International Journal of Engineering & Technology, 7 (4.11) (2018) 1-4

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Wearable Sensor and Internet of Things Technology for Better Medical Science: A Review

Arisa Olivia Putri[1], Musab A. M. Ali[2]*, Mohammad Saad[3], Sidiq Samsul Hidayat[4]

[1]*School of Graduate Studies, Management and Science University, 40100 Shah Alam, Selangor, Malaysia*
[2]*Faculty of Information Sciences and Engineering, Management and Science University, 40100 Shah Alam, Selangor, Malaysia*
[3]*Faculty of International Medical School, Management and Science University, 40100 Shah Alam, Selangor, Malaysia*
[4]*Department of Telecommunication Engineering, Politeknik Negeri Semarang, 50275 Semarang, Indonesia*
**Corresponding author E-mail: drmusab@msu.edu.my*

Abstract

E-health becomes one of the internet's products for healthcare. The problems of health service such as far hospital and expensive examination fees become the emergence of this technology. Consequently, people reluctant to check their health to hospital. E-health provides information on disease prevention, detecting early symptoms, and monitoring the patient's condition based on medical parameters from a far distance. Internet of things became the main concept in this system, which combines wearable sensors, communication systems, and mobile user interfaces. Reliable and valid system, easily carried, help the doctor to monitor patients from far distance expectantly to overcome the problems. The aims of this paper review are describing how an internet of things technology and wearable sensor help medical science and find the best way to create a health monitoring system.

Keywords: *Wearable Sensor; IoT; Validity; Reliability; Performance.*

1. Introduction

The Internet offers convenience in communicating, transacting, and searching for information. The Internet makes people change their habit from conventional method to digital method. People fulfill their needs using the internet because it can be accessed everywhere [1]. E-health becomes the development of internet for medical requirement [2]. E-health provides information on disease prevention, detecting early symptoms of the disease, and monitor the patient's condition based on medical parameters from a far distance [3]. In addition, E-health combines wearable sensors, smartphone and web interface[4] to make one system that connects each other. Some research shows the utilization of E-Health in many purposes such as Pulmonary disease [5], Parkinson disease [6], diabetes mellitus [7], and cardiac diseased [8]. Similarly, smartwatch becomes an alternative wearable sensor, combined with a smartphone as the interface for health monitoring [6, 8]. Furthermore, research must study not only the alternative device for health monitoring but also the reliability, validity, and performance of the wearable sensor. If the result shows a huge gap measurement using medical equipment, then the system has no reliability, invalid, and lack of performance. Therefore, the objective of schematic paper review to show the internet of things (IoT) and wearable sensors that can help healthcare in the function, shape, quality, and development. Finding the best technology in wearable sensors for health monitoring system to increase awareness about health and reduce cases of sudden death due to delay in treatment. The next section describes the methods in this study. Section 3 discussion of the study and section 4 concludes the paper.

2. Methodology

This review consisted of paper with years of research making 2016 until 2018. The author search references from IEEE Explore and PubMed using the terms "health monitoring", "smartwatch", "wearable sensors" and " internet of things". Both journal and conference papers related to the development of health monitoring, or wearable sensor which is for a health monitoring.

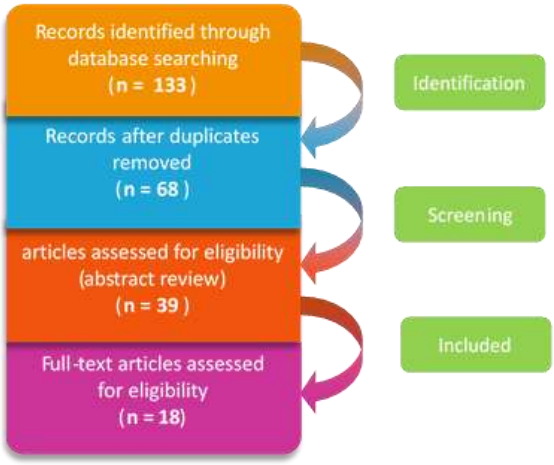

Fig. 1: The process flow for literature search

Fig. 1 shows a diagram of the literature review search flow. One hundred and thirty-three articles found in the investigation. Sixty-eight after significant articles stay after removing duplicate and

Copyright © 2018 Authors. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

read the title. Thirty-nine derived from reading the abstract. After reading the title and abstract and end up with 18 papers, we then start reading their content and thus deploying which of them will provide us with related information wearable sensor and the development of internet of things for healthcare. Furthermore, this paper also investigated another factor in future work, system, architecture, framework, and amount of participant.

3. Results and Analysis

3.1 Search Results

Eighteen articles published between the years 2016–2018 were included in the review [9-26] from conference or journal. Research originated from eleven different countries including Germany [9, 10], Romania [11, 12], India [13-18], Bangladesh [19], Iraq [20], Italy [21], Taiwan [22], Netherlands [23], Ecuador [24], Indonesia [25] and United Kingdom [26].

3.2. Study Focus and Participants

Most research created a device for health monitoring system that focuses on the users. The users can be a healthy person, hospital patients, elders, and soldiers [15, 21, 27-28]. An early warning to provide emergency notifications and make reliable and valid low-cost devices was the development of health monitoring system [12, 21, 25, 28]. Furthermore, the number of participants have various differences, some of them not clearly mentioned, and others papers used 5 to 20 participants for data collection, gender does not become an emphasis in the study [12, 15, 23, 27-28].

3.3. Wearable Sensor

The combination of sensors attached to the body and serves to detect vital conditions in the body called wearable sensors. Health monitoring system which has low-cost, wearable sensor and accurate value is a trend [16]. Some research had developed a low-cost device, which can monitor health real-time [11-12, 18]. It becomes a solution to the problems of expensive examination fees. The pulse sensor is a common sensor used to detect heartbeat [11, 17, 24]. In other hands, for detecting heart-beat, level of oxygen in the blood and blood pressure using photoplethysmography (PPG) sensor[21, 28]. A small, reliable, simple health monitor is the ultimate advantages of PPG sensor [21].



Fig. 2: The system of smartwatch for healthcare [24]

Some studies use smartwatch, as a health monitoring device to monitor vital condition like temperature, heart rate, oxygen in blood, stress level, and blood pressure [23, 29]. Furthermore, through the Bluetooth, the data will be sent to the mobile phone which is connected to cloud server database. The system of smartwatch for healthcare is shown in the Fig. 2. For smartwatch have their own user interface to monitor health for Android mobile. Some studies also show that can monitor through the website. As written one study not only uses the Thingspeak to monitor health status and provide alerts but also available LCD, which shows the users condition [17]. After data is sent to the cloud, they use several algorithms for data processing that will determine the level of patient health. The threshold algorithms used to determine the threshold in a sensor reading in the health monitoring system [17, 21]. With this algorithm doctors and medical personnel can find out whether the patient's condition is worsening.

3.4. Internet of Things (IoT)

Internet of Things (IoT) is a system that combines sensor/ camera, network, and cloud server that effective to facilitate the exchange of data automatically without always utilizing humans. The Internet of Things (IoT) technology is being developed continuously [7]. IoT consists of sensors and actuators connected to a wireless network which can monitor through the user interface (UI) simultaneously. Some recent technological advances allow the emergence of IoT such as nanotechnology, wireless sensor networks, mobile communications, and ubiquitous computing. However, there are some challenges such as sensors, communication methods, the protocols, etc. [7]. In communication methods, the speed of data delivery process is the most important [29]. If the data is delivered quickly, handling actions will also be done quickly.
The adoption of Internet of Things (IoT) technologies is the way to improve living conditions especially for the elderly using the development of sensor, internet, and Android-mobile [9]. Health monitoring system using IoT can utilize various sensors, microcontrollers, and user interface devices also provide secure, efficient, and intelligent services to applications [10]. As the result, doctor can analyse patient's condition using the sensor readings. On the next step, with RFID technology or a tag can be used as a card of the patient at the clinic, so that it is easier to know the identity of the patient while performing the registration or finding the record of the patients [30].

4. Discussion

Becomes one of the fastest developing medical research in recent years, the wearable sensor can be the alternative to perceive human condition [22]. Most of them build that system to monitor health, nevertheless the other benefit of this to promote the sports activity and combat physical inactivity thus raising awareness to maintain health [11]. Lately, the development of wearable sensor can facilitate remote monitoring. This development becomes the emergence of a smartwatch for health monitoring. Smartwatch detects their condition without visit hospital especially for elder people [16]. The Wearable sensor allows patients to measure and monitor their vital body parameters and enables remote monitoring for the doctor to know their patient's conditions [22].
In [28] make IoT-based systems for health monitoring and tracking of soldiers. The Aurdino board becomes a low-cost solution for this device. This technology can provide accurate location as it brings out GPS with the system to find the missing soldiers in critical condition. psychological parameters that use are heart rate, temperature, oxygen level [27].
In [14] design and develop a small, portable and low power consuming device called Fit-Wit, this system fit for all users with different age groups. Fit-wit combine Intel Genuino 101 board, LCD, pulse rate sensor, LM35 to make a health monitoring system [16].
In [11] make pulse sensors integrated inflexible structure can provide a non-invasive wearable system to make continuous patients monitoring. PPG sensors use reflection methods to detect body condition. First, blood absorbs more light than other tissues and a reduction in the amount of blood reveals an increase in the intensity of light scattered across the reflected back of the tissue. this reflection time difference functions to detect body condition [32].
In [25] said that the comparison between the number of guards and the elderly imbalances makes it impossible to monitor all the

elderly at all times. The wristband consists of several sensors will show the elders conditions. Results of sensor readings process in the microcontroller and using ESP8266 as the communication method, then the guardian can access the system through web application [24].

In [19] design real-time monitoring of health parameters such as pulse rate, HRV, blood pressure, SPO2 and blood glucose levels. it processes the PPG signal and calculates using the formula of each parameter [21].

In [31] make a healthcare system based on the smart wearable system that gives patients to measure and monitor their vital parameters and enables remote monitoring for the patients. ECG and accelerometer sensor attached to the human body to transmit the body parameters to the smartphone via IEEE 802.15.4 and to cloud server [22].

In [22] design a low cost, inexpensive and multichannel Seismocardiography (SCG) data collection and analysis method to strengthen the reliability of existing ECG-based cardiac monitoring systems. This system collecting the real ECG and SCG data with help of our IRB license, combined analysis of multichannel SCG and ECG data, SCG features derivation, abnormality detection of ECG data and SCG data. In [22] using Bluetooth and WiFi used to send data to the server [12].

In [16] design a low-cost IoT based on biomedical kit which can monitor the vital signs for example temperature readings and pulse rate for the people in rural areas. This system includes a temperature sensor, pulse oximeter, MSP430 and nRF4L01 for the data transmission to Raspberry Pi 3 that works as the hub [18]. The summary of list sensor that uses in the research above shows in Table 1. The communication method like ESP8266, Bluetooth or nRF24L01 also listed in Table 1.

Table 1: Comparison of different sensor and communication method in the literature

References	Sensor	Communication Method
[16]	LM35, Pulse Rate Sensor, Grove-gas sensor	ESP8266/WiFi
[27]	Pulse Sensor, LM35	Bluetooth
[32]	PPG Sensor, OLED SPO2	Bluetooth
[24]	Pulse sensor, MLX90614 temperature sensor, MPU6050 accelerometer sensor	ESP8266/WiFi
[21]	PPG sensor	Bluetooth
[22]	ECG, accelerometer	Xbee RF
[12]	ECG sensor, LIS331DLH accelerometer sensor	Bluetooth and Wifi
[18]	LM35 temperature sensor, TSL257 PPG Sensor	nRF24L01

Most research use pulse sensors to detect heart rate, Photoplethysmography (PPG) and Piezoelectric Pulse Transducer (PPT) will detect body parameters such as heart rate and oxygen level [30]. Temperatures become one of the parameter that is frequently monitored [15, 16, 31]. Some accelerometer sensors using The ADXL345 for falling detection [17]. Most research using the LM35 sensor as temperature sensor but MLX90614 placed on the wrist to measure the temperature because it has a low noise to make it more accurate [24]. The sensor results show a significant error value, the comparison shown in Table 2.

Another important factor in the health monitoring system is communication method, the faster data transmission to prevent the situation from worsening. Nrf24l01 is still the fastest and most efficient modules compared to other protocols [18]. However, most research uses Bluetooth low energy (BLE) because of the easiest configuration and compatible with Android mobile phone.

Table 2: Comparison result between MLX90614 and digital thermometer [25]

Experiment	Thermometer Digital (^{0}C)	MLX90614(^{0}C)	Difference (^{0}C)
1	34.1	33.714	0.386
2	34.7	34.011	0.689
3	35.2	35.388	0.188
4	34.2	33.742	0.458
5	33.9	34.097	0.197
6	33.8	34.767	0.967
7	34.6	35.083	0.483
8	35.4	35.503	0.103
9	35.9	36.311	0.411
10	35.2	35.729	0.529

For smartwatch actually have their own user interface to monitor health from Android-mobile. Some studies show that it provides web monitoring or mobile monitoring for the patients. As written one study not only uses Thingspeak to monitor health status and provide alerts, but also available LCD which shows the users conditions [12].

5. Conclusion

Future technology in health monitoring using wearable sensors and smartwatch is a low-cost solution. ECG monitoring systems, temperature, heart rate, blood pressure and even stress in real time reduce human mortality due to a lack of awareness of the importance of keeping these parameters at a safe level. In addition, the tendency to check every symptom at the hospital and the lack of capable medical personnel can already be overcome with health monitoring system. The PPG sensor is widely used because of the small device and utilized for several functions such as heart rate readings, blood pressure, and oxygen in the blood [30, 32, 33]. Comparison with pre-existing technology shown a low error rate of PPG sensor [21]. As the best sensor in this review, PPG sensor detects early symptoms of health problem. Bluetooth low energy becomes the easiest device for communication, although not the most efficient and fast one, the ease of configuration and compatible with mobile phones become the added value they have.

Acknowledgment

The author would like to thank Management and Science University and Dr. Musab A. M Ali for his technical support and proofreading the manuscript

References

[1] G. Eysenbach, "What is e-health?," J. Med. Internet Res., 3(2), e20, 2017.
[2] M. S. Klein-Fedyshin, "Consumer Health Informatics-integrating patients, providers, and professionals online," Med. Ref. Serv. Q., 21(3), 35–50, 2002.
[3] T. P. Hogan, B. Wakefield, K. M. Nazi, T. K. Houston, and F. M. Weaver, "Promoting access through complementary eHealth technologies: Recommendations for VA's Home Telehealth and personal health record programs," J. Gen. Intern. Med., 26(2), 628–35, 2011.
[4] H. Mshali, T. Lemlouma, and D. Magoni, "Adaptive monitoring system for e-health smart homes," Pervasive Mob. Comput., 43, 1–19, 2018.
[5] C. K. Tey, J. An, and W. Y. Chung, "A Novel Remote Rehabilitation System with the Fusion of Noninvasive Wearable Device and Motion Sensing for Pulmonary Patients," Comput. Math. Methods Med., 2017, 1-8, 2017.
[6] S. A. Fattah, M. M. Rahman, N. Mustakin, M. T. Islam, A. I. Khan, and C. Shahnaz, "Wrist-Card: PPG Sensor based Wrist Wearable Unit for Low Cost Personalized Cardio Healthcare System," Proceedings of the Int. Conf. Comput. Commun. Autom., 2017, pp. 1–7.
[7] F. DaCosta, Rethinking the Internet of Things. Apress, 2013.
[8] D. Minoli, Building the Internet of Things with IPv6 and MIPv6: The Evolving World of M2M Communications. John Wiley and Sons, 2013.

[9] S. E. de Lucena, D. J. B. S. Sampaio, B. Mall, M. Meyer, M. A. Burkart, and F. V. Keller, “ECG monitoring using Android mobile phone and Bluetooth,” Proceedings of the IEEE Int. Instrum. Meas. Technol. Conf. Proc., pp. 1976–1980, 2015.
[10] H. Ouyang, J. Tian, G. Sun, Y. Zou, Z. Liu, H. Li, L. Zhao, B. Shi, Y. Fan, Y. Fan, and Z. L. Wang, “Self-Powered Pulse Sensor for Antidiastole of Cardiovascular Disease,” Adv. Mater., 29(40), 1-10, 2017.
[11] A. R. Maria, S. Pasca, and R. Strungaru, “Heart rate monitoring by using non-invasive wearable sensor,” Proceedings of the E-Health and Bioengineering Conference, 2017, pp. 587–590.
[12] E. Lupu, R. Arsinte, and T. Sumalan, “Prototype of a wearable system for personal health control,” Proceedings of the E-Health and Bioengineering Conference, 2017, pp. 345–348.
[13] N. Patii and B. Iyer, “Health monitoring and tracking system for soldiers using Internet of Things (IoT),” Proceedings of the International Conference on Computing, Communication and Automation, 2017, pp. 1347–1352.
[14] N. Sharma, Z. Shareef, and S. R. N. Reddy, “Fit-Wit: Design and development of wearable healthcare device based on Intel Curie platform,” Proceedings of the International Conference on Computing, Communication and Automation, 2017, pp. 1271–1276.
[15] S. Kale, S. Mane, and P. Patil, “IOT based wearable biomedical monitoring system,” Proceedings of the International Conference on Trends in Electronics and Informatics, 2017, pp. 971–976.
[16] V. V. Garbhapu and S. Gopalan, “IoT Based Low Cost Single Sensor Node Remote Health Monitoring System,” Procedia Comput. Sci., 113, 408–415, 2017.
[17] P. Kalyan and G. S. Sharma, “IOT Based Heart Function Monitoring and Heart Disease Prediction System,” 3(12), 1-8, 2017.
[18] U. Satija, B. Ramkumar, and M. S. Manikandan, “Real-Time Signal Quality-Aware ECG Telemetry System for IoT-Based Health Care Monitoring,” IEEE Internet Things J., 4(3), 815–823, 2017.
[19] S. A. Fattah, M. M. Rahman, N. Mustakin, M. T. Islam, A. I. Khan, and C. Shahnaz, “Wrist-card: PPG sensor based wrist wearable unit for low cost personalized cardio healthcare system,” Proceedings of the IEEE Global Humanitarian Technology Conference, 2017, pp. 1–7.
[20] R. M. D. Omer and N. K. Al-Salihi, “HealthMate: Smart Wearable System for Health Monitoring (SWSHM),” Proceedings of the IEEE 14th International Conference on Networking, Sensing and Control, 2017, pp. 755–760.
[21] L. Mainetti, V. Mighali, L. Patrono, P. Rametta, and M. L. Stefanizzi, “An IoT-aware system for elderly monitoring,” Proceedings of the IEEE 3rd International Forum on Research and Technologies for Society and Industry, 2017, pp. 1–5.
[22] P. K. Sahoo, H. K. Thakkar, and M.-Y. Lee, “A Cardiac Early Warning System with Multi Channel SCG and ECG Monitoring for Mobile Health,” Sensors, 17(4), 1-28, 2017.
[23] M. Weenk, A. P. B. Alken, L. J. L. P. G. Engelen, S. J. H. Bredie, T. H. van de Belt, and H. van Goor, “Stress measurement in surgeons and residents using a smart patch,” Am. J. Surg., 216(2), 361-368, 2017.
[24] [24]P. Yanchapaxi, C. Tipantuña, and X. Calderón, “Wearable system for monitoring of human physical activities,” Proceedings of the Fourth International Conference on eDemocracy and eGovernment, 2017, pp. 245–250.
[25] K. E. Ansefine, Muzakki, Sanudin, E. Anggadjaja, and H. Santoso, “Smart and wearable technology approach for elderly monitoring in nursing home,” Proceedings of the IEEE 3rd International Conference on Engineering Technologies and Social Sciences, 2017, pp. 1–6.
[26] D. Iakovlev, S. Hu, H. Hassan, Vincent Dwyer, Roya Ashayer-Soltani, Chris Hunt, and Jinsong Shen., “Smart Garment Fabrics to Enable Non-Contact Opto-Physiological Monitoring,” Biosensors, 8(2), 1-14, 2018.
[27] S. Shaikh and V. Chitre, “Healthcare monitoring system using IoT,” Proceedings of the International Conference on Trends in Electronics and Informatics, 2017, pp. 374–377.
[28] N. Patil and B. Iyer, “Health Monitoring and Tracking System For Soldiers Using Internet of Things (IoT),” Proceedings of the Int. Conf. Comput. Commun. Autom., pp. 1347–1352, 2017.
[29] Syahid, S. S. Hidayat, A. Santoso, and A. H. Riyadi, “Rancang Bangun Sistem Monitoring Anak di Tempat Penitipan Anak Menggunakan Kamera CCTV Berbasis Android,” 3(1), 293–299, 2017.
[30] A. Rizali, T. A. Nugroho, S. S. Hidayat, and S. Widodo, “Sistem informasi berbasis RFID untuk rekam data medis (SIREDAM) pasien di poliklinik,” 1(1), 360–371, 2015.
[31] R. M. D. Omer, and N. K. Al-Salihi, "HealthMate: Smart Wearable System For Health Monitoring (SWSHM)," Proceedings of the IEEE 14th International Conference on Networking, Sensing and Control, 2017, pp. 755-760.
[32] F. DaCosta, Rethinking the Internet of Things. Apress, 2013.