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TELEMEDICINE FOR HEART DISEASE PATIENTS BASED ON IOT AND FOG COMPUTING USING DEEP BELIEF NETWORK

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Abstract- Telemedicine as well as all types of monitoring systems have proved to be an effective and affordable method for heart disease with a good extent of applicability. This analysis aims to present an IoT-based heart monitor for patients with heart disease. By using the LoRa authentication mechanism, the device will send the ECG signal to a Fog layer service. It also involves an AI algorithm for the detection of heart rhythms based on deep belief learning. It is possible to support the diagnosis made by the doctor with the automated identification of arrhythmias, achieving a clear clinical vision that enhances therapeutic decision making. On ECG records, the efficiency of the proposed system is assessed using two combined MobileNet networks that identify data with 95 % of heart rhythm accuracy.

Keywords- IOT, Fog Computing, ECG, Deep Belief Network and heart disease.

1. INTRODUCTION

The main diagnostic instrument in telecardiology systems is the electrocardiogram (ECG), which is the traditional procedure for assessing patients with cardiovascular disorders (rhythm or conduction disorders). The electrical potential of the heart is measured using electrodes that are connected to different sections of the body surface in a traditional 12-lead ECG device [1]. In order to record the ECG signal and send it to an analysis station, many monitoring systems are available on the market. These systems include traditional non-invasive monitoring devices such as Holter or external recorders of cardiac events [2]. Monitoring systems, however, have increasingly introduced new ECG capture devices that integrate more convenient and less intrusive sensors, known as wearable ECG monitoring systems [3]. While now available, these devices have usually been built for recreational purposes and there is still little clinical experience. There is therefore still a demand for a low-cost, easy-to-use monitoring system that reduces diagnostic time and prevents the patient from traveling to the health center. The Internet of Things (IoT) may be the key to creating a wearable ECG monitoring device in this situation. The IoT is a physical entity or computer network that links and communicates data over the Internet using sensors. It allows knowledge to be exchanged in real time and data to be gathered and analyzed on a small and large scale, something that is already changing the way medicine is structured and conceived. Many physician-patient experiences currently include equipment and instruments, including external medical devices, such as glucose monitors; implanted devices, such as pacemakers; or stationary devices, such as home monitoring devices and scanners [4]. The availability of access to such devices makes it possible to build a health system and service infrastructure: the Internet of Medical Things (IoMTT). The IoMT boom is driven by an increase in the number of connected medical devices that can produce, gather, analyze or transmit health data and link, transmit or store data in the cloud or internal servers to health care provider networks [5].

The introduction of new hardware technologies, such as radio frequency identification, has allowed the large-scale production of more powerful IoT and IoMT applications (RFID), Technologies for wireless networks (Bluetooth, Wi-Fi, low-energy ZigBee) and low-energy wireless area networks (LPWAN) such as LoRa and SigFox help enhance mobile access to the Internet.

Intelligent devices produce a huge amount of IoT data that needs to be processed and exploited in real time, so artificial intelligence (AI) tools are needed to process and contextualize this information in order to generate behavior without human interference. By providing customized treatments, AI algorithms can generate more specific and detailed diagnoses. Automatic ECG diagnosis has, for example, been studied for decades. Machine learning techniques such as fuzzy set theory, rough set theory, Hidden Markov models, artificial neural network and Support Vector Machine were introduced in the early years [6]. The automated diagnosis trend, however, points to the use of deep learning, which attempts to model high-level data abstractions using computer architectures that enable multiple, iterative, non-linear data transformations represented in the form of a matrix or tensor. This latest automatic learning model has opened the door to various automatic diagnostic applications [7].

In this paper, we propose a monitoring system equipped with an ECG device for patients with cardiovascular disorders, especially arrhythmias. The device is capable of transmitting the ECG signal using the LoRa communication protocol to a service located in the Fog layer. In addition, to help the physician make the diagnosis, it requires a deep belief learning-based AI algorithm. For the identification of Atrial Fibrillation and other heart rhythms, this method automatically classifies single short ECG lead records. This monitoring system may be of particular interest to patients living in rural areas or those needing telematics, since it facilitates remote bio-signal acquisition and eliminates the need for face-to-face consultation. Figure 1 shows Proposed Methodology work flow.

a) Physical level (Level 1): In addition to other devices for capturing other bio-signals, such as photoplethysmography (PPG), oxygen saturation (SpO2), phono cardiography (PCG) or temperature, it consists of physical devices such as the ECG device. The analog-to-digital conversion (ADC) system and LoRa communication protocol are included in these devices for the transmission of the captured signals.

b) Fog Level (Level 2): It is a middle level, consisting of elements of Fog computing, usually called Fog nodes. In this scenario, these nodes provide software resources such as deep learning algorithms and AI-Fog machines, which are responsible for processing, classifying, and auto-diagnosing the ECG signal and also the rest of the signals.

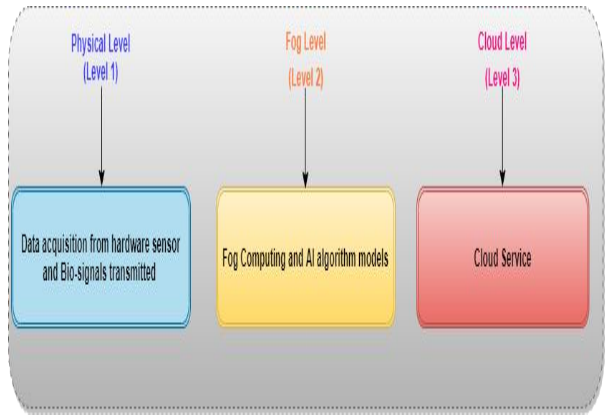

Figure 1: Proposed Methodology work flow

c) Cloud Level (Level 3): The top level is a cloud layer made up of cloud resources or applications that are required. This level includes, in this case, health centers, hospitals and any associated healthcare service. If some form of cardiac anomaly is observed, these services receive warnings from the second stage. If this is the case, the computer sends the auto-diagnosis (pre-analysis) along with the acquired knowledge, enabling the top level services to analyze the problem in depth.

The rest of this paper has contained the following sections. In section 2, related work of IOT's, Fog computing based on healthcare monitoring has narrated briefly. The section 3 discussed the proposed architecture and methodology of Telemedicine. In section 4, the results and discussion of the proposed methodology, simulation, experimental were shown and discussed. Finally, the section 5 concludes the proposed methodology.

2. RELATED WORK

The previous work of substantial research into the telemedical environment is largely limited and dispersed throughout this portion. One of the latest buzzwords in information technology is the IoT. It is made up of several artifacts that make it a giant information system. The two distinct terms align with the iot," the internet" is the initial, and therefore, the "Things" an area unit the web could be a worldwide network or the network of networks comprising countless networks of organizations which have been a worldwide network or network of networks comprising countless networks of organizations which being [8]. On the opposite hand, “Things” will belong to any object we all know during this world. It includes not solely electronic devices and appliances, a however additionally non-electronic product like a piece of furniture, fabric, material components, landmarks, monuments, moreover as a history, a sophistication and trade teams [9]. These objects are objected, marked, and processed with a uniform communication protocol to unify all around the United States not solely to observe them, however additionally to stay United States updated regarding the standing and states of the things. The IoT and its ability to code and monitor artifacts that permit businesses to be additional economical, minimize errors, speed up processes, and increase productivity resources [10]. With the flexibility to create the attention method patient-centered, non-hospital-based and provide patients the flexibility to the self-manage their sickness, get health care remotely, get medical help in an associate emergency, the iot has been the simplest candidate for a sensible health system [11]. Therefore, the importance of IoT has been realized not solely in the trade however additionally within the field of health care and work, having a such associate Brobdingnagian potential within the gift world. Within the future, its use is believed to be additional practiced within the space of IT integration to leap even any.

The fog is thought-about to be the “decreased a cloud” off from the sting of the network. It's conjointly one among the foremost promising core innovations for the 5G a wireless networking infrastructure of the longer term [12]. The Fog Node permits an end-user devices to figure along for the storage, a management, and the network communication tasks. Completing these tasks shut or at the tip users will minimize the latency, because it is clear that it takes for much longer to urge information from the cloud than to fetch it from the network edge itself [13, 14].

The fog server also can store completely different content like pictures, audios, native data like maps, accessibility of restaurants and retailers during a specific space, etc., almost like the cloud, and may be health knowledge in our case. The fog computing is very appropriate within the field of an iot with such capabilities several causing and requesting tasks the square measure on the sting of the network since the increase in the communication-capable objects and sensible devices. This request may be requested while not the necessity for cloud knowledge. The associate in a nursing an economical design may have been designed with such handiness, which might have a better service rate, the higher QoS and the fewer cloud burden. Hence, within the field of IT convergence, the appliance of the fog computing may be extremely realized [15, 16].

The LoRa a wide space network or the LoRa a wireless protocol in the other kind is ruled by the LoRa Alliance [17]. It's specially designed to be used with an iot to the most. It not solely makes wide area network property easier, however additionally needs a lot of lower in an operational power than its counterparts. However, its application is additional completed once coming up with a powerfully network with a low outturn necessity, because it has a low outturn. It uses the band a linear frequency modulated signals to a cypher the data and uses the whole channel information measure for a signal transmitted [18, 19].

3.PROPOSED ARCHITECTURE AND METHODOLOGY OF TELEMEDICINE

The planned design for a wise health observation system supported IOT and fog is conferred in Figure 2. Edge users ar equipped with varied forms of wearables, medical devices or medical sensors within the planned design. These devices will so perform totally different medical measurements. These measurements will track important signs of the body, like force per unit area, blood heat, heart rate, rate of respiration, etc. The devices ar connected to the LoRaWAN entry in order that, in our case, the knowledge generated by these finish devices may be directly sent to the Fog nodes or primary health centers. There is also quite one in every of these primary health centers that serves individuals supported their location. Although there's no web facility, the employment of the LoRaWAN entry makes it attainable to transmit the information recorded by those devices to the first health centers tens of kilometers away [20]. In villages or far off wherever, there's no correct web or web facilities, this could be a large profit. the knowledge sent through these devices is connected to the medical personnel's good devices, laptops or computers and protected within the storage of the hospital. For people United Nations agency is already diagnosed with sure medical issues, their medical info is keep supported their sickness in order that it's simple for his or her patient to be half-track by the medical workers [21].

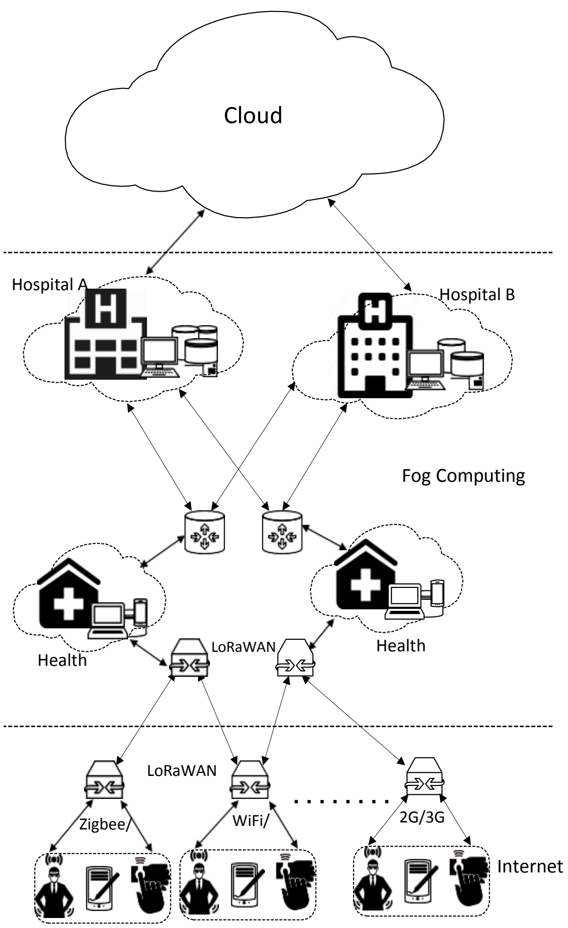

Figure 2: IOT and Fog based health monitoring system.

For an example, If the patient features a pressure the level downside, the information is incredibly necessary to notice, and the respiration rate data are incredibly necessary to trace if the patient has the dyspnea. So, supported the medical record of the patient, important body data are being held on at the Health Centers in medical information records. During this method, doctors or accountable medical employees can monitor the information stheir patient all the time and, if necessary, advise the tolerant their immediate visit to health centers; take different specific actions, like the telemedicine service, if applicable. Instant health services like motorcar services may also have been provided by the Health Centers by contacting the Hospitals within the amount once the case is incredibly serious or an emergency [22].

3.1. Module I

In reality, the physical layer consists of a series of capture devices to collect data on health-related signals to diagnose cardiovascular diseases. In order to allow the processing and prediction in real time, the collected data is then transmitted to the center fog layer. Accordingly, this section primarily describes the proposed bio-signal capture, pre-processing, transmission and analysis equipment, in particular the ECG. Figure 3 shows Level 1 architechture. Figure 4 shows healthcare sensor electrodes.

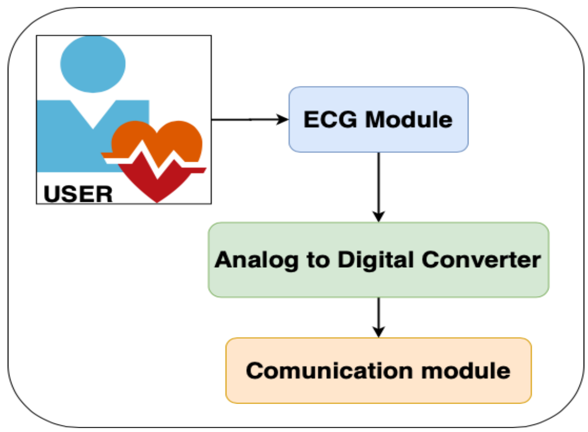

Figure 3**:** Level 1 architechture

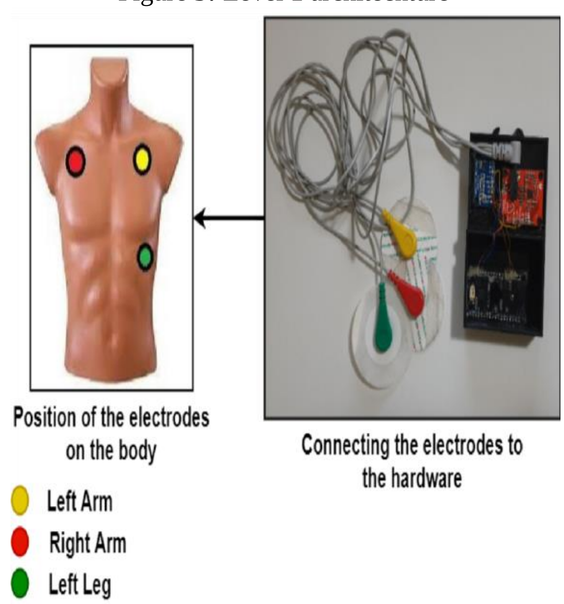

Figure 4: Healthcare sensor electrodes [23]

3.2 Module II

This second level is responsible for managing and analyzing all incoming data produced at the first level to determine whether there is an arrhythmia in the recording of the ECG. A low-cost raspberry pi device forms the hardware portion of this stage. The ECG data classification method will be in charge of this system.

Figure 5: Proposed Fog System [24]

Figure 5 shows proposed fog system. A computer vision model for the Tensor Flow open source platform, for the classification used a Mobile Network. Mobile Nets are small models with low latency and low power that can be used for processes of classification, detection, embedding and segmentation. In a resource-constrained environment, such as a computer or an integrated application, these models have been designed to work rapidly with high precision. We developed two Mobile Nets for our framework that were trained in the cloud and embedded in the raspberry pi later on.

For the classification, four types of rhythm patterns were considered to group the ECG signals: normal sinus rhythm (Nsr), auric fibrillation (Af), other rhythm (Or) and too noisy to identify (No). The knowledge is validated as brief (9-60 s long) and single-lead ECG recordings. ECG recordings were collected by the mobile device and the band pass was filtered [25]. Table 1 shows the different levels and its chronic heart disease.

Inputs:

- Array of ECG elements signal (ECG) for 1 minute.

Outputs:

- Rhythm, QRS width, ST-Elevation and regularity for ECG.

Buffered Reader ECG sensor
for all e_i^0 and e_v^0 ϵ ECG **DO**
    get Peaks ();
    getAvgCycleInterval ();
    getQRS ();
    isSTSegmentUP();
end for

Table 1 the different levels and its chronic heart disease [26]

Level			Heart disease
Color	**PC**	**Status**	
(green)	0–2	Normal	No disease
(blue)	03–25	Cold	Muscular pain
(yellow)	26–50	Sick	Chest infection
(orange)	51–65	Emergency	Arrhythmi a , apnea
(red)	66–100	Risk	Heart attack

4. RESULT AND DISCUSSION

This section addresses the implications of the proposed methodology of telemedicine technique, the results of the simulation and the validation of the work proposed, and the individual characterization of the approach proposed. Table 2: Shows the Heart Disease of various risk level Very Low-VL, Low-L, Medium-M, High-H, Very High-VH, IBIstd- Inter Beat Interval standard deviation.

Table 2: Shows the Heart Disease of various risk level Very Low-VL, Low-L, Medium-M, High-H, Very High-VH, IBIstd- Inter Beat Interval standard deviation.

Heart Disease Risk Level					
IBI std/IBI mean	VL	L	M	H	VH
VL	M	M	H	VH	VH
L	M	H	H	VH	VH
M	H	M	M	M	H
H	L	L	M	M	H
VH	VL	VL	H	M	L

Table 3: Deep Belief Learning Classification Efficiency

Mean Absolute Error	.0545
Root Mean Squared Error	.3468
Coverage of all Cases	94%
Total Number of Instances	100

Statistical results show that the proposed DBL (Deep Bilief Learning) system is capable of effectively classifying the risk category of each user's hypertension attack with a high classification accuracy and low error value (Mean absolute error, Relative absolute error, and Root mean squared error). To compare their output with DBL, various classification algorithms such as multilayer perceptron (MLP), K-nearest neighbor (KNN) and linear regression (LR) are also implemented so that their use can be experimentally justified. Fig. 6 is a comparison of various classification algorithms for different statistical measures [27-31]. The accuracy of the algorithms for classification is shown in Fig. 6(a), showing that classification algorithms based on DBL perform better than all other algorithms. Fig. Fig. 6(b) indicates the classification time used by various datasets with different algorithms. Results show that DBL takes less time for the risk level of hypertension attack to be classified. Fig. Fig. 6(c) indicates the different measures for classification, namely: sensitivity, accuracy, recall and F-measure. In all the statistical measures which justified the use of DBL in the proposed method, DBL gave better results than other comparable algorithms. Table 3 shows deep belief learning classification efficiency.

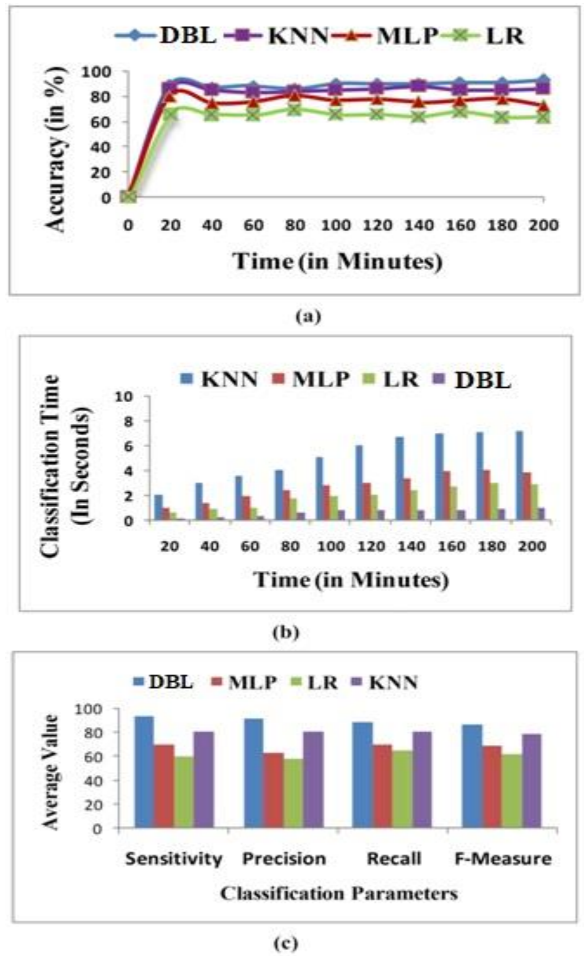

Fig. 6. Experimental Results of Classification Algorithms: (a) Classification Accuracy (b) Classification Time (c) Classification Measures

5. CONCLUSION

The major problem faced by all countries, governments and health care organizations is the high mortality rate due to cardiovascular diseases arising from high BP. In order to predict and prevent the risk of hypertension at an early stage at remote locations, real-time tracking and review of BP statistics is now possible due to advances in information and communication technology. In this paper, to classify stages of hypertension, the IoT-fog-based healthcare mon-itoring method is suggested for continuous monitoring of BP and other health parameters. DBL is used to estimate the level of risk of a hypertensive attack. The main point of this paper is to continuously produce a BP fluctuation warning from the fog device on user's mobile phones. In addition, each user's review results and compiled medical information are permanently stored on cloud storage to be shared with domain ex-perts such as physicians, doctors, personal caregivers and medical institutes in order to provide different precautionary measures and recommendations on time. The experimental effects of the device proposed are contrasted with the technology of cloud computing. The findings show that the proposed system achieves efficiency in bandwidth, minimal delay and higher response time accuracy.

REFERENCES

[1] Pani D., Dessì A., Saenz-Cogollo J.F., Barabino G., Fraboni, B., Bonfiglio, A. "Fully Textile, PEDOT:PSS Based Electrodes for Wearable ECG Monitoring Systems", IEEE Transactions on Biomedical Engineering, Vol.63,no.3, pp.540-549,2016.

[2] Mahmud,M.S.,Wang,H.Esfar-E-Alam,A.M., Fang,H., "AWireless Health Monitoring System Using Mobile Phone Accessories", IEEE Internet Things J.,Vol. 4, no.6,pp.2009-2018,2017.

[3] Djelouat.H., Baali. H, Amira. A., Bensaali. F., "IoT based compressive sensing for ECG monitoring", Proceedings of the IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), Exeter, UK. pp. 183-189,2017.

[4] Tianyi Chen, Qing Ling, Yanning Shen, Georgios B. Giannakis, "Heterogeneous Online Learning for "Thing-Adaptive" Fog Computing in IoT", IEEE Internet of Things ,Vol.5,no.6,pp. 4328 - 4341,2018.

[5] P. Verma, S. K. Sood, "Fog assisted-IoT enabled patient health monitoring in smart homes," IEEE Internet of Things Journal, Vol. 5, no. 3, pp. 1789-1796, 2018.

[6] J. Jiang, Z. Yan, J. Shi, P. Kandachar, and A. Frendenthal, "A mobile monitoring system of blood pressure for underserved in china by information and communication technology service," IEEE Transactions on Information Technology in Biomedicine, Vol. 14, no. 3, pp. 748-757, 2010.

[7] D. Claudio et al., "A dynamic multi-attribute utility theory–based decision support system for patient prioritization in the emergency department", IIE Transactions on Healthcare Systems Engineering,Vol. 4,no.1,pp.1-15, 2014.

[8] M. Peng, S. Yan, K. Zhang, and C. Wang, "Fog computing based radio access networks: Issues and challenges," IEEE Network, Vol. 30, no. 4, pp. 46-53, 2015.

[9] M. Satyanarayanan, "Pervasive computing: Vision and challenges," IEEE Personal Communications, Vol. 8, no. 4, pp. 10-17,2002.

[10] D. Saha and A. Mukherjee, "Pervasive computing: A paradigm for the 21st century," IEEE Computer, Vol. 36, no. 3, pp. 62-65, 2003.

[11] Lee, J., Jung, J., Kim, Y.T., "Design and development of mobile cardiac marker monitoring system for prevention of acute cardiovascular disease", Proceedings of IEEE Sensors,pp.1724-1727,2011.

[12] Majdi Bsoul, Hlaing Minn, Lakshman Tamil. "Apnea MedAssist: real-time sleep apnea monitor using single-lead ECG", IEEE Transactions on Information Technology in Biomedicine, Vol.15,no.3,pp.416-427,2011.

[13] C.T. Lin et al., "Wireless and wearable EEG system for evaluating driver vigilance", IEEE Transactions on Biomedical Circuits and Systems, Vol.8,no.2,pp. 165-176,2014.

[14] E.Sardini, M. Serpelloni and V. Pasqui., "Wireless wearable T-shirt for posture monitoring during rehabilitation exercises", IEEE Transactions on Instrumentation and Measurement, Vol.64,no.2,pp. 439-448,2015.

[15] E.E. Stone and M. Skubic., "Fall detection in homes of older adults using the Microsoft Kinect", IEEE Journal of Biomedical and Health Informatics, Vol.19,no.1,pp.290-301,2015.

[16] Mitra, U., Emken, B. A., Lee, S., Li, M., Rozgic, V., Thatte, G., Vathsangam, H., Zois, D., Annavaram, M., Narayanan, S., et al, "KNOWME: A case study in Wireless Body Area Sensor Network design", IEEE Commun. Mag, Vol.50, pp.116-125,2015.

[17] B.A. Reyes et al., "Novel electrodes for underwater ECG monitoring", IEEE Transactions on Biomedical Engineering, Vol.61,no.6,pp.1863-1876,2014.

[18] S. Abolfazli, Z. Sanaei, A. Tabassi, S. Rosen, A. Gani, and S. U. Khan, "Cloud adoption in

Malaysia: Trends, opportunities, and challenges," IEEE Cloud Comput., 2015.
[19]Muhammad.G,Alhamid.MF,Alsulaiman.M,Gupta. B., "Edge computing with cloud for voice disorder assessment and treatment", IEEE Commun Mag.,Vol.56,no.4,pp.60-65,2018.
[20] Hossain MS, Muhammad G., "Emotion-aware connected healthcare big data towards 5G", IEEE Internet Things J.,Vol.5,no.4,pp.2399-2406,2018.
[21] ImranA, ZohaA, Abu Dayya A. "Challenges in 5G:how to empower SON with bigdata for enabling 5G",IEEE Network, Vol.28,no.6,pp.27-33,2014.
[22] Schuiki F, Schaffner M, Gürkaynak FK, Benini L., "A scalable near-memory architecture for training deep neural networks on large in memory datasets", IEEE TransComput, Vol.68,no.4,pp. 484-497,2019.
[23]KerJ,WangL,RaoJ,LimT"." Deep Learning Applications in Medical Image Analysis,IEEE Access, Vol.6,pp.9375-9389,2017.
[24] Sharma S, Chen K, Sheth A., "Toward practical privacy-preserving analytics for IoT and cloud-based healthcare systems", IEEE Internet Comput,Vol.22,no.2,pp.42-51,2018.
[25] TawalbehLA, MehmoodR, BenkhlifaE, SongH., "Mobile cloud computing model and bigdata analysis for healthcare applications", IEEE Access, Vol.4,no.6171-6180,2016.
[26] Verma P, Sood SK., "Fog assisted-IoT enabled patient health monitoring in smart homes", IEEE Internet Things J., Vol.5,no.3,pp.1789-1796,2018.
[27] SoodSK, MahajanI, "A fog-based healthcare framework for Chikungunya", IEEE Internet of Things Journal, Vol. 5,no.2,pp.794-801,2018.
[28] Sood SK, Mahajan I., "IoT-fog-based healthcare framework to identify and control hypertension attack", IEEE Internet Things J., Vol.6,no.2,pp.1920-1927,2019.
[29] RodriguezJ,GoniA,IllarramendiA., "Real-time classification of ECGs on a PDA", IEEE Trans InfTechnol Biomed, Vol.9,no.1,pp.23-34,2005.
[30] ShiW,CaoJ,ZhangQ,LiY,XuL., "Edge computing: vision and challenges", IEEE Internet Things J., Vol. 3, no.5,pp. 637-646,2016.
[31] R.Deepan S.Senthil Kumar, "A Energy-Efficient Probabilisitic Coverage Protocol in Wireless Sensor Networks", International Research Journal of Multidisciplinary Science & Technology (IRJMRS),Vol.1,no.7,pp. 407-412,2016.