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Patient Monitoring and Disease Analysis Based on IoT Wearable Sensors and Cloud Computing

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Abstract **— The increasing number of patients to be treated in healthcare facility raising by the time because of awareness and importance of formal healthcare. Most of healthcare centers were unoccupied with automation systems such as continuous patient monitoring, the current method is scheduling the visit of doctor or nurse to the patient. This research designed and implement a new method of patient monitoring system in a treatment room using wearable sensors of the Internet of Things (IoT) technology and patient data analysis in cloud computing. The proposed system consists of several sensors to retrieve patient information such as body temperature, heart rate, blood pressure, electrocardiogram (ECG), and motion sensor. Those parameters used to analysis of patient disease and healthcare during treatment with real-time monitoring to assist to the medical professional to get the latest update on patient health. The system is designed in an embedded module that is applicable for mobile and connected through Wireless Fidelity (Wi-Fi) system in healthcare facilities. All the patient data retrieved by IoT sensors is delivered to cloud computing to keep the data and analyzed using Long Short-Term Memory (LSTM) Algorithm to check data related to the patient health and illness. Results show the performance of the IoT sensing system working fine and being able to detect and send the data in real-time, healthcare centers achieve patient information anytime and anywhere through a mobile device. Based on real scenario testing performance, the system accuracy ability to send data is more than 95% and alert while any abnormality is detected. In overall, the system has potential for further development and widespread use in the healthcare industry for the efficiency and practical healthcare operation.**

Keywords **—Patient Monitoring, Wearable Sensor, IoT, Cloud Computing**

I. Introduction

The development of the medical industry has significantly increased as seen in many healthcare facilities and hospital setups over time. The awardees of people to the importance of formal medical treatment at healthcare facilities or hospitals especially in developing countries. Previously, the conventional method of medical treatment was implemented by consuming traditional medicine or staying at home for illness recovery due to the economic limitation of professional healthcare by some people in suburban and rural regions. Most healthcare facilities operated in semi digitalize systems, for example, the patient data record and appointments have been implemented by computerizing. The other operations are still conventional such as obtaining patient information and data update directly visit in person by medical staff or nurses to the treatment room, limitation of the number of medical staff and doctors related to the lack of time for patient convenience. The increasing number of patients in some cases such as the previous Corona Virus Disease 2019 (COVID-19) pandemic makes worst condition in healthcare facilities which patient visited only once a day or once in two days, as well as in some cases patient is unable to visit because for infected disease.

IoT is a technology that was recently developed and applied for many applications such as transportation, environmental, manufacturing, automation system, and remote monitoring as well as in the medical industry which is a healthcare facility. IoT is one of the technology potentials to support medical care for the patient due to advantages of the ability to integrate into sensing system, wearable sensors for patients are compulsory due to continuous monitoring of patient health at all the time. Furthermore, enable of wireless connectivity as required in medical devices makes IoT systems strongly applicable for future development for healthcare device connectivity and data acquisition. Cloud computing is a technology integrated of the computerized system through the cloud that ability to do analysis, storage, networking, and intelligent system. The use of cloud computing for patient data analysis because of the flexibility, once data keep in the cloud then be able to access most from anywhere at any time.

Continuous patient monitoring with multiple sensors to collect all the patient information and the number of patients in real-time required a flexible and high-performance computer system to serve as well as analyze the data, for this reason then cloud computing is suitable for this condition. This research proposed a new technique of patient data collection through multiple wearable IoT sensors attached to the patient with data filtering and classification. This method applies to achieve faster response and minimize memory usage during analysis with data classification at the front process instead at the backend as commonly applied.

II. Literature Review

Several research in patient health monitoring has been done by other researchers for example as discussed by [1-6]. The used of wearable sensors to monitor patients' health with common sensor used such as body temperature and ECG, the device connected to the internet or computer system through wireless or cellular data network. IoT-based technology for assisting patients monitoring as discussed in [7-11], the use of IoT system for patient data collecting in the healthcare center, automatic data acquisition from sensors at a patient to forward to the server. The use of IoT wireless polysomnography intelligent system for patient sleep monitoring in [12, 13] that can analyze the health of patients during rest time and continuously monitor and diagnose. Integration and implementation of fog computing to IoT for patient monitoring is another method discussed in [14-18]. The use of fog computing to analyze patient data collected by IoT sensors. Several sensors use according to the healthcare need especially in an intensive care unit (ICU) with the critical type of sensor.

Application and implementation of machine learning for patient data analysis apply in [19-21]. The use of the machine or deep learning to find abnormal data detected by sensors is an early warning to the medical staff. Data encryption and classification did in the data server for the security and privacy of patient data. A big data integrated into the IoT sensor system to collect patient data in healthcare for further analysis as elaborate in [22, 23] the high volume of patient data collected is the potential to support and make a decision on the patient illness and medical treatment. A smart disease classification for the patient as discussed in [24] with an automatic evaluation of the patient database on body sensing and integration to a tri-axial accelerometer, a tri-axial gyroscope, and a tri-axial magnetometer. Energy efficiency and power saving for patient sensors applied in order to achieve long-lasting of patient sensing system as discussed [25, 26]. The method to obtain efficiency in medical operation by saving the power of device with sleep mode during unused. A continuous patient monitoring with the centric agent for detecting patient disease as mentioned in [27-29], end-to-end architecture from the sensing system to the database and data analysis is completely designed for patient treatment in a healthcare center.

The use of Virtual Reality (VR) for post-treatment and patient rehabilitation applied in healthcare centers as discussed in [30], VR has the potential and ability to assist patients to recover from the disease. There are rehabilitation treatments shown in the VR application through a mobile device that patients easily follow. Patient localization and movement monitoring through motion sensor is one technique to monitor patient health, during the COVID-19 pandemic, one of the symptoms is cough, thus as much the movement of the patient become potential and high suspect to the infection of COVID-19 as elaborate in [31-33], besides others supporting symptoms. A comprehensive machine learning for patient health analysis implemented in a medical treatment data then analysis to find the trend and prediction for future disease as discussed in [34], then a normal basic algorithm is used for patient data with results less accuracy for the prediction and advanced algorithm required for this condition.

III. IoT System for Patient Monitoring

Continuous monitoring of the patient during treatment in the healthcare center is required to obtain real-time data and the latest update on the status of the patient. Currently, the most method to monitor patient health is direct visits in person by medical staff and an interview to get information and if any complaints. Several methods to monitor patient status and obtain information, for example, the conventional method by visit schedule to patient or automation system by attaching sensors to the patient body. The increasing number of patients by the time and limitation of medical professionals and doctors in charge become an issue with results in late response and patient information. An automation system by pushes patient data to the system using information technology is urgently implemented at many healthcare facilities.

A. Patient Sensing System

Common parameters of a patient are required by professional medical as a basic indicator for further treatment and analysis such as body temperature, blood pressure (systolic/diastolic), heart rate, and patient motion or movement to check how many patients motion in a day. Fig. 1 shows a block diagram for the detection of basic parameters of the patient to be used for analysis and determine the potential of illness. Internal signal conditioning and filtering are done at this stage to avoid wasting the dataset to be sent to the cloud system. This method is applied to the proposed system to minimize storage and unnecessary data kept in the database. Raspberry Pi is used for data processing from a patient with multiple wearable sensors and communication to backend system which cloud computing through Wi-Fi system that normally available in many healthcare centers.

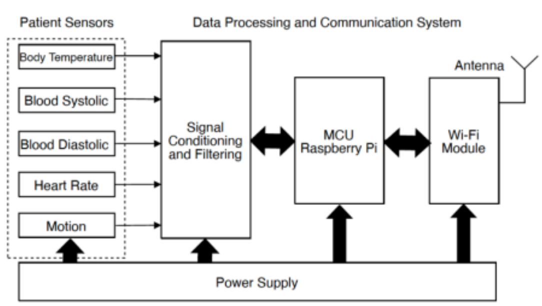

Fig. 1. Block diagram of pateint sensing system.

B. Architecture of Patient Monitoring System

The complete architecture of the patient monitoring system consists of many wearable sensors to achieve high accuracy data and real-time response. Cloud computing applies in this step due to the complex analysis and multi-sensors parameter of patient data. Fig. 2 shows a complete architecture of the patient monitoring system.

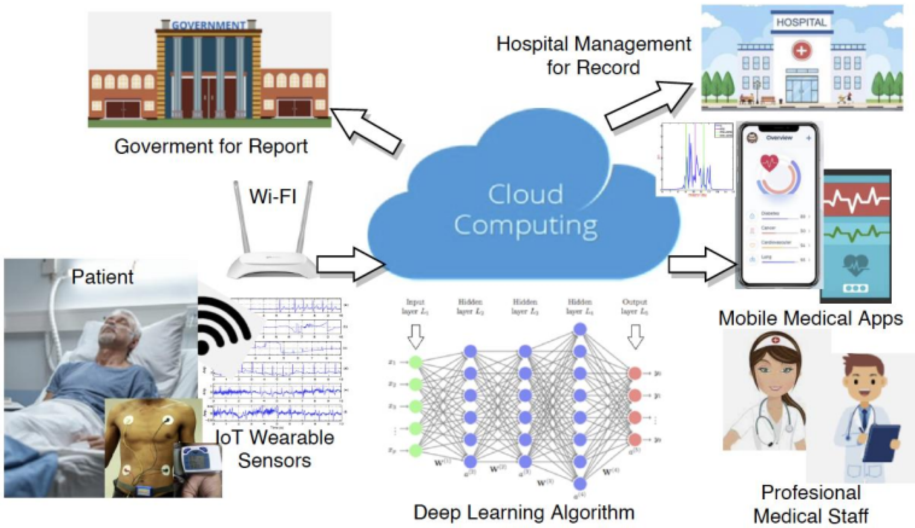

Fig. 2. The complete architecture of patient monitoring system used IoT wearable sensor.

The proposed system for patient monitoring application for a healthcare center for example medical clinic or hospital. Currently, a Wi-Fi network is a common infrastructure in many buildings or offices available as a medium to connect to the internet. Thus, in this system designed internet connectivity through Wi-Fi, all the information detected by IoT sensors is forward to cloud computing via a Wi-Fi network. Once data is available in cloud computing, a process to analyze patient data is done at this level then valuable information as required can be accessed by respective institutions for example hospital management for records and government for the report as well as medical professionals use mobile applications for report and action to the patient.

Deep Learning Algorithm

Deep learning is a subset of machine learning which enable to process of data in high variety and volume, many types of algorithm are invented according to the application and cases to solve. Long Short-Term Memory (LSTM) is an algorithm with the evolution of deep learning called Recurrent Neural Network (RNN), the first invented by Hochreiter and Schmidhuber to address problems of the aforementioned drawbacks of the RNN by adding additional interactions per module or cell. LSTM is a special model of RNN, that capable of learning in long-term dependencies and remembering information for prolonged periods as a default. Ability to do analysis based on long-term data and actively change in short-term of data than LSTM algorithm suitable to apply in any case to determine high accuracy results. Fig. 3 shows an architecture of the RNN-LSTM model of algorithm which consists of several main blocks called cell such as the input gate, output gate, and forget gate. In the dense output layer, the sigmoid activation function classifies the values in probabilities for the two predefined classes. The output called *ht* is decision-based input and pre-processing in every step called forget gate with function of *ft*.

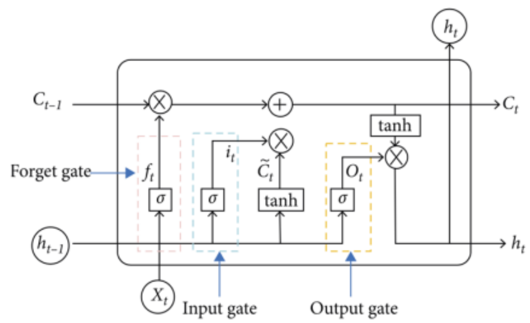

Fig. 3. The structure of RNN-LSTM algorithm

LSTM model can be elaborate as short-term memory which acts when the information is being acquired, retains that information for a few seconds, and then destines it to be kept for longer periods, or discards it. Long-term memory, permanently retains information, allowing its recovery or recall. It contains all our autobiographical data and all our knowledge. Refer to the architecture of the LSTM model which consists three major cells and the calculation of each cell and the process can be written as equation (1) to (6).

$$f_t = \sigma\,(W_f\,.\,[h_{t-1}\,, x_t] + b_f) \quad (1)$$

$$i_t = \sigma\,(W_i\,.\,[h_{t-1}\,, x_t] + b_i) \quad (2)$$

$$\grave{C}_t = \tanh\,(W_c\,.\,[h_{t-1}\,, x_t] + b_c) \quad (3)$$

$$C_t = f_t\, * C_{t-1} + i_t * \,\grave{C}_t \quad (4)$$

$$o_t = \sigma\,(W_o\,[h_{t-1}\,, x_t] + b_o \quad (5)$$

$$h_t = o_t\, * \tanh\,(C_t) \quad (6)$$

LSTM model can handle the problem with long-term dependencies of RNN in which the RNN algorithm cannot do in the prediction of the information stored in the long-term memory but can give more accurate prediction from the recent information. LSTM can use by default to retain the data for a long-term period. Normally used for predicting, processing, and classifying based on time-series data.

IV. Results and Discussion

The patient monitoring system has been designed and fabricated, several testing conducted to check the performance of the sensors and system. The sensors are attached to the patient body to detect human body temperature, blood pressure (systolic/diastolic), ECG (one pair), and movement or motion sensor. Fig. 4 shows complete sensors attached to the patient and console with a module of the microcontroller to detect patient data and then retrieve it with a filtering feature before forwarded to the cloud computing. Placement of sensor is very important to achieve high accuracy data retrieved by all the sensors including system calibration. Valuable patient information keep in local memory, although the system is not connected to the internet, once the system and connectivity are ready then all the data will be forwarded to the cloud computing via a Local Area Network (LAN) or Wi-Fi system in a healthcare centre.

Fig. 4. Analysis diagram of real-time sensor data to forecasting number

Measurement and experiment were conducted as initial testing at one medical clinic with 10 volunteers which male and female as well as of different ages. Measurement of human body parameters as a simulation to the patient with the duration of 5 hours for every volunteer, all the data and information keep in the monitoring system. During testing all the sensors attached to the volunteer body some scenarios for example simple movement, walking, sleeping, and other scenarios to achieve various information according to the activities. Table 1 shows complete information of volunteers in the testing, different gender male and female chosen in testing to achieve different results of human properties, as well as for other parameters such as age, height, weight, and background or history of the illness previously. The total time to collect information is 5 hours, the duration estimate representative to achieve human properties as a normal patient and other additional features.

TABLE I. Detail of Volunteer in Experiments

No	Volunteer	Gender	Age (Years)	Height (cm)	Weight (Kg)	History
1	A	Male	42	160	68	Normal
2	B	Male	35	158	63	Normal
3	C	Male	45	163	73	High Blood
4	D	Female	46	155	56	Normal
5	E	Male	65	162	70	Normal
6	F	Male	28	165	73	Asthma
7	G	Female	31	153	56	Normal
8	H	Female	54	150	50	Normal
9	I	Female	44	155	60	Normal
10	J	Male	38	160	62	Coronary

Results from the system can collect information about the patient and send data to the cloud with the number of information as patient parameters from the sensor. Fig. 5 shows the graph data collected consisting of patient body temperature, blood pressure (systolic/diastolic), heart rate, and movement. The results as in fig. 5 are in normal condition with data flow during collection within 5 hours that volunteer requested to steady position and less movement.

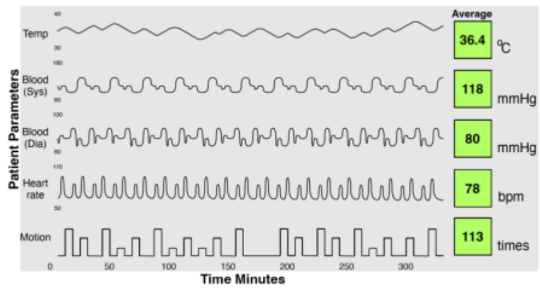

Fig. 5. Patient data detected by sensors in normal condition

Another scenario of experiment and testing by request of the volunteer in an abnormal condition, for example, a bit exercise to make high heart rate and blood pressure, little bit walking and increasing of movement to obtain simulation data in high as well as the abnormal graph. This scenario tests and checks whether the system can detect abnormal conditions based on data received and the sensitivity of the system. Fig. 6 shows the data received from the sensor and plotted in a graph with some abnormal points detected by the system and highlighted as alert from patient. The red circle indicated that patient data received in abnormal condition that required for further analysis to determine kind of disease and how to countermeasure the disease.

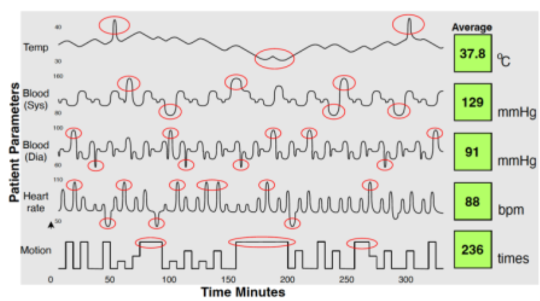

Fig. 6. Patient data detected by sensors in abnormal condition in red circle

A mobile application was developed to assist medical staff, for example, medical doctors or nurses to check and monitoring patient status. The proposed system with an IoT sensor that can monitor multiple patients at the same time using IoT network and send data to cloud computing, once data is available and processing is done in the cloud then finally mobile device gets the patient information from the cloud with an identity number based on patient information. This method is very helpful for the healthcare facilities to do patient data management and share the information to the respective institution or government. Fig. 7 shows a sample of mobile application to monitor patient data and information refer to the data uploaded to cloud computing as well as after processing with the latest information.

Fig. 7. Mobile application of patient monitoring system

V. CONCLUSION

A system for patient monitoring has been designed and developed to achieve and retrieve continuous patient health information. Several sensors are used to obtain valuable data from the patient, and pre-processing is applied to filter unnecessary data kept in cloud computing. Deep learning algorithms implemented in the cloud computing to analyze patient data to achieve high accuracy in the decision. Results shows, that all the patient data was detected and forwarded to cloud computing with successful more than 95%, while error occur due to internet connectivity through Wi-Fi, finally all the data was successfully received by cloud computing but there is a delay in the data transfer. Patient data analysis be able to determine abnormal data received from the patient and the status of the health or illness of the patient. Future development to achieve more detailed diseases and symptoms to patient potentially to do in the next step, while alert of abnormality to the patient have been done in this stage.

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REFERENCES

[1] T. Wu, F. Wu, C. Qiu, J. M. Redouté, and M. R. Yuce, "A Rigid-Flex Wearable Health Monitoring Sensor Patch for IoT-Connected Healthcare Applications," *IEEE Internet of Things Journal,* vol. 7, no. 8, pp. 6932-6945, 2020, doi: 10.1109/JIOT.2020.2977164.

[2] Y.-H. Chen and M. Sawan, "Trends and Challenges of Wearable Multimodal Technologies for Stroke Risk Prediction," *Sensors,* vol. 21, no. 2, p. 460, 2021. [Online]. Available: https://www.mdpi.com/1424-8220/21/2/460.

[3] D. K. Jain, K. Srinivas, S. V. N. Srinivasu, and R. Manikandan, "Machine Learning-Based Monitoring System With IoT Using Wearable Sensors and Pre-Convoluted Fast Recurrent Neural Networks (P-FRNN)," *IEEE Sensors Journal,* vol. 21, no. 22, pp. 25517-25524, 2021, doi: 10.1109/JSEN.2021.3091626.

[4] M. Umer, S. Sadiq, H. Karamti, W. Karamti, R. Majeed, and M. NAPPI, "IoT Based Smart Monitoring of Patients’ with Acute Heart Failure," *Sensors,* vol. 22, no. 7, p. 2431, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/7/2431.

[5] G. N. K. Reddy, M. S. Manikandan, and N. V. L. N. Murty, "On-Device Integrated PPG Quality Assessment and Sensor Disconnection/Saturation Detection System for IoT Health Monitoring," *IEEE Transactions on Instrumentation and Measurement,* vol. 69, no. 9, pp. 6351-6361, 2020, doi: 10.1109/TIM.2020.2971132.

[6] M. M. Jaber *et al.*, "Remotely Monitoring COVID-19 Patient Health Condition Using Metaheuristics Convolute Networks from IoT-Based Wearable Device Health Data," *Sensors,* vol. 22, no. 3, p. 1205, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/3/1205.

[7] F. Stradolini *et al.*, "An IoT Solution for Online Monitoring of Anesthetics in Human Serum Based on an Integrated Fluidic Bioelectronic System," *IEEE Transactions on Biomedical Circuits and Systems,* vol. 12, no. 5, pp. 1056-1064, 2018, doi: 10.1109/TBCAS.2018.2855048.

[8] J. A. L. Marques *et al.*, "IoT-Based Smart Health System for Ambulatory Maternal and Fetal Monitoring," *IEEE Internet of Things Journal,* vol. 8, no. 23, pp. 16814-16824, 2021, doi: 10.1109/JIOT.2020.3037759.

[9] M. Haghi *et al.*, "A Flexible and Pervasive IoT-Based Healthcare Platform for Physiological and Environmental Parameters Monitoring," *IEEE Internet of Things Journal,* vol. 7, no. 6, pp. 5628-5647, 2020, doi: 10.1109/JIOT.2020.2980432.

[10] M. Raza, M. Awais, N. Singh, M. Imran, and S. Hussain, "Intelligent IoT Framework for Indoor Healthcare Monitoring of Parkinson's Disease Patient," *IEEE Journal on Selected Areas in Communications,* vol. 39, no. 2, pp. 593-602, 2021, doi: 10.1109/JSAC.2020.3021571.

[11] A. M. Said, A. Yahyaoui, and T. Abdellatif, "Efficient Anomaly Detection for Smart Hospital IoT Systems," *Sensors,* vol. 21, no. 4, p. 1026, 2021. [Online]. Available: https://www.mdpi.com/1424-8220/21/4/1026.

[12] C. T. Lin *et al.*, "IoT-Based Wireless Polysomnography Intelligent System for Sleep Monitoring," *IEEE Access,* vol. 6, pp. 405-414, 2018, doi: 10.1109/ACCESS.2017.2765702.

[13] Y. Chen, W. Sun, N. Zhang, Q. Zheng, W. Lou, and Y. T. Hou, "Towards Efficient Fine-Grained Access Control and Trustworthy Data Processing for Remote Monitoring Services in IoT," *IEEE Transactions on Information Forensics and Security,* vol. 14, no. 7, pp. 1830-1842, 2019, doi: 10.1109/TIFS.2018.2885287.

[14] N. A. Mudawi, "Integration of IoT and Fog Computing in Healthcare Based the Smart Intensive Units," *IEEE Access,* vol. 10, pp. 59906-59918, 2022, doi: 10.1109/ACCESS.2022.3179704.

[15] S. K. Sood and I. Mahajan, "IoT-Fog-Based Healthcare Framework to Identify and Control Hypertension Attack," *IEEE Internet of Things Journal,* vol. 6, no. 2, pp. 1920-1927, 2019, doi: 10.1109/JIOT.2018.2871630.

[16] J. A. Rincon, S. Guerra-Ojeda, C. Carrascosa, and V. Julian, "An IoT and Fog Computing-Based Monitoring System for Cardiovascular Patients with Automatic ECG Classification Using Deep Neural Networks," *Sensors,* vol. 20, no. 24, p. 7353, 2020. [Online]. Available: https://www.mdpi.com/1424-8220/20/24/7353.

[17] G. Yang *et al.*, "IoT-Based Remote Pain Monitoring System: From Device to Cloud Platform," *IEEE Journal of Biomedical and Health Informatics,* vol. 22, no. 6, pp. 1711-1719, 2018, doi: 10.1109/JBHI.2017.2776351.

[18] E. A. Kadir, A. Efendi, and S. L. Rosa, "Application of LoRa WAN Sensor and IoT for Environmental Monitoring in Riau Province

Indonesia," in *2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI)*, 16-18 Oct. 2018 2018, pp. 281-285, doi: 10.1109/EECSI.2018.8752830.

[19] S. S. Sarmah, "An Efficient IoT-Based Patient Monitoring and Heart Disease Prediction System Using Deep Learning Modified Neural Network," *IEEE Access,* vol. 8, pp. 135784-135797, 2020, doi: 10.1109/ACCESS.2020.3007561.

[20] I. Ahmed, G. Jeon, and F. Piccialli, "A Deep-Learning-Based Smart Healthcare System for Patient's Discomfort Detection at the Edge of Internet of Things," *IEEE Internet of Things Journal,* vol. 8, no. 13, pp. 10318-10326, 2021, doi: 10.1109/JIOT.2021.3052067.

[21] S. A. Alsareii *et al.*, "Machine Learning and Internet of Things Enabled Monitoring of Post-Surgery Patients: A Pilot Study," *Sensors,* vol. 22, no. 4, p. 1420, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/4/1420.

[22] D. C. Yacchirema, D. Sarabia-JáCome, C. E. Palau, and M. Esteve, "A Smart System for Sleep Monitoring by Integrating IoT With Big Data Analytics," *IEEE Access,* vol. 6, pp. 35988-36001, 2018, doi: 10.1109/ACCESS.2018.2849822.

[23] E. A. Kadir, S. M. Shamsuddin, S. Hasan, and S. L. Rosa, "Wireless monitoring for big data center server room and equipments," in *2015 International Conference on Science in Information Technology (ICSITech)*, 27-28 Oct. 2015 2015, pp. 187-191, doi: 10.1109/ICSITech.2015.7407801.

[24] P. Pierleoni, A. Belli, O. Bazgir, L. Maurizi, M. Paniccia, and L. Palma, "A Smart Inertial System for 24h Monitoring and Classification of Tremor and Freezing of Gait in Parkinson's Disease," *IEEE Sensors Journal,* vol. 19, no. 23, pp. 11612-11623, 2019, doi: 10.1109/JSEN.2019.2932584.

[25] E. Spanò, S. D. Pascoli, and G. Iannaccone, "Low-Power Wearable ECG Monitoring System for Multiple-Patient Remote Monitoring," *IEEE Sensors Journal,* vol. 16, no. 13, pp. 5452-5462, 2016, doi: 10.1109/JSEN.2016.2564995.

[26] E. H. Hafshejani *et al*., "Self-Aware Data Processing for Power Saving in Resource-Constrained IoT Cyber-Physical Systems," *IEEE Sensors Journal,* vol. 22, no. 4, pp. 3648-3659, 2022, doi: 10.1109/JSEN.2021.3133405.

[27] M. A. Uddin, A. Stranieri, I. Gondal, and V. Balasubramanian, "Continuous Patient Monitoring With a Patient Centric Agent: A Block Architecture," *IEEE Access,* vol. 6, pp. 32700-32726, 2018, doi: 10.1109/ACCESS.2018.2846779.

[28] B. Dammak, M. Turki, S. Cheikhrouhou, M. Baklouti, R. Mars, and A. Dhahbi, "LoRaChainCare: An IoT Architecture Integrating Blockchain and LoRa Network for Personal Health Care Data Monitoring," *Sensors,* vol. 22, no. 4, p. 1497, 2022. [Online]. Available: https://www.mdpi.com/1424-8220/22/4/1497.

[29] E. A. Kadir, H. Irie, S. L. Rosa, B. Saad, S. K. A. Rahim, and M. Othman, "Remote Monitoring of River Water Pollution Using Multiple Sensor System of WSNs and IoT," in *Sensor Networks and Signal Processing*, Singapore, S.-L. Peng, M. N. Favorskaya, and H.-C. Chao, Eds., 2021// 2021: Springer Singapore, pp. 99-113.

[30] O. Postolache, D. J. Hemanth, R. Alexandre, D. Gupta, O. Geman, and A. Khanna, "Remote Monitoring of Physical Rehabilitation of Stroke Patients Using IoT and Virtual Reality," *IEEE Journal on Selected Areas in Communications,* vol. 39, no. 2, pp. 562-573, 2021, doi: 10.1109/JSAC.2020.3020600.

[31] M. Mercuri *et al*., "2-D Localization, Angular Separation and Vital Signs Monitoring Using a SISO FMCW Radar for Smart Long-Term Health Monitoring Environments," *IEEE Internet of Things Journal,* vol. 8, no. 14, pp. 11065-11077, 2021, doi: 10.1109/JIOT.2021.3051580.

[32] I. d. M. B. Filho, G. Aquino, R. S. Malaquias, G. Girão, and S. R. M. Melo, "An IoT-Based Healthcare Platform for Patients in ICU Beds During the COVID-19 Outbreak," *IEEE Access,* vol. 9, pp. 27262-27277, 2021, doi: 10.1109/ACCESS.2021.3058448.

[33] S. S. Vedaei *et al*., "COVID-SAFE: An IoT-Based System for Automated Health Monitoring and Surveillance in Post-Pandemic Life," *IEEE Access,* vol. 8, pp. 188538-188551, 2020, doi: 10.1109/ACCESS.2020.3030194.

[34] U. Satija, B. Ramkumar, and M. S. Manikandan, "Real-Time Signal Quality-Aware ECG Telemetry System for IoT-Based Health Care Monitoring," *IEEE Internet of Things Journal,* vol. 4, no. 3, pp. 815-823, 2017, doi: 10.1109/JIOT.2017.2670022.

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