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An efficient IoT based biomedical health monitoring and diagnosing system using myRIO

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ABSTRACT

With the growing and aging population, patient auto monitoring systems are becoming more popular. Smart sensors linked with the internet of things (IoT) make patients' auto monitoring system possible. Nowadays myRIO with LabVIEW is more popular for easy data acquisition, instrument control, and automation. This paper proposed myRIO and IoT based health monitoring and diagnosing system (HMDS) to acquire heartbeat rate, pulse, blood pressure (BP), temperature and activities of the patient using various smart sensors with more accuracy. The acquired raw data from the various sensors had been sent to the myRIO using ESP 8266 Wi-Fi module. The received raw data by the myRIO would be processed to the equivalent medical parameters using LabVIEW and the same might be transferred to the remote monitoring system (RMS) using cloud via a gateway. The abnormalities in the obtained data would be monitored and the diagnosis was made. The experimental setup was developed using various wearable sensors, ESP 8266, myRIO with LabVIEW and cloud with the gateway.

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1. INTRODUCTION

The usage of the IoT in healthcare is becoming popular day by day. Smart healthcare plays a significant role in healthcare applications through embedded sensors and actuators in patients for monitoring and tracking their activities. The IoT is used in clinical care to monitor and diagnose physiological status of patients through bio medical sensors by acquiring and analyzing the physiological information. The analyzed physiological data of the patient will be sent to the remote processing expert unit to make suitable decisions and actions for diagnosis and treatment. Smart healthcare systems are not only for patients, but also useful for normal people to check their health status by using wearable devices and sensors. In general, through smart health care system, some of important physiological information of the patient or normal humans such as body temperature, blood pressure, heart rate, electrodermal activity, and glucose level will be acquired and analysed more frequently. The Smart healthcare sytem will provide accurate diagnosis result if and only if the acquired data is more accurate. Nowadays research in the field of biomedical embedded engineering is focusing on acquiring more accurate data from the bio medical sensors.

One of the major challenges is to acquire more accurate data because the misconception of acquired data may even affect the human life. The accuracy of the acquired data from bio medical senors will depend on the resolution of the processing devices. Arduino, Raspberry pi and other embedded controllers are playing a vital role in processing the acquired data from the biomedical sensors using textual programming language like sketch, python and embedded C programming. Similar to these processing devices and controllers, the data acquisition (DAQ) called myRIO is becoming popular in analyzing the acquired data with high resolution. In myRIO, the analog inputs are multiplexed to a single analog-to-digital converter (ADC) that samples all channels and each analog output channel has a dedicated digital-to-analog converter (DAC), so they can all update simultaneously. One of the important features of myRIO is that it operates through FPGA. The DAC for the analog output channels is controlled by a serial communication from FPGA and the ADC Resolution of myRIO is 12-bits. The data acquired through myRIO will help the physician to analyse the data precisely and find the complexity of the disease. The paper is focusing to develop a smart real time health monitoring and diagnosing sytem using myRIO and sensors with high resolution. It also aims to improve the processing speed with more accurate analysis of the acquired data. Finally, the proposed system diagnoses the disease or disorder based on the gathered data using IoT through the remote monitoring system (RMS) [1]. The paper is organized initially in the way of briefing the related works, detaling the architecture and the implementation of the proposed system and finally concluding with result and analysis.

2. RELATED WORKS

IoT finds its applications in several fields of life such as healthcare, smart homes, agriculture, and Industrial Automation. IoT explores new dimensions of patient care through real-time health monitoring and access to patients health data.This section explores various literature related to health care systems with their merits and gaps. The review of literature is organized by grouping the processing devices involved in developing the Health care systems.

Patient health monitoring (PHM) was proposed by [2] to prevent sudden death rates using sensors and their communication. In the work the patient's physiological parameters are continuously tracked and the same will be communicated to the family members in case of any emergency. The temperature and heartbeat sensor values of the patient are acquired through sensors which are linked to the Arduino-Uno controller. In case of any unexpected changes in patient heart-rate or body temperature, alert is sent to the patient's family. This system also showed patient's body temperature and heartbeat rate tracked live data with time-stamps over the Internet. But the work did not consider the accuracy level of acquired data and the remote monitoring and diagnosing unit to analyse the physiological condition of the patient. Also, the work considered body temperature and heart beat physiological parameters only. Similarly, in [3-6] the health care systems have been developed using Arduino-Uno controller.

IoT based smart health care system (SHCS-IoT) was proposed and reviewed by [7] by integrating Raspberry Pi, PIC/Arduino controller with various wireless body area sensors by forming network. From the work, it is observed that the physiological parameters such as temperature, heart beat and blood pressure of the patient are monitored by placing the sensors on the human body to monitor the health condition without disturbing the daily routine of the patients; these physiological parameters are then communicated to physician server using long range wireless technology. But in the work, the physiological data of the patient are processed using both Arduino/PIC controller and Raspberry Pi. This will increase the redundancy and complexity in the formation of WBSN. Also, the work just processes the acquired data and did not consider the diagnosis part. In [8, 9] and [10], the health care systems have been developed using Raspberry Pi.

In [11] the architectural view of smart health care system using IoT was designed and implemented for monitoring the patient body parameters in real time. In the work the medical parameters of the patients are collected by sensors and the data is transferred to the ATMEL Microcontroller 89s52 which is further transferred to the MySQL database server. This MySQL database server manages the data and provides ease of access.

Wireless monitoring system for microwave-based comprehensive vital sign measurement was proposed in [12]. In the work, a unique electromagnetic energy coupling sensor/antenna is equipped with a mobile app to display the processed values in real time for clinical use to monitor the health condition of remote patients. ARM controller and Zigbee transceiver are interfaced with ECG, PPG, respiratory rate and temperature sensors to acquire and to process the health condition of remote patient. Though the work, proposed wireless remote monitoring sytem, it did not consider the accuracy of acquisition of data. For processing the data micro controller involves the conventional textual embedded C programming. In [13-20], smart health care systems have been proposed using various versions of micro controller.

To monitor the human pain remotely, [21] developed a wearable sensor of eight channels to read facial expressions. The data is sent through the gateway in real-time, and the caregivers receive them in mobile web application [22]. From the above literature, it is inferred that the majority of the work have been implemented using either Arduino, Raspberry pi or any other versions of microcontroller. To address these identified gaps in the existing research work, the paper is proposing a novel efficient IoT based biomedical health monitoring and diagnosing system (HMDS) using myRIO. In the proposed work, myRIO replaces the conventional processing devices such as Arduino, Raspberry pi and microcontroller. One of the advantages of the proposed system is that it uses GUI based programming instead of conventional time-consuming text-based programming. The details of the proposed system and its architecture will be elaborated in the following sections.

3. ARCHITECTURE OF THE PROPOSED HEALTH MONITORING AND DIAGNOSING SYSTEM

This paper is intended to design an efficient health monitoring and diagnosing system for the automation of health care centers with high accuracy and speed. The proposed system comprises MEMS based wearable smart sensors, Wi-Fi module, LabVIEW based myRIO data acquisition system using FPGA with 12 bit ADC resolution and remote monitoring and diagnosing system. The overall architecture of the proposed work is shown in Figure 1.

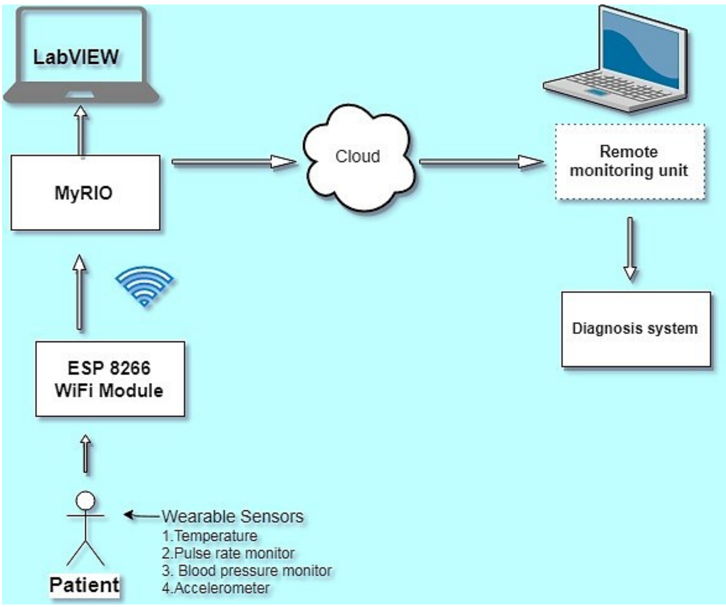

Figure 1. Architecture of the proposed health monitoring and diagnosing system

The HMDS is developed to monitor the heartbeat rate, pulse, blood pressure, temperature and movement and activities of the patient with high accuracy and speed. To acquire this biomedical information from the patient, various MEMS based wearable sensors have been used. These wearable sensors will be collecting and recording real-time information about a patient's physiological condition and motion activities. These sensors are inserted into clothes, textile fiber, and elastic bands or directly attached to the human body to acquire the physiological conditions.

The M212 low-cost heart rate sensor and pulse sensor have been fixed in the elastic band and tied to the wrist of the patient to acquire reliable pulse readings. These sensors will frequently update the pulse rate of the patient to the data acquisition system through the Wi-Fi module. Similarly, a wearable ultrasound patch is used to track the Blood pressure of the patient. These sensors will continuously update the blood pressure status to the myRIO data acquisition system. Human body temperature is acquired using the MAX30205 sensor. This sensor is particularly used to detect the feverishness of the patient and most accurate in the region of 37 degrees to 39 degrees celsius. The temperature sensor simply alerts the monitoring system that the patient is having a fever or not. If the body temperature of the patient is greater than 98.6 degree fahrenheit, then the sensor will alert the monitoring system that the patient is under feverish condition. The accelerometer ADXL335 is fixed in the arm to acquire the patient's motion activities which will be valuable in fall detection, posture analysis, and walk pattern or sleep quality.

All these acquired biomedical information from the patient through the various sensors will be in the form of raw data which will be processed accurately, according to the accuracy level of the myRIO DAQ. Now, these raw data are sent to the data acquisition system myRIO through ESP 8266 Wi-Fi module. The LabVIEW software will takes care of the collected raw information and converts them into the respective biomedical parameters such as BPM for heartbeat rate, pulse count for pulse rate, mm/hg for BP, step count or activities for the accelerometer. This biomedical information about the patient will be maintained in the local monitoring system (LMS). The same data will be sent to the remote monitoring system through IoT cloud and gateway by myRIO to obtain the expert's opinion and diagnosis. Thingspeak is used for IoT public cloud, Siemens 2040 is used as IoT gateway to transfer the data from the local monitoring system to the RMS. The diagnosis system will provide adequate medication if any abnormality is found and the same will be intimated to the caregivers and physician as well as the local monitoring system.

In general, smart health care systems have been developed using Arduino, Raspberry Pi or various versions of microcontrollers. Arduino is an 8-bit microcontroller with 10-bit ADC. The acquired information from the sensors will be converted to the respective value based on the resolution of the respecting processing device. Since Arduino is 8-bit controller it requires all the inputs between 0 and 255 to process and analyse the acquired information. Due to this reason the acquired 10-bit data is to be mapped to 8-bit data for the process; 0 to 1023 should be mapped to 0 to 255. Hence the speed of the system will be degraded as well as the accuracy level of the acquired information will be reduced. The 8051 microcontroller will require additional ADC circuit which will increase the device complexity of the system and decrease the speed of operation. Similarly, either PIC or ARM controller and Raspberry Pi are having only 10-bit inbuilt ADC. To achieve high level of accuracy of the acquired information and to increase the speed of the entire process. The proposed HMDS uses LabVIEW based myRIO data acquisition system using FPGA with 12-bit ADC resolution. As myRIO is having 12-bit ADC, it can convert the acquired physiological information between 0 and 4095 instead of 0 and 1023 converted by either Raspberry Pi or Arduino. This ensures that myRIO provides high accuracy of the acquired information. The small variation in the interpretation of the acquired information will affect the human life. As myRIO is interpreting the acquired information precisely over Arduino and Raspberrypi, it ensures higher accuracy. Similarly, myRIO DAQ will process the acquired information using FPGA which will ensure high speed of the process. The details of the various sensors and components of the proposed HMDS are briefed in the following subsections.

3.1. Wearable smart sensors and Wi-Fi module

This section will elaborate on various wearable smart sensors that are used in acquiring the patient's medical parameters such as heart rate sensor, pulse sensor, BP sensor, temperature sensor, and accelerometer. Also, it briefs the functionality of the ESP8266 Wi-Fi module.

3.1.1. Heart rate sensor

BH1790 optical sensor is used to measure the pulse waves of the human heart. The heart pumps the blood in the vessels. Consequently, the blood volume is changed. The optical sensor and light-emitting diode (LED) measures the pulse waves by determining the variation of blood volume. Also, the sensor uses an optical filter to reduce the affection of ambient light and to increase the quality of the measured data out-doors.

3.1.2. Pulse sensor

The sensor used for measuring pulses in this research is SEN11574. This sensor has two sides. The first side contains the circuit, which amplifies signals and cancels the noise. On the other hand, the second side has an LED with an ambient light sensor. The sensor is directly placed over a vein in the human body (on either fingertips or ear tips). The working mechanism of this sensor is the LED emits light on the blood, and the light sensor counts the reflected light from the blood. In this way, the SEN11574 measures the pulses rate of the human heart. LED on the front side of the sensor is placed over a vein in the human body.

3.1.3. BP sensor wearable ultrasound patch

The wearable blood pressure used in this research is a thin patch. The size of this sensor is small (240 µm). Besides, it is stretchable and it enables non-invasive. It could be used in different locations of the human body. The sensor's structure is an array of electronic components (islands) and copper wires configured in spring shape (bridges). Islands and bridges are patterned in a sheet of silicone elastomer. Each island comprises of piezoelectric transducers. When electricity passes through islands, they produce ultrasound waves. The ultrasound waves had been used to get information about the wave format of blood vessels located four centimeters under the human's skin. The doctors can use the information to analyze the status of the human's hearts and blood flowing.

3.1.4. Human body temperature sensor MAX30205

MAX30205 is high accuracy, low supply voltage range (2.7 to 3.3V), and precision centigrade temperature sensors. It is a clinical-grade sensor and offers ±1 °C (max) for thermometer applications. It consumes a very low supply current (only 600μA). The MAX30205 converts the measured analog temperature data to a digital form. Furthermore, it provides over-temperature alarm and shutdown output. It accepts a command through I2C from the controller.

3.1.5. ESP 8266

The ESP8266 module is a low-cost Wi-Fi transceiver development kit. It can be used either as embedded with another system as a Wi-Fi feature or an independent component. It provides a connection point to IoT. It is a 32 bit CPU, small size, and low consumption power.

3.1.6. NI-myRIO

A key component of the proposed system is myRIO because it is having 12-bit ADC and works using FPGA to ensure high accuracy and speed of the system. NI-myRIO is development hardware used to read and process the real-time data [23, 24]. NI-myRIO has UART, accelerometer and input/output audio terminals [25].

3.1.5. Graphical and data flow programming in LabView

LabVIEW uses a programming language called G. This is one of the important advantages of the proposed because G-code is a Graphical user interface programming which uses icons and blocks instead of conventional time-consuming textual code. The various sensors raw data acquired from the patient will be sent to the block diagram of the LabVIEW G code. The code developed in the block diagram will transcribe the raw data to the understandable standard medical parameters.

4. IMPLEMENTATION OF THE SYSTEM

The patient's health parameters such as bpm, no. of pulses, mm of hg, angular movement, step count and temperature in Fahrenheit are continuously monitored by the various smart sensors like heartbeat rate, pulse, blood pressure, temperature and movement and activities of the patients respectively. The acquired data will be communicated to the LMS and RMS through gateways and cloud. LabVIEW will transcribe the data into the standard medical format which can be viewed in the LabVIEW front panel.

Step-by-step algorithms to implement the system are:

a. Step 1: Acquire various parameters from patients/persons using MEMS smart sensors.
b. Step 2: Communicate to myRIO through ESP8266 Wi-Fi module to transfer the acquired data parameters from various sensors.
c. Step 3: MyRIO will analyze and present the collected raw data to the standard medical parametric values like pressure in mm/hg and temp in degree C/F
d. Step 4: Maintain the database of the acquired physiological data in the cloud and update periodically
e. Step 5: Connect the cloud with RMS located in the hospital where the patient/person is taking diagnosis and treatment
f. Step 6: Whenever the acquired physiological data crosses, the threshold value prescribed by the physician then the physician and caregivers will be intimated through an alarm.

Figure 2 shows the flow chart of the proposed HMDS. The proposed system acquires the physiological data from several sensors periodically and analyzes the acquired data through the program developed in the block diagram of LabVIEW and myRIO. As and when the body temperature of the patient exceeds the standard temperature of the human body the HMDS will alert the patient to take medicine. The acquired physiological information of the patient will be maintained in the cloud for future analysis and reference.

5. EXPERIMENTAL SETUP AND RESULTS

The experimental setup of the proposed IoT based health monitoring and diagnosing system using myRIO is shown in Figure 3. The experimental setup at the LMU comprises of myRIO interfaced with LabVIEW. The alarm will be indicated through an LED/buzzer. The patient's condition will be displayed through LCD. The same may be displayed in the front panel of the LMU and RMU through the gateway. Cloud will maintain the detailed data logging of the patient. The experimental setup and the output indication of each sensor are displayed through LCD as shown in Figures 3, 4, 5 and 6 respectively. The details of data logging and data in LMU and RMU are shown in Figure 7.

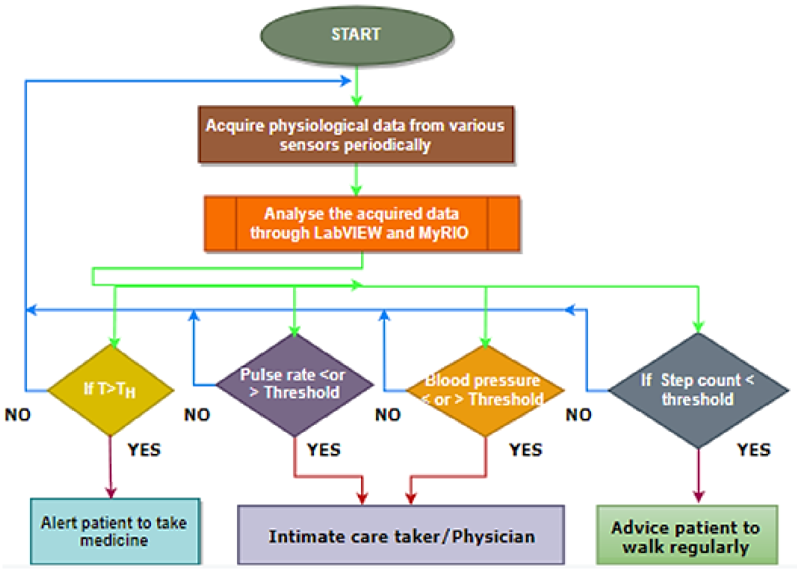

Figure 2. Flow chart of the health monitoring and diagnosing system

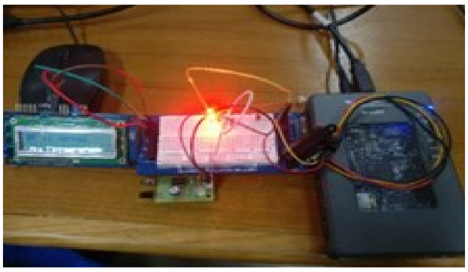

Figure 3. Experimental setup of proposed IoT based

Figure 4. Blood Pressure indication of the patient

Figure 5. Step count indication

Figure 6. Output of Pulse monitor

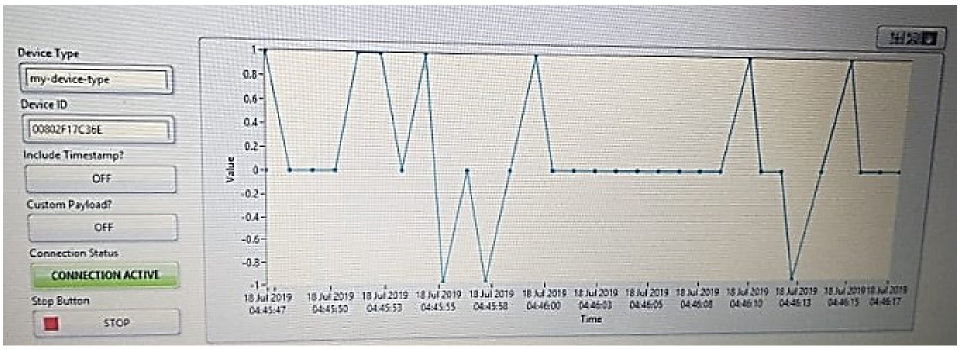

Figure 7. Data logging

Tables 1 and 2 present the confusion matrices for heart rate and blood pressure biological information acquired through the proposed HMDS and the existing SHCS-IoT [7], PHM [2] respectively. The confusion matrices are constructed for the samples of 24 numbers of patient's biological information such as heart rate and blood pressure. From the confusion matrix, the accuracy performance of proposed HMDS and other existing systems have been evaluated using as show in (1).

$$Accuracy = \frac{TP+TN}{(TP+TN+FP+FN)} \tag{1}$$

where: TP = True Positive, TN= True Negative, FP= False Positive, and FN= False Negative

TP is defined as the normalities in the heart rate or blood pressure that matches correctly with the actual positive and predicted value. TN is defined as the abnormalities in the heart rate or blood pressure that matches correctly with the actual positive and predicted value. FP is defined as predicted values incorrectly predicted as actual positive. FN is defined as positive values predicted as negative.

Table 3 compares the accuracy performance of the proposed HMDS system with the existing SHCS-IoT [7] and PHM [2]. From the result it is inferred that the proposed HMDS shows improved performance of 29.42%, 46.67% over the existing SHCS-IoT and PHM inrespect of heart rate biological information accuracy respectively. Similarly the proposed HMDS shows 27.77%, 43.74% over the existing SHCS-IoT and PHM inrespect of blood pressure accuracy respectively. The improved accuracy performance of the proposed system is due to 12-bit ADC resolution of myRIO DAQ with the processing using FPGA. The accuracy performance is illustrated in Figure 8 graphically. Similarly, the proposed HMDS shows improved speed of operation when acquiring four parameters together, through myRIO DAQ beacause of FPGA processing is shown in Figure 9. The proposed HMDS improved the processing speed by 30%, 40.2% over the exixting SHCS-IoT and PHM respectively

Table 1. Confusion matrix for heart rate

HMDS		SHCS-IoT [7]		PHM [2]	
TP=17	FN=0	TP=12	FN=3	TP=11	FN=3
FP=2	TN=5	FP=4	TN=5	FP=6	TN=4

Table 2. Confusion Matrix for Blood Pressure

HMDS		SHCS-IoT [7]		PHM [2]	
TP=16	FN=0	TP=13	FN=2	TP=11	FN=3
FP=1	TN=7	FP=4	TN=5	FP=5	TN=5

Table 3. Accuracy performance comparison

	Accuracy (%)	
	Heart rate	Blood Pressure
HMDS	91.67	95.83
SHCS-IoT [7]	70.83	75
PHM [2]	62.5	66.67

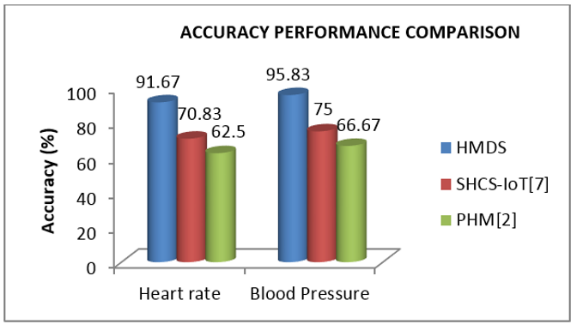

Figure 8. Accuracy performance comparison

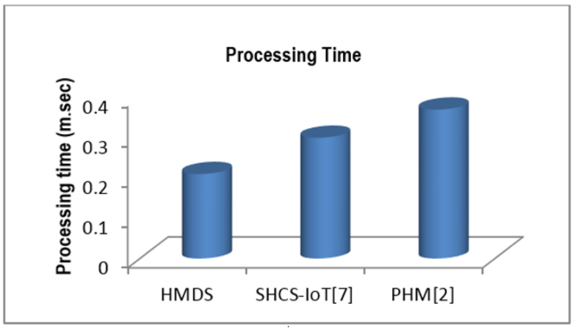

Figure 9. Processing time performance comparison

6. CONCLUSION

The IoT based HMDS using LabVIEW has been proposed to monitor the health condition of the patient. The various wearable smart sensors are used in acquiring the patient's medical parameters such as heart rate, pulse, BP, temperature and step count. LMU interfaced with LabVIEW and myRIO analyzed the received sensor data transferred through the Wi-Fi module. LMU and RMU will give the entire medical information of the patient to the experts/caregivers/diagnosis system. The results ensure that the proposed HMDS considerably improved the accuracy and speed of operation performaces over the existing smart health care system. The work may be extended to monitor other medical parameters of the patient as well as to suggest the treatment/prescription of medicine to the patient using machine-learning algorithms.

REFERENCES

[1] G. Janjua, D. Guldenring, D. Finlay, and J. McLaughlin, "Wireless chest wearable vital sign monitoring platform for hypertension," *Proc. Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. EMBS*, no. 676201, pp. 821-824, July 2017.

[2] D. S. R. Krishnan, S. C. Gupta, and T. Choudhury, "An IoT based Patient Health Monitoring System," *Proc. 2018 Int. Conf. Adv. Comput. Commun. Eng. ICACCE*, no. June, pp. 1-7, June 2018.

[3] Rajalakhshmi S., S. Nikilla, "Real Time Health Monitoring System Using IoT," *South Asian Journal of Engineering and Technology,* vol. 2, no.18, pp. 52-60, 2016.

[4] Feiroz Khan T. H., et al., "Health monitoring system using arduino" *International Research Journal of Engineering and Technology (IRJET)*, vol. 05, no. 10, pp. 1672-1677, Oct 2018.

[5] Chouhan S. and Sandhya P., "Internet of thing based car parking system,'" *Asian Journal of Pharmaceutical and. Clinical Research*, vol. 10, pp. 97-100, Apr. 2017.

[6] Mahesh Kumar D., "Healthcare monitoring system using wireless sensor network", *Int. J. Advanced Networking and Applications*, vol. 04, no. 01, pp. 1497-1500, 2012.

[7] Ashlesha A. Patil and Suralkar S. R., "Review on-IOT based smart healthcare system," *International Journal of Advanced Research in Engineering and Technology*, vol. 8, pp. 37-42, 2017.

[8] D. A. M. Budida and R. S. Mangrulkar, "Design and implementation of smart HealthCare system using IoT," *Proc. 2017 Int. Conf. Innov. Information, Embed. Commun. Syst. ICIIECS 2017*, vol. 2018-January, pp. 1-7, 2018.

[9] V. Pardeshi, S. Sagar, S. Murmurwar, and P. Hage, "Health monitoring systems using IoT and Raspberry Pi-A review," *IEEE Int. Conf. Innov. Mech. Ind. Appl. ICIMIA 2017 - Proc., no. Icimia*, pp. 134-137, February 2017.

[10] S. Bankal, I. Madan and S. S. Saranya, "Smart healthcare monitoring system using IoT," *Int. J. Applied Eng. Res.,* vol. 13, no. 15, pp. 11948-11989, 2018.

[11] B. Abinayaa and A. A. Raja, "Smart Portable Monitoring Device for Asthma Patients," *Middle-East J. Sci. Res.*, vol. 24, no. S1, pp. 136-142, 2016.

[12] D. Bibb, R. R. G. Perron, G. C. Huang, and M. F. Iskander, "Development of a Wireless Monitoring System for Microwave-Based Comprehensive Vital Sign Measurement," *IEEE Antennas and Wireless Propagation Letters*, vol 15, no. c, pp. 1249-1252, 2016.

[13] M. R. Patil and P. B. Hogade, "On Line Real Time Health Monitoring of ICU Patients using ARM7," *Int. J. Comput. Sci. Netw.,* vol. 1, no. 3, pp. 2277-5420, June 2012.

[14] A. Nath, et al., "Development of a wireless Automotive Health Monitoring System for Doctor's Chamber," *2019 10th Int. Conf. Comput. Commun. Netw. Technol. ICCCNT 2019*, pp. 1-5, July 2019.

[15] Z. Yang, Q. Zhou, L. Lei, K. Zheng, and W. Xiang, "An IoT-cloud Based Wearable ECG Monitoring System for Smart Healthcare," *Journal of medical systems*, vol. 40, no. 12, 2016.

[16] N. V. Panicker, "Development of a Blood Pressure Monitoring System for Home health Application," *Proc. IEEE Int. Conf.Circuit, Power Comput. Technol. (ICCPCT)*, pp. 1-4, March 2015.

[17] C. Sara, M. T. Scholar, and J. V Priyadarsini, " Design and Implementation of Health Monitoring System Using Arm7," *International Conf. on Communication and Electronics Systems (ICCES),* pp. 1-4, October 2016.

[18] S. B. Baker, W. Xiang, and I. Atkinson, "Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities," *IEEE Access*, vol. 5, no. c, pp. 26521-26544, November 2017.

[19] R. A. Rashid, M. R. A. Rahim, M. A. Sarijari, and N. Mahalin, "Design and implementation of Wireless Biomedical Sensor Networks for ECG home health monitoring," *Int. Conf. Electron. Des.*, pp. 6-9, December 2008.

[20] T. Z. Fadhil and A. R. Mandeel, "Live Monitoring System for Recognizing Varied Emotions of Autistic Children," *ICOASE 2018 - Int. Conf. Adv. Sci. Eng.*, pp. 151-155, October 2018.

[21] G. Yang et al., "IoT-Based Remote Pain Monitoring System: From Device to Cloud Platform," *IEEE J. Biomed. Heal. Informatics*, vol. 22, no. 6, pp. 1711-1719, November 2018.

[22] R. Sukanesh, et al., "Cellular phone based biomedical system for health care," *2010 IEEE Int. Conf. Commun. Control Comput. Technol. ICCCCT 2010*, pp. 550-553, October 2010.

[23] A. Abirami, et al., "Acquisition of Heart rate using NI-myRIO," *International Journal of Innovative Research in Electrical, Instrumentations and Control Engineering*, vol. 3, no. 3, pp. 137-140, March 2015.

[24] R. G. A. Associate, "Control and Interfacing of BLDC Motor with LABVIEW Using MYRIO," *International Journal of Research in Advent Technology*, vol.4, no.8, pp. 97-101, August 2016.

[25] E. Doering, "Ed. NI myRIO-project essentials guide." National. Instruments, 2014.