J. Integr. Sci. Technol. 2024, 12(2), 731

Journal of Integrated
SCIENCE & TECHNOLOGY

Smart environment for IoT based disease diagnosis healthcare framework

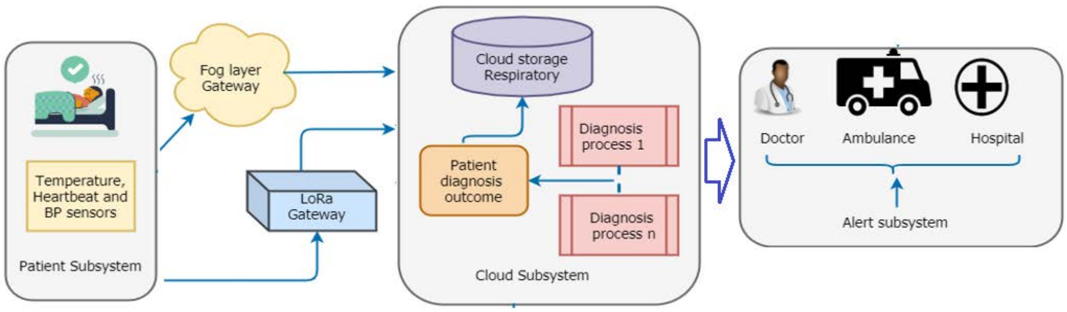
Chandan Kumar Roy,* Ritesh Sadiwala

Department of Electronics and Communication Engineering, RKDF University, Bhopal,India

Received on: 12-Jul-2023, Accepted and Published on: 30-Sep-2023

Article

ABSTRACT



In this paper, a distributed framework based on the internet of things paradigm is designed for monitoring human biomedical signals in activities involving physical exertion. Development of IoT devices in the healthcare environment has revitalized multiple features of these applications. Relative to this context, a cloud-centric IoT based healthcare monitoring disease diagnosing framework is designed which predicts the potential disease with its level of severity. In this article, a system that can monitor vital sign parameters and transmits data through wireless communication was developed, and then those data transferred to the network via Wi-Fi modules. Data can be accessed at any time and represent the patient's current condition. The system developed consists of NodeMCU as a controller that has been equipped with Wi-Fi modules, Sensor MAX30100 as a pulse detector and MLX90614 sensor as a body temperature detector. This system equips a nurse or doctor to monitor the patient's data in real time through application software on web application.

Keywords: User Diagnosis Result (UDR), Sensor MAX30100, Sensor MLX90614, Cloud Computing, Internet of Things (IoT)

INTRODUCTION

In recent years, there has been a rapid introduction of new assisted living technologies due to a rapidly aging society. In fact, it is estimated that 50% of the population in Europe will be over 60 years old in 2040, while in the USA it is estimated that one in every six citizens will be over 65 years old in 2025.

Most people over 85 years usually require continuous monitoring.[1] Therefore, taking care of elderly people has become a challenging and very important issue. Increasing the proportion of the elderly, together with different handicapped or disabled people, such as with gait disorders, neurological alterations (Parkinson's Disease, Alzheimer Disease or other dementia), lack of visual acuity, balance disorders, heart or respiratory alteration, memory loss, etc. will lead to an increase in the need for additional infrastructure, medical services and housing adaptation. In the context of major demographic change, the elderlies are limited in daily activities, depending on the help of companions or family. The issue is to change the perception of society that older people have to remain active, live independently (using information and communication technologies ICT), with the ultimate aim to increase the quality of life of these people.

Ambient Assisted Living (AAL) approach is the way to guarantee better life conditions for the aged and for people with chronic diseases and in sickness recovery status by the development of innovative technologies and services. AAL system will bring an optimistic change on different aspects of health and lifestyle. The AAL system is based on multiple sensors for measuring body temperature, blood pressure, glucose, oxygen, and weight. This system is mostly adequate for the patients of diabetes and cardiac arrhythmia. Ambient Assisted Living systems allow doctors and family members to monitor their patient remotely introduced by B. d. T. P. Gomes, et.al.[2]. Recent advancements in using IoT in healthcare helped the dream of AAL to become a reality has developed by Rashidi, et.al.[3].

In a study, Marti and Setia et.al.[4] reported development of heartbeat monitoring applications through finger tests using Arduino. Application monitoring on this system is accessed using a computer, so it will be difficult to be carried anywhere, where in

*Corresponding Author: Chandan Kumar Roy, Department of ECE, RKDF University, Bhopal, Madhya Pradesh, India.
Email: roychandan447@gmail.com

Cite as: *J. Integr. Sci. Technol., 2024, 12(2), 731.*
URN:NBN:sciencein.jist.2024.v12.731

 ISSN: 2321-4635
http://pubs.thesciencein.org/jist

the era of industry 4.0 almost everything can be done anywhere. Previous studies have shown that remote patient monitoring has a positive impact on the prevention of infectious diseases such as tuberculosis and monitoring the temperature and toxic gas conditions in the room. This was introduced by Taryudi, et.al.[5] .Therefore, this study aimed to develop an IoT-based health monitoring system that can be accessed anywhere online using a smartphone.

Using IoT medical system, a series of measurements are used to collect information like frequent changes in health parameters over time and occurrence of abnormal conditions numerously during a definite time interval. Moreover, IoT devices and medical sensor. Readings can be utilized effectively in diagnosing a disease with its severity during a specific time interval. Three subsystems are designed to carry out disease diagnosing process. Firstly, IoT devices and medical sensor based readings are acquired using user subsystem. Then for data analysis, component-based cloud subsystem is defined to carry out disease diagnosing process. Lastly, different alert based signals are sent to responder and caregiver for future necessary action based on the results computed at the cloud subsystem. In health domain, IoT context uses an extensive historical dataset of continuous measurements over a period of time to diagnose a disease. The diagnosis in a healthcare environment requires an accumulative set of measurements for effective results which cannot be possible by having a single clinic visit. In this regard, the paper contributes by (i) Proposing fog assisted IoT enabled disease diagnosis framework for the m-health perspective. (ii) Forming a health diagnosis system at server side for computing User Diagnosis Results (UDR). (iii) Handling the disease severity by adopting alert generation mechanism. Personal healthcare using IoT devices will provide a way to healthy life with low cost. Hence, effective healthcare system emphasizing on patient-centric practice is designed using medical IoT devices.

RELATED WORKS

This section analyzes and realizes various health monitoring systems and data mining methods used in IoT based healthcare environment.

A system was developed by Kadhim et.al.[6] with low-cost healthcare monitoring for people suffering from many diseases using common techniques such as wearable devices, wireless channels, and other remote devices. Network-related sensors, either worn on the body or in living environments, collect rich information to assess the physical and mental state of the patient. This work focuses on scanning the existing e-health (electronic healthcare) monitoring system using integrated systems. The main goal of the e-health monitoring system is to offer the patient a prescription automatically according to his or her condition. The doctor can check patient health continuously without physical interaction. The study aims to explore the uses of IoT applications in the medical sector, and its role in raising the level of medical care services in health institutions. Also, the study will addressed the applications of IoT in the medical field and the extent of its use to enrich traditional methods in various health fields and to determine the extent of the ability of IoT to improve the quality of health services provided. The study relies on a descriptive research approach through an analysis of the literature published in this field. The results of the study refer to the application of IoT in the health institutions; it will help to obtain accurate diagnoses for patients, which will reflect on the quality of service provided to the patient. It will also reduce periodic patient reviews to the hospital by relying on IoT applications for remote diagnosis. Also, an application in health institutions will contribute to providing data correct for the diseases that patients suffer from, and hence employing them in preparing scientific research to obtain more accurate results. It also introduces the review of the Internet-based healthcare monitoring system (HCMS) and the general outlines on opportunities and challenges of the patient's Internet-based patient health monitoring system.

A system developed by M. El Kamali, et.al.[7] that can monitor vital sign parameters and transmits data through wireless communication was developed, and then those data transferred to the network via Wi-Fi modules. Data can be accessed at any time and represent the patient current condition. So that a nurse or doctor can monitor the patient's data in real time through an application software on Smartphone. Overall the system developed consists of DFRobot Firebeetle ESP32 as a controller that has been equipped with Wi-Fi modules, Sensor MAX30100 as a pulse detector and MLX90614 sensor as a body temperature detector. Also added is a GPS (Global Positioning System) module to detect patient locations in real time and an OLED (Organic light-emitting diode) module as data viewer. The test results show that the overall system was worked properly with a 6.5% error for pulse detection, 4% for oxygen detection and 1.7% for body temperature. As for the accuracy of the position generated by GPS that is 7 meters.

A system developed by Selvaraj et.al.[8] that an innovative multidimensional, personalized coaching system to support healthy aging. This system supports elderly citizens by giving them hints and suggestions for a healthy lifestyle based on the data acquired from their daily activities. This project uses ICT based solutions to extract user data from indoor and outdoor spaces and can be scalable in a city-wide context to cover all citizens of a big city. Using the acquired data, the project builds a virtual personalized coach, which gives advice to improve the citizens well-being.

The use ICT based solutions to extract data from users in indoor spaces was introduced by N. Van den Berg, et.al.[9] The main idea of this approach is to create a web-based social network to stimulate elderly citizens and promote healthy behaviors. This web-based system provides information about the health conditions of the monitored users. The project gathers information about the users and shows it in an easy way to be interpreted by informal careers, friends and family members. The data obtained are shared over the Web to have a remote access point; however, the project does not gather data from outdoor spaces and it is not prepared to be used in a city-wide context, because the architecture is focused on obtaining data from indoor spaces without giving a scalability process.

D. Khadraoui, et.al.[10] introduced an interesting approach based on ICT tools to gather information about elderly citizens and make suggestions about what is the best itinerary to take when they need to move around the city. These itineraries are based on the users' capabilities and consider their physical conditions. The platform uses a mobile device to help the users in their travels. The project only considers outdoor spaces. This project does not gather data from indoor spaces and it is not prepared to be used in a city-wide context because the project is designed to be used only by few users.

A. Mihovska, et.al.[11] introduced a project that uses a ‘‘smart wall’’. This wall provides information about the health status of the monitored user, giving information in real time about his/her clinical measures such as cardiopulmonary conditions or neuromuscular movements. The main objective is to promote the independent living of elderly citizens by gathering information about their health status in an indoor environment. This approach only gathers data from indoor spaces, and it is prepared to be scalable in a city-wide context. However, this project does not gather data from outdoor spaces; nor it considers needs and performances of the elderly citizens when they perform outdoor activities.

B.Singh et.al.[12] was introduced an open framework for providing semantic interoperability of IoT platforms for active and healthy aging. The project provides a set of different layers based on IoT solutions to gather data from citizens and share it to third parties by using the Linked Open Data principles. The core idea of the project is to create an intelligent environment to mitigate the frailty conditions and preserve the elderly citizens’ quality of life by giving them a way to be self-independent.

Yuehong, et.al.[13] developed a Smart sensing units (sensor unit) involve different sensitive sensors connected to the patient’s body for tracking health situation, recovering health records, and detectors of sensing data. These units link to the Internet via any network to transfer recorded data to cloud unit (server). In the e-healthy system, sensing units prefer to be portable and simple.

Moser, et.al.[14] was introduced a Smartphone technology to connect Blood pressure sensor, Bodyweight sensor, Pulse Oximeter, Glucometer, Accelerometer. Through these sensors to collect information about chronic disease progression.

X. Kong et.al.[15] developed a Mobile phone technology connected with Wi-Fi module, Bluetooth, RFID, ECG and Blood pressure. With the help of these devices, collected the patient data and stored in website.

Turner J., et.al.[16] developed a Smartphone technology connected to Heart rate sensor, Bluetooth, microcontroller, electrode pads, display. Through these sensors and devices to collect information about Cardiovascular disease.

Kumar, S.P et.al.[17] introduced a project that uses a Arduino Uno, Temperature sensor, Heart rate sensor, Body position sensor, Wi-Fimodule. This provides information about the health status of the monitored user, giving information in real time about his/her clinical measures such as Heart problem conditions or noise detection.

Penmatsa, et.al.[18] developed a system that uses ECG, Bluetooth, Temperature sensor, Heart rate sensor, Arduino, Bio-sensor. This provides information about the health status of the monitored user, giving information in real time about his/her clinical measures such as Detecting abnormalities in hear.

A. Sharma, et.al.[19] introduced IoT Healthcare technologies will speed up the health care market in the next generation, as its potential varies from clinical surveillance and diagnostic automation to many potential applications. In creating health information systems, the IoT-based healthcare framework plays an important role.

Bansa, et.al.[20] was introduced a broad variety of technologies is in use for intelligent medical services: ambulance, intelligent computing, cameras, chips’ laboratories, interactive control, wearables, networking and big-data.

DESIGNED FRAMEWORK

The designed methodology is described in Fig. 1. The conceptual framework of IoT based m-Health Monitoring system consists of three phases. In phase1, Patients’ health data is acquired from medical devices and sensors. The acquired data is relayed to cloud subsystem using a gateway or local processing unit (LPU). In phase 2, the medical measurements are utilized by medical diagnosis system to make a cognitive decision related to personal health. In phase 3, an alert is generated to the parents or caretakers in context of person’s health. Moreover, if emergency situation prevails then alert is also generated to the nearby hospital to handle the medical emergency. The details regarding each phase have been described ahead:

User subsystem:

Users’ health data is acquired by data acquisition system, which allows seamless integration of intelligent, miniature low-power sensors and other medical devices. These sensors are planted in, on or around the human body to monitor body function. In our methodology, the person’s body sensor network is composed of both wearable and implanted sensor devices. Each sensor node is integrated with bio-sensors such as Body temperature and Blood pressure etc.These sensors collect student physiological parameters in structured and unstructured form, forward them to a coordinator known as a local processing unit (LPU) or Gateway forming cloud layer, this can be a portable device or smart-phone. Since heterogeneous IoT devices have different internal clock structure, therefore they need to be synchronized for timely processing at cloud layer. Moreover, in the current perspective where time is an important attribute, the gateways must be programmed to provide temporal synchronization for various datasets before transmission. Acquired data are transmitted to the connected cloud storage repository, using wireless communication media such as mobile networks 3G /CDMA /GPRS or Wi-Fi as shown in Figure 1.

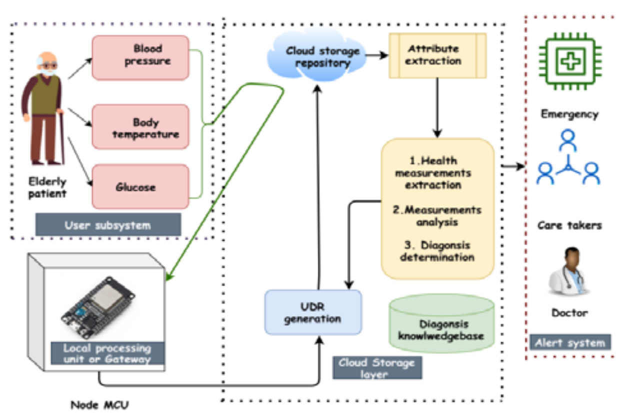


Figure 1: Overview of designed system

Cloud storage layer

The health-based sensory IoT data of each user is stored at Cloud-based platform. Since the data is ubiquitously sensed and required for different time units, so it is stored at cloud side server called as cloud storage repository. The health-related measurements are transferred to medical diagnosis system, where the analysis and diagnosis mechanism is followed to determine the person's health condition.

A user is a person whose health status is determined by using IoT based health application. Let USERi be a specific person with some Identification ID provided to the server. This ID is used for personal information gathering and medical measurements. Furthermore, identification number uniquely defines a person from other persons in terms of record values. Lastly, the user profile can be interpreted as confidential information of user maintained in user profile database. Let User_Profile be a record of ($USER_i$, PERSONAL $DATA_u$, PROFILE_TYPEv). This means specific profile type of $USER_i$ with PERSONAL DATAu. The user profile gives detail knowledge to the authorities related to person's previous health information. For example, user profile type ''age'' with personal information ''23'' and another record like ''heredity disease'' may be taken into consideration as a user profile. The details regarding personal profile generation is described in Table 1.

Table 1: Health attributes collected by health monitoring system

Users attributes	Description
Age	Age of user in years
Gender	Whether the user is male or female. (0/1)
Weight	Weight of user in kg
BP systolic/ diastolic	Systolic/ diastolic blood pressure (mmHg)
Body temperature	Patient current body temperature
Respiration index	Respiration index calculation.
Family history	User family history related to diseases
History of disease	Users' previous health history
Belongs to high-risk area	Location of the user home. (0/1)

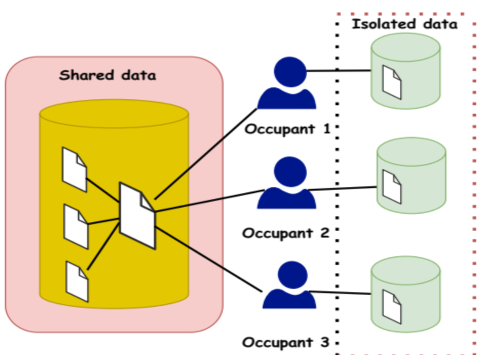


Figure 2: Isolated and shared data in multi-occupant storage

In multi- occupant data storage, isolation is one main strategy to gain data security. Isolation could be implemented in three ways: isolated database, shared database with isolated data table, and shared data table with isolated data access. Isolated database has the highest level of data security, but it has a relatively high space complexity in data storage and access. Shared data table has the lowest data security, but it is efficient in data storage and access. Isolated data table is a compromise solution to data security and data access.

In our architecture of Cloud storage layer, shown in Figure 2, considering the efficiency and security of data access, two-level tenants are defined. Occupants in the first level are assigned to healthcare agencies. In this level, isolated databases are adopted to isolate data generated by one healthcare agency from those generated by other agencies. Using isolated databases, the security of data access will be ensured by the authorized healthcare agencies. In the second level, occupant IDs are assigned to individual patients. Shared tables are used to store data generated by the same healthcare agencies. Only authorized users could access the clinical data of particular patients related to occupants. Owing to the huge amounts of patients needing healthcare services, shared tables in this level would allow accessing data more quickly compared with isolated databases or isolated tables.

Alert generation

In our health domain, user diagnosis result based information is utilized to generate alert to doctors and caregivers. The user

UDR: ($USER_i$, T_{start}, T_{end}) $\rightarrow$ ($DESS_p$, Level, Probability) is considered as the input record to generate warning or emergency alerts. In our methodology, alert generation is based on user-health state and probabilistic value generated for disease $DESS_p$ noted as $P(DESS_p)$. The T_{start} gives the information related to starting time of the diagnosis procedure and continued up to T_{end} time. The disease type is determined using $DESS_p$ attribute, disease stage is optional and determined by Level attribute, and probability defines the reliability of the disease. Firstly, the user's UDR is retrieved from the diagnosis module. If the UDR instance probabilistic value is less than the prefixed threshold value then register the person health state as Safe.

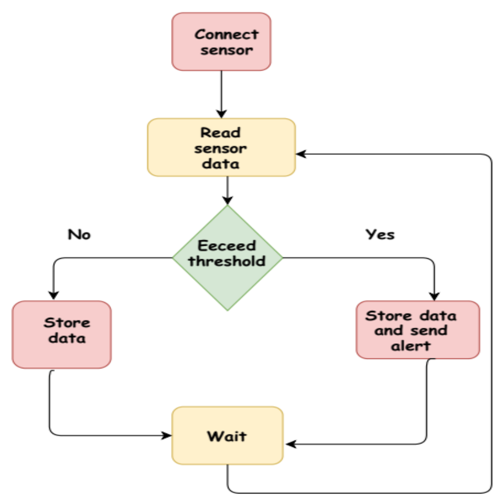


Figure 3: Flow chart of diagnosis module

On the other hand, if the probabilistic value is greater than the prefixed threshold value then put person health to Unsafe as shown in Figure 3. Moreover, an alert based threshold (α) has been considered to implement alert generation mechanism as follows:

Algorithm 1: Disease diagnosis in designed methodology Input: A set of values (i.e. series of measurement for a context type) Output: Set of records (Disease, Level, Expression for Value, probability)

Begin
{
// For a given measurement value, perform scale_based analysis.
Scale _Result = execute Scale Analytics (measurements);
Irregular Scale_Result = Scale_Result. Size( );
// For a given measurement value, perform pattern_ based analysis.
Pattern_Result = execute Pattern Analytics (measurements);
Irregular Pattern_Result = Pattern_ Result. Size ( );
// For a given measurement value, perform frequency_ based analysis.
Frequency_Result = execute Frequency Analytics (measurements);
Irregular Frequency_Result = Frequency_Result. Size ( );
If (Irregular Scale_Result = Irregular Scale_Result Range or Irregular Pattern_Result = Irregular Pattern_
Result Range or Irregular Frequency_Result = Irregular Frequency_Result Range)
UDR. add (Disease, Level, Probability);
Return UDR ;
}
End

1. If ($USER_i$_HEALTH = Unsafe) AND ($P(DESS_p) < \alpha$) then system generates warning alert signal to doctor and caretakers. This signal helps the doctor or caregiver to get timely information about the person health to avoid future causalities.

2. If ($USER_i$_HEALTH = Unsafe) AND ($P(DESS_p) > \alpha$) then generate emergency signal to the nearby hospital so that emergency situation can be handled on the spot. The alert messages are also delivered to doctors and caretakers on their respective devices.

The Algorithm 2 precisely describes the alert generation mechanism. The alert generation completely depends upon the diagnosis instance matrix UDR as described above. The disease name with its probability gives certain knowledge to the doctor and caretaker about person current health status. In addition, if emergency situation prevails then alert will be sent to emergency medical provider so that nearby hospitals and doctor can be intimated to handle medical emergency effectively. Moreover, this diagnosis method in IoT environment is less intrusive to the users and helps the caretaker as well as doctor with comfort in taking care of patient. Lastly, this designed methodology helps the doctor to diagnose the disease at the initial stage so that early precautions can be taken for better healthcare.

Algorithm 2: Alert Generation in Designed Methodology.

Input: UDR :($USER_i$, T_{start}, T_{end}) → ($DESS_p$, Level, Probability)
Step 1: Retrieve user probabilistic value related to $DESS_p$ during starting time T_{start}, and ending time T_{end}.
Step2: If (probabilistic value > threshold value), then goto **Step 4** else goto Step 3.
Step 3: $USER_i$_HEALTH = Safe ;
Calculate New SDR after N time unit; Go to Step 1;
Step 4: $USER_i$_HEALTH = Unsafe;
If ($USER_i$_HEALTH = Unsafe) AND ($P(DESS_p) < \alpha$)
Generate Warning alert to family members , goto Step 1;
Else if ($USER_i$_HEALTH = Unsafe) AND ($P(DESS_p) > \alpha$)
Generate emergency alert signal to responder with users temporal health information.
Step 5: Transfer current UDR ( ) to the concerned Doctor and Care-Takers.
Step 6: Exit

RESULTS AND DISCUSSION

They sent the recorded data to the server using sensors. We show results of the application and web browser in Arduino. The accuracy of the scheme suggested is calculated by the formulas.

$$\text{Accuracy} = \sum \frac{\alpha(xi)}{m} \quad (1)$$

The accuracy of the scheme designed is determined by (1). The specificity of the percentage for the data in the experiment is (1), $\alpha(xi)$, and m is the number of tests. In this series of data, the average accuracy is 98%. The test results show that intelligent and logical decision-making renders the IoT device dependent on the sensor effective and workable. The IoT approach increases device functionality and performance. The effects are determined by the formula showed the percentage error (2). Here accuracy is essential for the accepted value and it achieves an accuracy of the experiments.

$$\text{Error \%} = \frac{\text{Accepted value - Experimental value}}{\text{total value}} \times 100 \quad (2)$$

Table.2: Report of Patient

Patient data	
Patient name (PN)	P1
Patient ID (PID)	32154
Patient address	ABC
Body Sensor data	
Body temperature	100°F
Pulse rate (PR)	77 BPM
Blood pressure (BP)	95/140
Symptoms	
Fever	
Headache	
Weight loss	

Table 2 shows the patient report sample produced on the server when data is received from sensors and transmitted via smart devices. The patient's records, the sensor data and the effects of the patient are three sections of the study. The data gathered through sensors are presented in Table 3 for 5 patients at different intervals. The input data is obtained and calibrated; the second stage includes utilizing the patient diagnostic outcome module to determine the state of the patient. The tuning performance values of the input data are displayed in Table 4.

Table 3: Sensor data for the experiments

PN	Temperature (°F)	Pulse rate (PR) (%)	Blood pressure (BP-low)	Blood pressure (BP-high)
P1	99.4	105	82	125
P2	100.5	98	102	180
P3	102.3	108	82	133
P4	102.8	75	85	138
P5	103.2	65	94	140

The data obtained by the temperature monitor, the pulse rate (PR) sensor and the blood pressure sensor (BP) are variations of Figure 4. Particularly we can observe that for patient P5 all the data is abnormal.

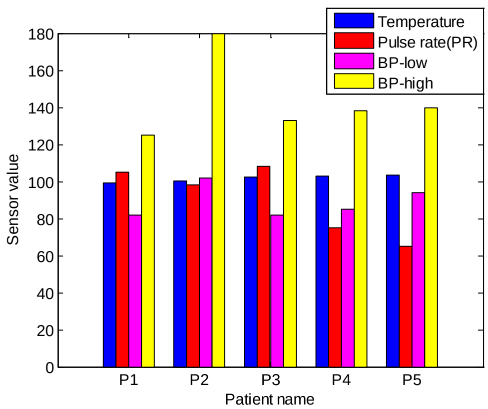


Figure 4: Data discrepancy collected through sensors.

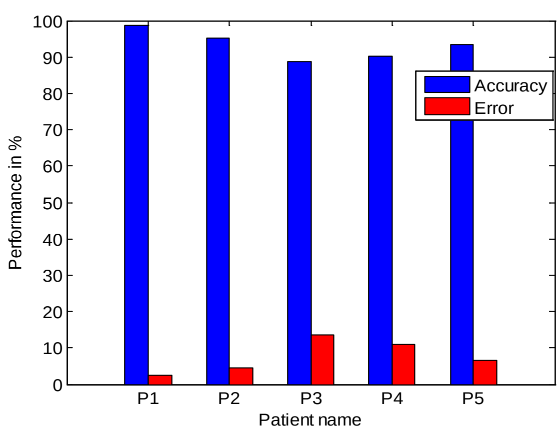


Figure 5: Results of patient diagnostic outcome.

Table 4: Tuning of sensor data with patient diagnostic outcome module

PN	Temperature	PR	BP	Accuracy (%)	Error (%)
P1	H	L	VH	98.6	2.5
P2	H	L	H	95.2	4.6
P3	N	H	M	88.7	13.5
P4	L	H	M	90.1	11.1
P5	N	N	L	93.5	6.7

H: High, L: Low, VH: Very High, N: Normal, M: Medium

The patient diagnostic result module decides, and as seen in Figure 5, the accuracy of the decision is calculated. We see the accuracy of the method for the suggested system in Table 4 from 94% to 100%. It shows that the system designed operates under rules specified for patient care and management decision-making. The IoT-based Home Monitoring Portal enables the patients to receive health care at home, to stay informed about their current status and progress, to access their own health information, to record the tremor using a smart device, and to contact his doctor. PD specialists could access anytime and anywhere the record of the patients' tremor results, increasing the accuracy of diagnosis and improving the quality of healthcare. Home health monitoring systems of patients with Disorders has the potential to improve healthcare and provide an efficient and cost effective process. Keeping the patients under observation for a certain period of time in order to evaluate the severity of symptoms helps the differential diagnosis between Parkinson's disease and other similar diseases.[21,22]

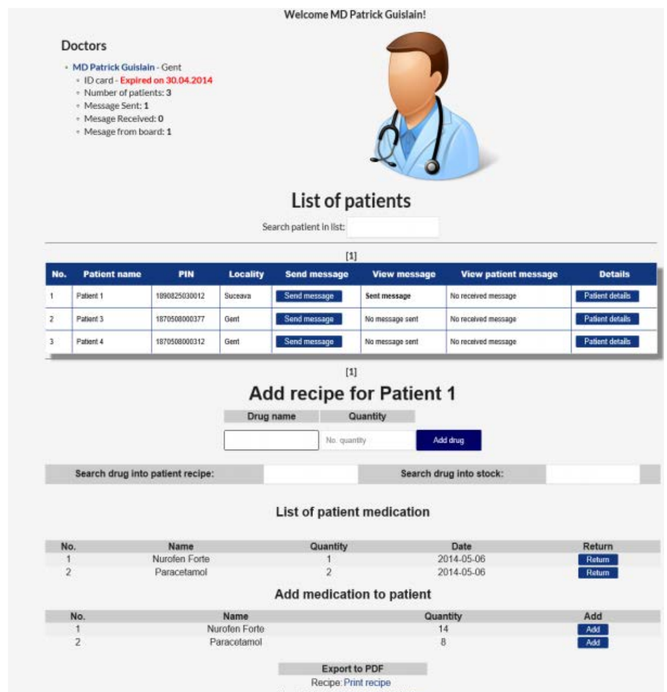


Figure 6: Home Monitoring Portal for patients with disease or other Disorders

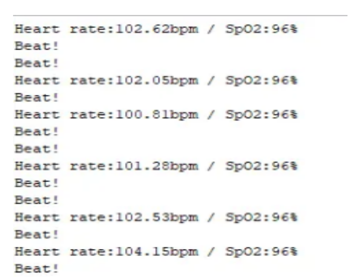


Figure 7: BPM and Blood oxygen value percentage

CONCLUSION

In conclusion, herein, a conceptual framework of the m-healthcare system generating user diagnosis result (UDR) based on health measurements provided by medical and other sensors have been designed. In this way, the system can trigger specific events (e.g., to notify family members or medical staff) when particular dangerous situations occur (e.g., abnormal in blood pressure). The designed solution presents some original contributes with respect to the state of art in the field of AAL systems.

CONFLICT OF INTEREST STATEMENT

The authors declared no conflict of interest there for publication of this work.

REFERENCES AND NOTES

1. J.M. Corchado, J. Bajo, A. Abraham. GerAmi: Improving healthcare delivery in geriatric residences. *IEEE Intell. Syst.* **2008**, 23 (2), 19–25.
2. B. de T.P. Gomes, L.C.M. Muniz, F.J. da Silva e Silva, L.E.T. Ríos, M. Endler. A comprehensive and scalable middleware for Ambient Assisted Living based on cloud computing and Internet of Things. *Concurr. Comput. Pract. Exp.* **2017**, 29 (11), 4043.
3. P. Rashidi, A. Mihailidis. A survey on ambient-assisted living tools for older adults. *IEEE J. Biomed. Heal. Informatics* **2013**, 17 (3), 579–590.
4. Nandang, R. Sri. Aplikasi Monitoring Detak Jantung Melalui Finger Test Berbasis Arduino. *Java Health Jounal*. 2020.
5. T. Taryudi, D. Daryanto, I. Darmawati, H. Purnama, L. Lindayani. Peningkatan Kapasitas Tenaga Kesehatan dalam Monitoring Penyakit Menular Berbasis Internet of Things. *J. Abdimas BSI J. Pengabdi. Kpd. Masy.* **2019**, 2 (2), 332–339.
6. K.T. Kadhim, A.M. Alsahlany, S.M. Wadi, H.T. Kadhum. An Overview of Patient's Health Status Monitoring System Based on Internet of Things (IoT). *Wirel. Pers. Commun.* **2020**, 114 (3), 2235–2262.
7. M. El Kamali, L. Angelini, M. Caon, et al. Towards the Nestore e-Coach: A tangible and embodied conversational agent for older adults. In *UbiComp/ISWC 2018 - Adjunct Proceedings of the 2018 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2018 ACM International Symposium on Wearable Computers*; **2018**; pp 1656–1663.
8. S. Selvaraj, S. Sundaravaradhan. Challenges and opportunities in IoT healthcare systems: a systematic review. *SN Appl. Sci.* **2020**, 2 (1), 139.
9. N. Van Den Berg, C. Meinke, R. Heymann, et al. AGnES: Supporting general practitioners with qualified medical practice personnel - Model project evaluation regarding quality and acceptance. *Dtsch. Arztebl.* **2009**, 106 (1–2), 3–9.
10. D. Khadraoui, H. Ayed, D. Nicolas. Sustainable E 2 mobility services for elderly people—Platform system architecture. In *Science and Information Conference*; IEEE, SAI; pp 943–948.
11. A. Mihovska, S.A. Kyriazakos, R. Prasad. eWall for active long living: Assistive ICT services for chronically ill and elderly citizens. In *Conference Proceedings - IEEE International Conference on Systems, Man and Cybernetics*; IEEE, **2014**; Vol. 2014-January, pp 2204–2209.
12. B. Singh, S. Urooj, S. Mishra, S. Haldar. Blood pressure monitoring system using wireless technologies. *Procedia Comput. Sci.* **2019**, 152, 267–273.
13. H.A. Alothman, M.T. Khasawneh, N.N. Nagarur. Internet of things in manufacturing: An overview. *ASME Int. Mech. Eng. Congr. Expo. Proc.* **2018**, 2, 3–13.
14. L.E. Moser, P.M. Melliar-Smith. Personal Health Monitoring Using a Smartphone. *Proc. - 2015 IEEE 3rd Int. Conf. Mob. Serv. MS 2015* **2015**, 344–351.
15. K. Xiaomin, B. Fan, W. Nie, D. Yi. Design on mobile health service system based on Android platform. In *Proceedings of 2016 IEEE Advanced Information Management, Communicates, Electronic and Automation Control Conference, IMCEC 2016*; **2017**; pp 1683–1687.
16. J. Turner, C. Zellner, T. Khan, K. Yelamarthi. Continuous heart rate monitoring using smartphone. In *IEEE International Conference on Electro Information Technology*; **2017**; pp 324–326.
17. S. Ananth, P. Sathya, P. Madhan Mohan. Smart health monitoring system through IoT. In *Proceedings of the 2019 IEEE International Conference on Communication and Signal Processing, ICCSP 2019*; ISMAC, **2019**; pp 968–970.
18. P.L. Penmatsa, D.V.R.K. Reddy. Smart Detection and Transmission of Abnormalities in ECG via Bluetooth. In *Proceedings - 2016 IEEE International Conference on Smart Cloud, SmartCloud 2016*; **2016**; pp 41–44.
19. A. Sharma, A.P. Bhatt. Quantum Cryptography for Securing IoT-Based Healthcare Systems; **2021**; pp 124–147.
20. M. Bansal, B. Gandhi. IoT Big Data in Smart Healthcare (ECG Monitoring). *Proceedings of the International Conference on Machine Learning, Big Data, Cloud and Parallel Computing: Trends, Perspectives and Prospects, COMITCon 2019*. **2019**, pp 390–396.
21. H. Rajoriya, R. Sadiwala. Deep compressive sensing and reconstruction algorithm in wireless Internet of Things. *J. Integr. Sci. Technol.* **2023**, 11 (2), 487.
22. J. Tiwari, R. Sadiwala. Personality prediction from Five-Factor Facial Traits using Deep learning. *J. Integr. Sci. Technol.* **2023**, 11 (4), 578.