International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 7 Issue 2, February - 2023, Pages: 29-35

A Smart Patient Monitoring System for Analyzing Diabetes Mellitus

Akpado, K. A.1, Achebe, P. N.2, Obioma, P. C. 3

1Department of Electronic and Computer Engineering
Nnamdi Azikiwe University
Awka, Nigeria
k.akpado@unizik.edu.ng
2Department of Electrical and Electronic Engineering
Chukwuemeka Odumegwu Ojukwu University
Uli, Nigeria
patug165@gmail.com
3Department of Electronic and Computer Engineering
Nnamdi Azikiwe University
Awka, Nigeria
pc.obioma@unizik.edu.ng

Abstract*—The rise in population of the elderly and the increasing rate of death among this class of people requires that their health status be continuously monitored and checked. The paper focused on developing a prototype device for measuring patient vital parameters e.g. Blood pressure (Systolic & Diastolic), Body Temperature, Electrocardiogram (ECG) and Heart rate with artificial intelligent (AI) based health monitor for disease prognosis on diabetes mellitus. The system is capable of predicting other disease types but only type 2 diabetes was considered in this paper. In order to validate the workability and effectiveness of developed system, experimental results obtained from some volunteers have been presented in terms of blood pressure, heart rate, and temperature.*

Keywords— *Blood pressure; Diabetes mellitus,; Heart rate; Patient monitoring system; Temperature*

1. INTRODUCTION

Recent advances in technologies in the use of wireless body sensor have made it possible to develop sensor nodes which can be worn over body, implanted and embedded in the body. Body sensor nodes are small devices that have the ability to process signals sensed from the human body and communicate instantly to the required destination where these data can be processed and used for various diagnosis. The use of wireless sensor networks to monitor and check the state of health of the patient will make it possible to provide early warning and prompt response in healthcare services. This is regarded as electronic health (e-health) monitoring systems or patient monitoring systems (PMS), which are designed by incorporating different smart electronic wearable body sensors (WBSs) and devices so as to collect data and provide required information or knowledge for the end-user (usually a medical doctor).

Patient monitoring system plays critical role in ensuring that real time information are gathered to make sure that people with ill health conditions are promptly attended to and diagnosis or treatment rendered just in time. Series of operations are carried out by e-health monitoring systems to detect and maintain the functioning conditions of the human body system. These include: monitoring current state of the system based on observation, managing the physical condition of the system, and plan the suitable preservation and restore operations [1] of the body to normalcy.

With several chronic diseases such as cardiovascular and diabetic diseases influencing the quality of life of many people especially, the elderly, electronic aided medical expert system are increasingly be implemented. The important objective of PMS is to ensure the quality of patient and as such, the application in medical field has dramatically increased.

Diabetes is one of the most dreaded chronic diseases in the world, which is caused by an increase or decrease in glucose level in the body [2]. There is a high chance for diabetic patient to be affected by other health challenges such as damage to blood vessels, or heart diseases if the diabetes continues for a long time.

In Nigeria, diabetes is obviously becoming a national health problem and the complexities of properly treating the people suffering from this disease are largely well known [3]. Many of the people living with diabetes that developed complications are not properly managed or treated especially those dwelling in the rural or remote places because of the limited number of diabetes specialists [3], [4].

In this paper, the objective is to PMS for measuring patient vital parameters such as Blood pressure (Systolic & Diastolic), Body Temperature, Electrocardiogram (ECG) and heart rate as away to provide e-health support for diabetic patients.

2. REVIEW OF RELATED LITERATURE

Kakria et al. [5] developed a real-time heart monitoring system considering the cost, ease of application, accuracy, and data security. The system is designed to provide an interface between the doctor and the patients for two-way communication. The work aimed to help the remote cardiac patients in getting latest healthcare services which might not be possible otherwise due to low doctor-to-patient ratio. The developed monitoring system is then evaluated for 40 persons (aged between 18 and 66 years) using wearable sensors while holding an Android device (i.e., smartphone under supervision of the experts). Fortier and Viall [6] described the design process for a mobile patient-centric, self-monitoring, symptom recognition and self -intervention system supporting chronic cardiac disease management. The system design was undertaken in five phases, refining author's concept from crude prototype to brass board system ready for product development and experimental testing. The system comprises a mobile smart phone and wearable sensor device through blue tooth and cell phone technology to a backend data repository, data mining, knowledge discovery, knowledge evolution and knowledge processing system, providing clinical data collection, procedural collection, and intervention planning, medical situational assessment and health status feedback for users. The system aids patients in learning to recognize disease specific symptoms and understand the effect on their health of adherence to interventions. Mary et al. [1] proposed an E-health monitoring system to monitor patients in smart environment. The system was designed to monitor patient from their home so as to enhance the level of medical support. Significant sign parameters of body temperature, blood pressure and heart beat were monitored by the e-health monitoring system. A set of numerical values were presented to describe the realistic characteristics performance of the system. Chatrati et al. [7] developed a smart home monitoring system for analyzing the blood pressure and glucose level of patient at home and notifies the healthcare personnel when any abnormality is detected. The system combines conditional decision-making and machine learning techniques to respectively predict hypertension and diabetes status. The home heath monitoring system sends alert and real-time notifications to registered medical expert. Ogunniyi et al. [3] presented a telehealth monitoring system with the aids of GPS, smartphone and cellular network facility to monitor patients with diabetes during diabetic emergencies. The objective was to analyze telehealth intervention in patient's diabetes management when emergency occurs with the sole aim to provide early diagnosis and treatment. Rghioui et al. [2] designed an intelligent system to monitor diabetic patient and the simultaneously allow physicians to remotely perform surveillance on their patients via sensors integrated into smart portable devices and smartphones. The system incorporates intelligent models that detect whether a threshold has been exceeded by a parameter that may or may not result in emergency. Rghioui et al. [8] presented a diabetes monitoring system. The study applied four different machine-learning algorithms for the classification of data set. These algorithms are: Naïve Bayes, Sequential Minimal Optimization (SMO), Random Forest, and OneR. The objective was to choose the algorithm with best classification accuracy. Diabetic patient data was predicted with these algorithms on WEKA tool. The efficiency and the effectiveness of the machine-learning schemes were compared in terms of accuracy, precision and sensitivity. The experiment of the study proved that Random Forest algorithm outperformed the other machine-learning algorithms considered.

3. SYSTEM DESIGN

This section presents the developed circuit diagram of the system, which was designed using a schematic capture tool known as Proteus Virtual System Modeling. At this point, the programming codes that will drive and coordinate the activities of the various components were developed and burn into a microcontroller. The essence of this circuit is to carry out real-time simulation so as to ascertain with fact the real-life workability of the developed system. The circuit design developed is shown in Fig. 1.

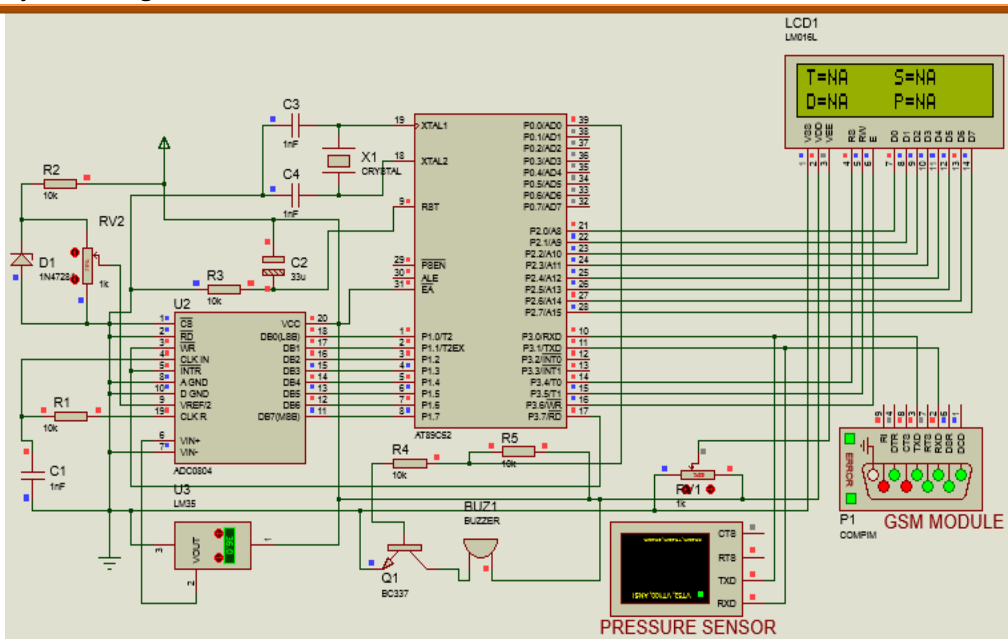

Fig. 1 Circuit diagram of proposed PMS

The major components of the proposed system are:

- Wearable blood pressure sensor: This wearable blood pressure sensor is a kind of monitoring device that allows a patient to measure his or her blood pressure and heart rate at a time and store them in its memory for reference purpose. Blood Pressure & Pulse reading are shown on display with serial out for external projects of embedded circuit processing and display.
- Temperature sensor and ADC unit: The temperature sensor which is the second sensor is only used to monitor the body temperature of a patient. The choice type of temperature sensor used for this system is LM35 because of its advantages over other temperature measuring sensors. The ADC0804 is a device of CMOS 8-bit successive approximation converter (ADC) that use a differential potentiometric-ladder — similar to the 256R products. These converters are designed to allow operation with the NSC800 and INS8080A derivative control bus with Tri-state output latches directly driving the data bus.
- Electrocardiogram (ECG) sensor: This sensor is a cost-effective board used to measure the electrical activity of the heart. This electrical activity can be charted as an ECG or Electrocardiogram and output as an analog reading. ECGs can be extremely noisy, the AD8232 Single Lead Heart Rate Monitor acts as an op-amp to help obtain a clear signal from the PR and QT Intervals easily.
- Microcontroller unit: This is brain of the entire working system. It controls every other unit of the system. The choice of microcontroller used in this work is AT89S52. The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory.
- LCD display unit: This is the display unit of this work. With the purpose of making this system portable, we decided to use a 16X2 liquid crystal display. LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits.
- Power supply unit: Having considered the individual components of the system and their current and voltage usage, the power supply of this circuit was made to be a 5V rechargeable DC battery.

4. SYSTEM PERFORMANCE AND TEST RESULTS

4.1 System Prototype

The hardware construction of the PM system was carried out and after a series of test to certify the system performance, the system was packaged. The packaging was done while considering the following factors: portability, ease of access to power supply, and cost. The packaging was done using a Perspex material (plastic in nature). The working packaged system is shown in Fig. 2 including the system package of the ECG shown in Fig. 3.

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 7 Issue 2, February - 2023, Pages: 29-35

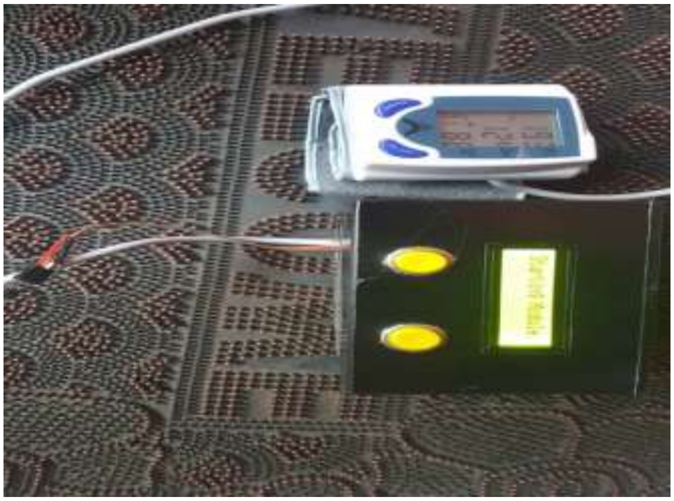

Fig. 2 System package

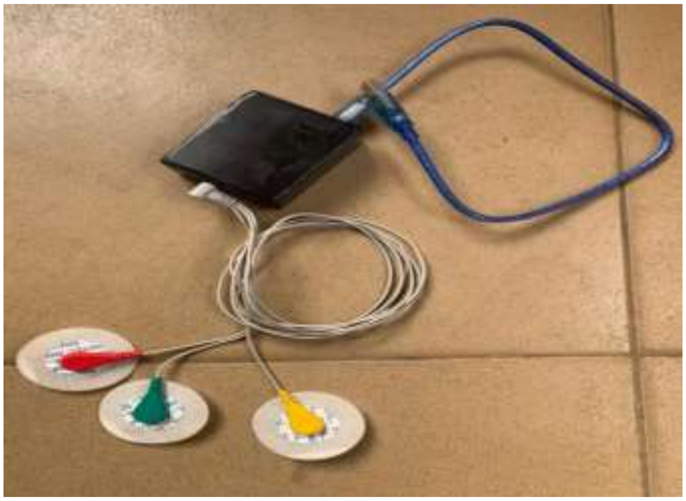

Fig. 3 System Package of the ECG

4.2 A System Performance Test Analysis

The testing of the designed system was conducted on a volunteer as shown in Fig. 4.

Fig. 4. Testing of the designed system on a volunteer

- **Blood Pressure and Heart Rate:**

The wearable blood pressure sensor was wrapped around the volunteer's arm, when the push BP button was pressed, the volunteer's diastolic pressure, systolic pressure and heart rate was detected and transmitted as shown in Fig. 5 to 7

Fig. 5 Graphical representation of obtained systolic pressure

Fig.6 Graphical representation of obtained diastolic pressure

Fig. 7 Graphical representation of obtained heart rate of the volunteer

- **Temperature Measurements**

The Temperature of the volunteer was tested using the LM 35 temperature sensor; the temperature was detected, collected and transmitted as shown in the screenshot in Fig. 8.

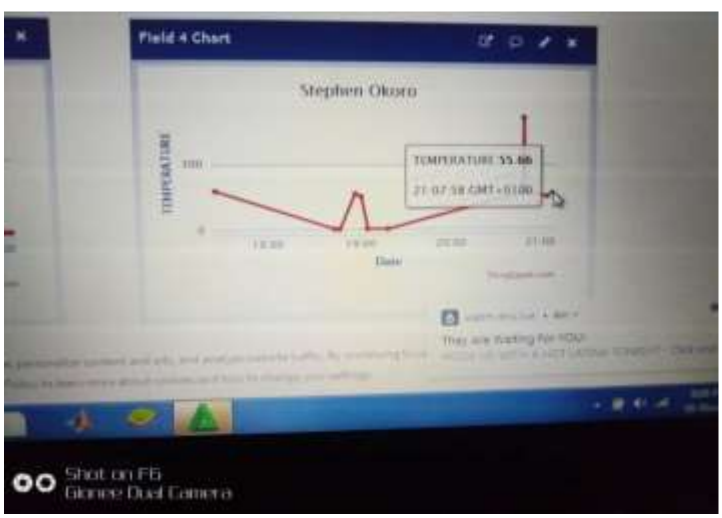

Fig. 8 Graphical representation of obtained temperature of the volunteer

- **ECG Signal Measurement**

The serial data obtained from the ECG sensor is hard to visualize if one is just viewing the values. Using the Arduino IDE one can view the data on a graph using the Arduino Serial Plotter as one option. The obtained waveform is as shown in Fig. 9 when the sensors are placed correctly and not moving.

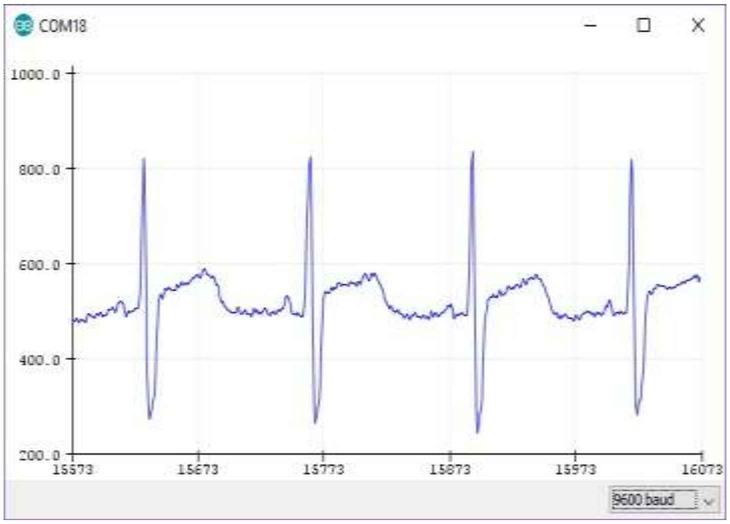

Fig. 10 ECG signal measurement

From the results obtained from the volunteer, the following inferences shown in Table 1 were made as regarding the performance of the device.

Table 1 PM Device Result Analysis

Test	Observation	Result
Systolic Pressure	191 mmHg	Systolic pressure reading is abnormal and indicates hypertensive crisis and requires emergency response (Verification is needed by medical personnel)
Diastolic Pressure	106 mmHg	Diastolic pressure reading is abnormal and indicates high blood pressure and requires emergency intervention. (Verification is needed by medical personnel)
Pulse Rate	72 bpm	Pulse rate of 72 beats per minute is normal for an adult.
Temperature	55.66 °C	Body temperature is abnormal. (Verification is needed by medical personnel)
ECG Signal	-	The values obtained from the ECG signal sensor is continuous and time varying as represented.

5. CONCLUSION

This paper has presented a smart patient monitoring system (PMS) for analyzing diabetes mellitus. It focused on patients' self-management tool which comprises of instruments of self-care, mobile and home care using a proto type device to measure vital parameters like ECG, temperature, and heart rate. with Artificial intelligence based health monitor, they help patients deal with their own medical conditions, or those of their loved ones, outside the walls of formal institutions.

The AI algorithm implemented in this paper is machine learning algorithm in patient self-management tool diabetes care. This machine learning based system in disease prediction primarily works according to the symptoms/parameters given by the user. The type 2 diabetes mellitus disease will be predicted using this algorithm and comparison of the datasets within the parameters provided by the user. However, this paper was only designed to evaluate the performance of the developed prototype PMS. Another study by the authors provides the analysis of the machine-learning algorithm in predicting diabetes.

REFERENCES

[1] Mary, L. Z., Valantina, G. M., Premi, M. S. G., & Sheeba, G. M. (2019). E health monitoring systems in smart environments. *Journal of Pharmaceutical Sciences and Research, 11*(9), 3130-3132.

[2] Rghioui, A., Jaime, L., Harane, M., & Oumnad, A. (2020). A smart glucose monitoring system for diabetic patient. *Electronic*, *9*(678), 1-18.

[3] Ogunniyi, J. O., Emuoyibofarhe, J. O., & Olamoyegun, M. A. (2021). Tele-healthcare monitoring system-based for the management of diabetes emergencies. *E-Health Telecommunication Systems and Networks,10,* 83-94.

[4] Olamoyegun, M. A., Emuoyibofarhe, O. J., Ala, O. A., & Ugwu, E. (2020). Mobile phone use in the management of diabetes in nigeria: a new potential weapon. *West African Journal of Medicine, 37,* 201-208.

[5] Kakria, P., Tripathi, N. K., & Kitipawang, P. (2015). A real-time health monitoring system for remote cardiac patients using smartphone and wearable sensors. *International Journal of Telemedicine and Applications,* Article ID 373474, 1-12.

[6] Fortier, P. J., & Viall, B. (2011). Development of a mobile cardiac wellness application and integrated wearable sensor suite. In *The Fifth International Conference on Sensor Technologies and Applications*, 301-306.

[7] Chatrati, S. P., Hossain, G., Goyal, A., Bhan, A., Bhattacharya, S., Gaurav, D., Tiwari, S. M. (2020). Smart home health monitoring system for predicting type 2 diabetes and hypertension. *Journal of King Saud University – Computer and Information Sciences, 34*(2022), 862-870.

[8] Rghioui, A., Naja, A., Jaime, L. M., & Oumnad, A. (2021). An IoT based diabetic patient monitoring system using machine learning and node MCU. *Journal of Physics: Conference Series, 1743* (2021) 012035.