International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 4
DOI: https://doi.org/10.17762/ijritcc.v11i4.6379
***Article Received**: 30 January 2023 **Revised**: 01 March 2023 **Accepted**: 09 March 2023*

Self-detection System for Type 2 Diabetes Mellitus by Aspiration of the Patient's Urinalysis

Brian Meneses-Claudio[1], Jean Meneses-Claudio[2], Milagros Vicuña-Ramirez[3], Yrene Uribe-Hernández[4], Juan Saberbein-Muñoz[5], Maria Salinas-Cruz[6], Melissa Yauri-Machaca[7]

[1]Facultad de Ciencias Empresariales
Universidad Científica del Sur
Lima, Perú
bmeneses@cientifica.edu.pe
[2]Facultad de Patología
Universidad Nacional Mayor de San Marcos
Lima, Perú
Jean.meneses@unmsm.edu.pe
[3]Facultad de Patología
Universidad Científica del Sur
Lima, Perú
mvicunar@cientifica.edu.pe
[4]Facultad de Ciencias Empresariales
Universidad Nacional de Cañete
Lima, Perú
yuribe@undc.edu.pe
[5]Facultad de Tecnología
Universidad Nacional de Educación Enrique Guzmán y Valle
Lima, Perú
jsaberbein@une.edu.pe
[6]Facultad de Pedagogía y Cultura Física
Universidad Nacional de Educación Enrique Guzmán y Valle
Lima, Perú
msalinasc@une.edu.pe
[7]Research and Technology Direction
Business on Making Technologies
Lima, Perú
yaurimelissa@gmail.com

Abstract— Diabetes mellitus is a very silent disease, which, according to various studies, has been growing every year, among them are patients with type 2 diabetes mellitus that is characterized by why they do not produce enough insulin in their body, causing them to inject insulin in an uncontrolled way, caused discomfort by the number of times they inject. Some patients do not know if they have type 2 diabetes, and over time several inefficient and expensive diabetes screening systems have been developed, limiting their use by everyone. Similarly, if this disease is not detected in time, it can compromise other parts of the body so it is always necessary to control your eating habit, on the other hand, this type 2 disease can be detected in fasting of the patient. According to the problem exposed, in this research a self-detection system of type 2 diabetes mellitus was carried out by aspirating a urinalysis to detect through the sweet smell of urine if the patient may have type 2 diabetes mellitus by means of gas sensors and carbon nanotubes fused by a microcontroller. Through the operation of the system, it was observed that the tests were performed with an efficiency of 98.99%, being an accepted value for a reliable and safe diabetes analysis, demonstrating that it can detect type 2 diabetes mellitus by aspirating the smell of urine.

Keywords- Urinalysis, Diabetes mellitus, Microcontroller, Gas sensors.

I. INTRODUCTION

In the last 10 years, there has been a noticeable growth in the number of cases of patients with diabetes mellitus, which has affected to date more than 390 million patients worldwide [1], with an increasing risk factor. This disease of type 2 diabetes has proven to be fatal for all patients because the hormone produced by the pancreas (insulin) is made in a scarce way. [2], complicating its use effectively in helping blood glucose get into parts of the muscles and liver [3], Therefore, given the lack of insulin, patients with diabetes mellitus are constantly injected with insulin [4].

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 4
DOI: https://doi.org/10.17762/ijritcc.v11i4.6379
***Article Received**: 30 January 2023 **Revised**: 01 March 2023 **Accepted**: 09 March 2023*

Likewise, this disease of diabetes mellitus is commonly related to the increase in obesity.[5], causing a considerable negative impact on the patient's life, as well as on their economic condition due to their treatment [6]. That is why, in recent years, research into biomedical devices that allow obtaining early information about blood glucose through algorithms has been enhanced. [7], Assisting the physician with diagnosis and preservation of the patient's health.

The treatment of patients with type 2 diabetes mellitus can be cumbersome for various reasons such as making decisions about the amount and frequency of insulin injection during the day by the patient. [8], resulting for most patients difficult to control their blood glucose level, as well as painful due to the number of times they have to inject insulin inappropriately that can affect the patient. [9]. On the other hand, type 2 diabetes mellitus not only presents complications mentioned so far, but also the symptoms that some patients acquire such as thirst, fatigue, hazy look, are difficult to cope with. [10]. Glucose behavior can also be affected by factors such as sugar consumption and stress. [11], that if not detected in time can affect different parts of the patient's body, to the extent of losing some part by amputation because it has no cure, so you must maintain constant control about the level of glucose in the blood [12]. Type 2 diabetes mellitus can be detected by a fasting glucose test, which is a cumbersome method that requires time, so a new method proposed is detection by a glucose test through the patient's urine.

The objective of this research is to develop a self-detection system for type 2 diabetes mellitus by aspirating a urinalysis to detect through the sweet smell of urine if the patient may have type 2 diabetes mellitus. Its development is based on the use of gas sensors and carbon nanotubes fused by means of a PIC 18F4550 microcontroller for the acquisition of information on the analysis of urine inhalation with different types of urinary volatile compounds that diabetic patients have. The programming of the PIC 18F4550 microcontroller was done by means of MPLAB for the proper operation of the system.

In section II, the literature review of previous research will be carried out. In section III, the methodology about the system will be carried out by means of a block diagram. In section IV, the operation of the aspiration of the urine of patients will be carried out. In section V, the results of the tests carried out will be carried out. In section VI, the discussion of the system versus others will take place. In section VII, the conclusion and recommendation of the system will be carried out.

II. LITERATURE REVIEW

Diabetes is a silent disease that if not treated in time and correctly can compromise other parts of the patient's body, causing them a lot of damage to their health, therefore, the use of technological systems could help the patient. For example: In [13], The researchers mention that diabetes when related to the high value of sugar, its value is determined by a usual way through a fasting blood test, being uncomfortable at the time of performing this analysis, likewise, it is the most used by most hospitals, therefore, they decided to perform a biomedical system for the detection of diabetes based on sugar levels through the intensity of the sensor in the strip elastic. The researchers' procedure is based on the reading of the sensor placed on the patient's arm to measure the sugar level using electrical pulses and interpret it using an actuator supported by an Arduino nano. As a result, they presented a 90% efficiency in detecting the sugar level of patients, concluding that the system works based on a non-traumatic way, being a contributor for diabetic patients who are in a health center or their home.

In [14], The researchers mention that this disease to date has been growing, mentioning that the main reason is due to the lack of knowledge in the adult population about diabetes and they have no prevention to avoid this disease that affects each patient differently, therefore, they decided to make a diabetes preventive system by intelligently measuring the patient's glucose. The researchers' procedure relies on an intelligent learning pattern to monitor blood sugar levels and determine if the patient may be at risk of acquiring this disease through a microcontroller. As a result they presented a 91% efficiency in monitoring their glucose to the patient, concluding that this system was developed with efficient components that allow this system to work perfectly.

In [15], The researchers mention that in the market there is a diversity of biomedical equipment that promises to measure blood sugar, highlighting that these systems have a high percentage of error so it is not reliable to manipulate it in patients, therefore, they decided to make a control system for diabetic patients by means of a low-cost sensor. The researchers' procedure is based on circular resonator circuits with dielectric components that together allow a transferable sensor. As a result, they presented an 89.47% efficiency in controlling sick patients, reaching the conclusion that this system was developed for the field of biomedicine, allowing to control the patient's blood glucose level.

In [16], The researchers mention that the diabetes factor is increasing, and that the main causes are due to poor nutritional control by people, foods with high levels of sugar without control, therefore, they decided to perform a wireless glucose meter system to control the patient's levels and prevent diabetes. The researchers' procedure supports making a sugar meter by means of Arduino connected to an Xbee module for wireless communication. As a result, they presented a 92.13% efficiency in measuring the patient's glucose, concluding that this system sends the information wirelessly to the system so that the measurement made to the patient can be visualized.

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 4
DOI: https://doi.org/10.17762/ijritcc.v11i4.6379
***Article Received**: 30 January 2023 **Revised**: 01 March 2023 **Accepted**: 09 March 2023*

III. METHODOLOGY

The methodology used to perform this system is based on the self-detection of type 2 diabetes mellitus through the aspiration of the patient's urinalysis to diagnose this disease and can receive initial treatment, so that this system allows the doctor to obtain complete information. In Figure 1 a block diagram was developed specifying the three stages of the system.

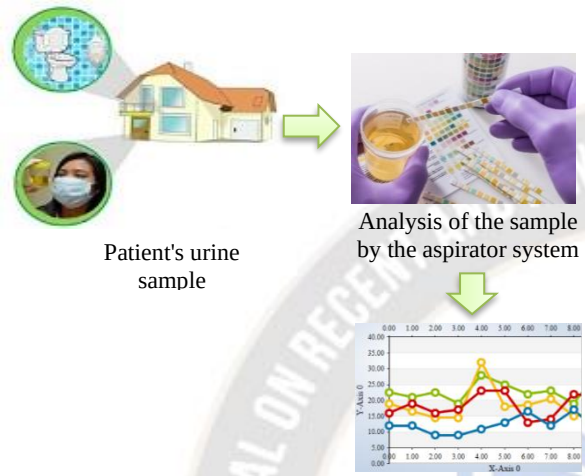

Figure 1. System block diagram

A. *Patient's urine sample*

The reason for obtaining the patient's urine sample is to be able to perform an early study on a case of diabetic patient by observing the patient's urine odor, which is a new method unlike the classic method that requires blood and is uncomfortable for most patients. Through this urine sample, it is intended to make a quick and painless diagnosis, for this, patients have to have their intimate area cleaned and fill the sterile glass bottle of 30 ml fasting, specifically the portion of the center of the urine to store it in a cool space.

B. *Analysis of the sample using the suction system*

The analysis of the system is based on the aspiration of odor from the patient's urine, taking as important data that the characteristic odor of diabetic patients presents a high degree of methyl nitrate, as well as elevated levels of organic compound of 4-heptanone [17]. On the other hand, there are several systems developed previously that use methods such as chromatography for the detection of volatile gases, but this methodology is expensive and that would prevent most patients from being treated with these systems.

The system will work like a nose by the function of sucking the honeyed smell of the patient's urine, which, based on several studies carried out previously, will be able to hit the odors of the type 2 diabetic patient with the help of an array of sensors for the acquisition of information on the analysis of the inhalation of urine.

C. *Result of the analysis*

The result of the system analysis will show the evaluation of polymer gas sensors along with fused carbon nanotubes. With both components, the system would detect the odoriferous composition in the patient's urine sample, being able to differentiate the sample of a diabetic patient versus a healthy patient in real time. Likewise, this system applies a methodology of rapid and painless detection that can be used from the comfort of home in a practical way, monitoring the patient's blood glucose level and being able to preserve their health.

IV. FUNCTIONING OF PATIENTS' URINE ASPIRATION

For the operation of the system, first, the properties of the urine of a healthy patient that has 94% water, 1.89% non-organic salt, among other substances must be taken into account. These values may vary, although it should be noted that some substances such as glucose, proteins, among others, are not present in the urine due to kidney function. For this reason, gas detection was carried out by means of sensors with carbon nanotubes, for that, various tests were carried out with volatile elements to determine their reaction, being able to find ammonia and ketone in the analyzed samples.

According to this analysis, ketone is not found in the urine sample of the healthy patient, but in diabetic patients, therefore, poly acid solution (sulfonic styrene) will be used to distinguish the diabetic patient with the detection of ketone in their urine sample. Likewise, three samples of non-diabetic people and four diabetic people were evaluated to check the correct analysis of the system, recognizing them and putting them together by means of a mathematical method programmed in the PIC 18F4550 microcontroller.

In Figure 2, the analysis of the seven people can be observed, where the "T" represents healthy people with a similarity percentage of 7 4%, while the "D" represent diabetic people with a similarity percentage greater than 94%, which shows that the patient has type 2 diabetes mellitus.

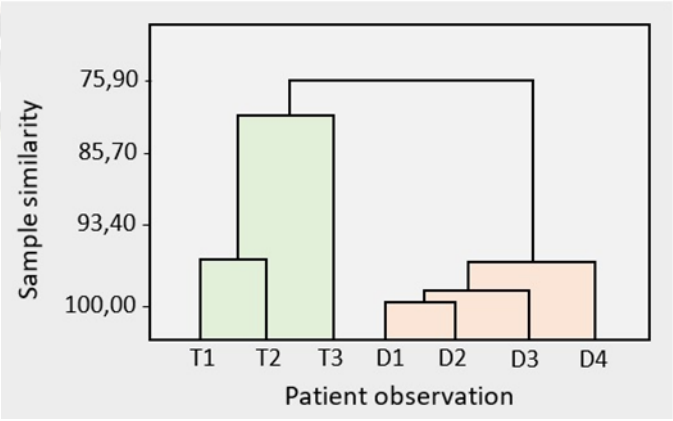

Figure 2. Analysis of patients' urinalysis

International Journal on Recent and Innovation Trends in Computing and Communication
ISSN: 2321-8169 Volume: 11 Issue: 4
DOI: https://doi.org/10.17762/ijritcc.v11i4.6379
***Article Received**: 30 January 2023 **Revised**: 01 March 2023 **Accepted**: 09 March 2023*

V. RESULTS

The result obtained by the system, demonstrates the operation of the sensors for the detection of type 2 diabetes mellitus by aspirating the smell of urine, showing its correct functioning when specifying among non-diabetics instantaneously, compared to other diabetic people so that the doctor can perform an adequate treatment.

The development of the system was done efficiently, when performing the corresponding tests, it was determined that it works with an efficiency of 98.99%, being an adequate value for professional doctors to have support when detecting the blood sugar level of patients and monitoring their treatment without any problem.

The result obtained by the system, determines if the person can be a diabetic patient in a non-uncomfortable way, unlike the traditional method where they require the patient's blood to analyze their blood sugar level, which over time causes the skin to become inflamed and harmful to the patient.

The system shows as a result that its operation is important for those with needle phobia, likewise, its test result is instantaneously to measure the level of glucose in the blood, which, depending on the percentage of similarity, classifies the person by the amount of ketone present in their urine sample.

From the result obtained, it was determined that its implementation in various medical centers would help people diagnose type 2 diabetes mellitus, by using low-cost electronic components that allow the ease of being implemented in any medical center, having as main characteristic the speed of its result and the non-discomfort for the patient.

VI. DISCUSSION

The operation of the system helps patients responsibly, likewise, it applies various new techniques to be able to self-detect type 2 diabetes mellitus, which is why it differs from other investigations previously by the methodology used, for example, the research carried out by [13], where the researchers decided to launch a biomedical system for the detection of diabetes based on sugar levels by means of the intensity of the sensor in the elastic strip. Obtaining as a result an efficiency of 90%, but this system does not indicate the detection levels found with its analyzes, likewise, it does not apply any filter to avoid errors that may affect the handling.

The research conducted by [14], where the researchers decided to direct a diabetes preventive system by intelligently measuring the patient's glucose. Obtaining as a result an efficiency of 91%, but this system does not apply conditions for the control of glucose, so its analysis can generate erroneous values that are not stored on any server, being lost quickly after the measurement.

The research conducted by [15], where the researchers decided to route a control system for diabetic patients through a low-cost sensor. Obtaining as a result an efficiency of 89.47%, but this system to be based on a sensor should have filters that could alter the measurement with ambient noise, so it does not have that or information of the placement distance.

The research conducted by [16], where the researchers decided to route a wireless glucose measuring system to monitor patient levels and prevent diabetes. Obtaining as a result an efficiency of 92.13%, but this system has interferences in wireless communication, hindering the correct reception of the patient measurement, which can cause a wrong diagnosis.

VII. CONCLUSION AND RECOMMENDATION

The system concludes that it presents an important performance in the operation of the system based on gas sensors that auto detect the diabetes the patient, classifying it according to its percentage of similarity.

From the system it is concluded that its development is a benefit for the field of medicine, likewise, its manipulation is friendly that even the same person can use it from the comfort of his home to rule out type 2 diabetes mellitus.

From the system it is concluded that its operation is not unsafe or causes any harm to the patient, since it is an external analysis of their urine sample, that makes the doctor, or the patient do not take too long to know the results.

As future work, a wireless module will be added to the system so that it can send the result of the patient's analysis to a mobile device and view it.

It is recommended that, at the time of performing the urine analysis, the necessary amount of the sample should be taken into account so that there is no variation in the result.

REFERENCES

[1] P. J. Navarrete Mejía, F. A. Lizaraso Soto, J. C. Velasco Guerrero, and L. M. Loro Chero, "Diabetes mellitus and arterial hypertension as a risk factor for mortality in patients with Covid-19," *Revista del Cuerpo Médico Hospital Nacional Almanzor Aguinaga Asenjo*, vol. 13, no. 4, pp. 361–365, Feb. 2020, doi: 10.35434/RCMHNAAA.2020.134.766.

[2] A. López Casanova, R. Triana de la Paz, A. Ruiz Triana, N. Díaz Alfonso, and Y. Gutiérrez Escarrása, "Síndrome metabólico en pacientes diabéticos tipo 2," *Acta Médica del Centro*, vol. 13, no. 3, pp. 284–296, Oct. 2019, doi: 10.1161/CIRCULATIONAHA.109.192644.

[3] V. Reyes Alcázar, I. Carrillo Murcia, and J. J. Mira Solves, "Definition of indicators for type II diabetic patient-centered care," *J Healthc Qual Res*, vol. 36, no. 6, pp. 345–354, Nov. 2021, doi: 10.1016/J.JHQR.2021.05.004.

[4] C. Lazo and S. Durán Agüero, "The effect of diabetes mellitus diagnosis and its complication with eating disorders," *Revista chilena de nutrición*, vol. 46, no. 3, pp. 352–360, Jun. 2019, doi: 10.4067/S0717-75182019000300352.

[5] E. Ramón Arbués *et al.*, "Prevalence of overweight/obesity and its association with diabetes," *Nutr Hosp*, vol. 36, no. 1, pp. 51–59, Jan. 2019, doi: 10.20960/NH.1980.

[6] F. López Simarro, E. Redondo Margüello, J. J. Mediavilla Bravo, T. Soriano Llora, J. Iturralde Iriso, and A. Hormigo Pozo, "Prevention and treatment of infectious diseases in diabetic patients," *Medicina de Familia. SEMERGEN*, vol. 45, no. 2, pp. 117–127, Mar. 2019, doi: 10.1016/J.SEMERG.2018.07.007.

[7] R. I. Benites Loja and M. A. Coral Ygnacio, "A review of system implementations for diabetes trend identification," *Interfases*, no. 016, pp. 231–251, Dec. 2022, doi: 10.26439/INTERFASES2022.N016.5957.

[8] R. Vinces Chong, O. Villamarin Vaca, A. Tapia Mieles, J. Gorozabel Alarcón, C. Delgado Gorozabel, and M. Vinces Zambrano, "Diabetes Mellitus y su grave afectación en complicaciones típicas," *Polo del Conocimiento: Revista científico - profesional*, vol. 4, no. 2, pp. 181–198, 2019, doi: 10.23857/pc.v4i2.901.

[9] V. L. Naranjo Aldas and J. M. Torres Torres, "Insulin therapy for the treatment of patients with type 2 diabetes mellitus," *Ciencia Latina Revista Científica Multidisciplinar*, vol. 6, no. 5, pp. 2170–2204, Oct. 2022, doi: 10.37811/CL_RCM.V6I5.3244.

[10] F. A. Trevizani, D. T. Doreto, G. S. Lima, and S. Marques, "Atividades de autocuidado, variáveis sociodemográficas, tratamento e sintomas depressivos entre idosos com Diabetes Mellitus," *Rev Bras Enferm*, vol. 72, pp. 22–29, Dec. 2019, doi: 10.1590/0034-7167-2017-0579.

[11] A. C. Mariño Jara, M. I. Vinces Zambrano, A. N. Pico Tagle, A. P. Morales Tipán, O. X. Ruiz Lara, and C. M. Chango Checa, "Factores de riesgo que inciden en la presencia de diabetes," *RECIMUNDO: Revista Científica de la Investigación y el Conocimiento, ISSN-e 2588-073X, Vol. 2, Nº. 4, 2018, págs. 189-238*, vol. 2, no. 4, pp. 189–238, 2018, doi: 10.26820/recimundo/2.(4).octubre.2018.189-238.

[12] A. A. O. Blanco, G. Q. Compeán, and L. M. T. Treviño, "Personalized Glucose Metabolism Modeling for Type 2 Diabetic Patients Using Evolutionary Algorithms," *Memorias del Congreso Nacional de Ingeniería Biomédica*, vol. 8, no. 1, pp. 327–330, Nov. 2021, doi: 10.24254/CNIB.21.61.

[13] A. Singh Gautam, S. Kumar Jana, and M. Pratim Dutta, "Automated diagnosis of diabetic retinopathy using image processing for non-invasive biomedical application," *2019 International Conference on Intelligent Computing and Control Systems, ICCS 2019*, pp. 809–812, May 2019, doi: 10.1109/ICCS45141.2019.9065446.

[14] Y. Obeidat and A. Ammar, "A System for Blood Glucose Monitoring and Smart Insulin Prediction," *IEEE Sens J*, vol. 21, no. 12, pp. 13895–13909, Jun. 2021, doi: 10.1109/JSEN.2021.3070706.

[15] A. E. Omer, G. Shaker, and S. Safavi Naeini, "Wearable CSRR-based Sensor for Monitoring Glycemic Levels for Diabetics," *Proceedings - IEEE 20th International Conference on Bioinformatics and Bioengineering, BIBE 2020*, pp. 922–928, Oct. 2020, doi: 10.1109/BIBE50027.2020.00156.

[16] T. H. Yew Ling, L. Jin Wong, and T. Shu Ming, "Wireless Blood Glucose Device with Database for Health Assessment and Monitoring," *2019 7th International Conference on Smart Computing and Communications, ICSCC 2019*, Jun. 2019, doi: 10.1109/ICSCC.2019.8843603.

[17] M. M. A. Gutiérrez, A. P. Cantero, and L. C. Martínez, "Diagnostic and therapeutic protocol for diabetic nephropathy," *Medicine - Programa de Formación Médica Continuada Acreditado*, vol. 13, no. 17, pp. 974–977, Oct. 2020, doi: 10.1016/J.MED.2020.09.023.