glucose data from the sensor to a device where you can view it. For some CGM systems, the transmitter is reusable and attaches to each new sensor. For other CGM systems, the transmitter is part of the disposable sensor.Depending on the CGM system, glucose data from the sensor is sent to either a handheld device called a receiver (similar to a cell phone), an app on your smartphone or an insulin pump.You can download CGM data (real-time glucose levels, trends and history) to a computer anytime. Some CGM systems will send data continuously. You can also share the information with your provider.CGM is not a cure for diabetes. It's a tool (and not one you can set and forget). You need to actively use CGM for it to be helpful. But once you get the hang of how to use it, CGM may help you better manage your blood sugar levels and overall health in less .

IV. APPLICATIONS

Non-invasive method of obtaining sugar level has huge applications where IoT is to be introduced and time ofprocessistobereduced.Someofthemainapplicationsofobjectnon-invasive methodare Simple mechanism, easy to use, cost efficiency, no human assistance required, no need of finger prickingandsoon.Itishelpfulintheresearchareaswherethe results obtained is quick.

V. CONCLUSION

In this review, measurement of blood glucose levels is suggested based on a model of non-invasive control of glucose. Blood glucose monitoring system architecture is being successfully implemented and tested. The concentration of glucose was calculated on a non-invasive sensor based for different patients. Similarly temperature , BP and heart beat for different patients are measured based on their corresponding sensors. Insulin infusion device is activated when glucose level go to high. The process is regulated by the Arduino microcontroller. Therefore the amount of glucose is measured and the value is shown and updated in IOT

REFERENCES

[1]. Mohi-ud-din, Q. "GSM based Needleless Blood Glucose Monitoring System." J Bioengineer & Biomedical Sci 7, no. 231 (2017): 2..

[2]. Lin, Tamar, YuliaMayzel, and KarnitBahartan. "The accuracy of a non-invasive glucose monitoring device does not depend on clinical characteristics of people with type 2 diabetes mellitus." Journal of drug assessment 7, no. 1 (2018): 1-7.

[3]. Zheng, Hui, Jing He, Peng Li, MengjiaoGuo, Hui Jin, Jie Shen, ZhijunXie, and Chihung Chi. "Glucose Screening Measurements and Noninvasive Glucose Monitor Methods." Procedia computer science 139 (2018): 613-621.

[4]. Li, Dachao, Haixia Yu, Xian Huang, Fuxiang Huang, Xiaotang Hu, and Kexin Xu. "Prediction of blood glucose using interstitial fluid extracted by ultrasound and vacuum." In Optical Diagnostics and Sensing VII, vol. 6445, p. 64450I. International Society for Optics and Photonics, 2007.

[5]. Haxha, Shyqyri, and JaspreetJhoja. "Optical based noninvasive glucose monitoring sensor prototype." IEEE Photonics Journal 8, no. 6 (2016): 1-11.

[6]. Wang, Hui-Chen, and An-Rong Lee. "Recent developments in blood glucose sensors." Journal of food and drug analysis 23, no. 2 (2015): 191-200.

[7]. Zhang, Wenjun, Yunqing Du, and Ming L. Wang. "Noninvasive glucose monitoring using saliva nano-biosensor." Sensing and Bio-Sensing Research 4 (2015): 23-29.

[8]. Yadav, Jyoti, Asha Rani, Vijander Singh, and Bhaskar Mohan Murari. "Near-infrared LED based non-invasive blood glucose sensor." In 2014 International Conference on Signal Processing and Integrated Networks (SPIN), pp. 591-594. IEEE, 2014.

[9]. Shichiri, Motoaki, Yoshimitsu Yamasaki, RyuzoKawamori, Nobuyoshi Hakui, and Hiroshi Abe. "Wearable artificial endocrine pancreas with needle-type glucose sensor." The Lancet 320, no. 8308 (1982): 1129-1131.

[10]. Lai, Jui-Lin, Han-ning Wu, Hung-Hsi Chang, and Rong-Jian Chen. "Design a portable bio-sensing system for glucose measurement." In 2011 International Conference on Complex, Intelligent, and Software Intensive Systems, pp. 71-76. IEEE, 2011.