

Wireless Sensor Network and Web Application Hybrid Scheme for Healthcare Monitoring

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Abstract

Problems on healthcare delivery have become the current concern in most studies in the academe and industries. These studies have been conducted by using evolving technical solutions. These solutions are driven by technological advancements both in medical sensors and low-power networked systems. Wireless Sensor Networks (WSNs) prompted the emergence of most healthcare systems in recent years. This work proposes a system architecture for a remote healthcare monitoring system using pulse sensor and temperature sensor to measure the physiological parameters including Heart Pulse (HP) and temperature of patients. The presented system is evaluated using several persons with different ages, gender, and situations. The conducted technique is achieved respecting to the cost of service, signal quality, and quality of service. Finally, the current system is effective given that all reported results are standard values.

Keywords: Healthcare monitoring, Body sensor networks, Sensor, Heart pulse, Body temperature

1. Introduction

The global elderly population is growing, and the general population is aging (Gray et al., 2007; Viswanathan et al., 2012; Hao et al., 2008). An increasing number of individuals suffer from chronic diseases such as diabetes, cardiovascular diseases, Alzheimer's disease, and other forms of dementia (Bonato, 2005; Bonato, 2003; Bloom et al., 2012). These diseases provide an additional burden to healthcare systems (Baig et al., 2013; Baig et al., 2013; World Health Organization, 2014). Nearly one billion people worldwide currently suffer from chronic diseases and most of these individuals require healthcare technologies (Minaie et al., 2013; Dorr et al., 2007; Wac, 2013). Several chronic diseases can be determined by observing the changes of a patient may encounter but other types of diseases such as heart attacks can occur suddenly and may cause death even before the patient arrives at the hospital (Pantelopoulos and Nikolaos, 2010; Harrington et al., 2011; Magrabi et al., 2013). Recent developments in technical solutions in industrial and technological fields led to increasing the interest of researchers and experts in discovering suitable solutions to problems in healthcare delivery (Lmberis and Dittmar, 2007; Varshney, 2007; Mitra et al., 2012).

Despite the growing interest in healthcare systems, many challenges exist in the provision of healthcare solutions in the forefront are costs and adaptability of the

elderly to healthcare techniques (Minaie et al., 2014; Kluge, 2011; Stanberry, 2001). One of the most important technologies that have been emerged recently and that could change the future of the healthcare is Wireless Sensor Networks (WSNs) (Li and Yang, 2015; Wang and Wang, 2014). WSN technology has significantly improved the healthcare services offered to different populations (Virone et al., 2006; Callen et al., 2013; Jovanov and Milenkovic, 2011).

Researchers have increasingly become interested in improving technical solutions that address problems in healthcare delivery. However, accurately predicting the future of any healthcare domain is a complicated task. Hence, delivery of healthcare services to members of the global aging population poses major challenges. Moreover, delivery of these services is affected by different situations that require cost cutting for healthcare services. Akshay and Krishna (2016) designed and presented a healthcare improvement system which can be used to providing higher quality healthcare services in the population of Rural India. The proposed system can be easily carried and rapidly measurements with implemented algorithms. Whilst, the system required helping a doctor to detect abnormal activity and to keep tracking of those particular person/patient (Akshay and Krishna, 2016). Almadani et al. (2015) conducted an E-Ambulance framework of smart health monitoring system of patients for the remote professional medical model. The presented system provided a paramedic

staff with automatic responses of warnings and suggestions inside an ambulance. But, it lacks to use diverse medical systems over different wireless technologies like ZigBee, WiFi, and Bluetooth technologies (Almadani et al., 2015). On the other hands, a real-time monitoring system for various health parameters of a patient was implemented by Mahgoub and Khalifa (2015). These parameters include temperature and Oxygen which are calculated and transmitted by a computer based on a remote client. There are some limitations of their results such as affecting noise which obtained from sensors, permanent damage to the Light Emitting Diode (LED) sensors, and there is a little bit complicated when calculating the SpO2 (Mahgoub and Khalifa, 2015). As well, a new model was proposed by Tamura et al. (2015) to improve team-based healthcare for testing and monitoring the physiological parameters of patients which can be used as a rehabilitation training system. The proposed system included a highly efficient database, unobtrusive monitoring, and interventions by health professionals. Whilst, the system required more testing in a home-based healthcare environment (Tamura et al., 2015). Likewise, González et al. (2014) conducted a novel alternative to measure heart rate and body temperature for patient care in real-time settings via combined between Wireless Sensor Network (WSN) and Mobile Augmented Reality (MAR). The discussed work can be extended to involve some improvements such as database implementation with the cloud and more manufacturing specifications for sensors (González et al., 2014). As alongside, Triantafyllidis (2014) proposed a smartphone healthcare system to measure physiological parameters of the patient by using portable/wearable sensors and monitoring the condition of a patient and configure monitoring plans for the health professionals in an individualized manner (Triantafyllidis et al., 2014).

In this study, we propose a system architecture for a remote healthcare monitoring system for the patients using heart pulse sensor and temperature sensor. The system specifically measures a patient's physiological parameters, such as Heart Pulse (HP) and temperature.

The rest of this paper is structured as follows. Section 2 presents the methodology and the materials used in the proposed system architecture. Section 3 provides all steps of the implementation and testing methods, and Section 4 discusses the results. Section 5 presents and discusses the previous studies in terms of analysed and tracking their performance based on diverse characteristics. The conclusions, remaining challenges, and future directions for this system are presented in Section 6.

2. Methodology (Materials and Methods)

This section presents and clearly describes the components of the electronic circuit design that includes software and hardware requirements as well as methods and implementation of the system monitoring. The system aims to measure and analyse the temperature and HP of patients. The results are stored by a computer-based

application via WAMP server, which can be accessed remotely.

2.1 Electronic Circuit Design (Materials)

To implement the electronic circuit, hardware and software components are required. These components were selected based on three criteria, namely, low cost, availability, and ease of programming. The hardware components required for the implementation are Arduino UNO board, Wi-Fi shield and Sensors (pulse and temperature sensors). In addition, the required software components are Arduino program, Processing program (V 3.0.1) and Wamp server 5.

2.2 Circuit Design

According to Fig. 1, the sensor placed on a fingertip earlobe or wrist of the patient. The parts of the sensor were connected to the Arduino device via pins (the first part to five Volt, the second to Δ , and the third to the ground). Whilst, the Wi-Fi shield device was setup with the Arduino device. In addition, all signal inputs were processed in the Arduino device. The signal was sent wirelessly via the Wi-Fi shield to the computer based device such as a laptop. MySQL refer to archived patient information, and the information will be shown by PHP.

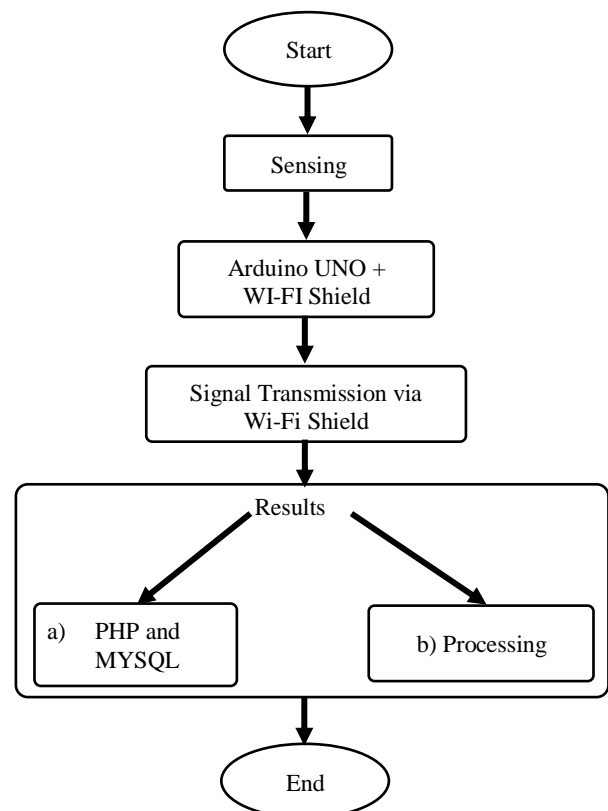


Fig. 1. Flowchart for the Proposed Healthcare Monitoring System

3. Implementation and Testing the Proposed System

3.1 Implementation

Fig. 2 describes clearly all the processes for the system implementation. The application programs installed in the laptop include modules for physiological signal examination, data transmission control, wireless communication control, and status processing. The module for physiological signal examination includes functions that measure body temperature and HP. The built-in medical sensors periodically check the physiological information of

the patients in process one (sensing process). These data are compressed and processed in Arduino, which is the centre for data processing and status control. The result is presented directly by Processing 3.0.1 or Wi-Fi shield data are transferred wirelessly using the available internet provider to a laptop to store the data and present the results in process Two (transmission process). Process Three (storage process) was completed using WAMP server 5.5.12 to create a database (MySQL) and a graphical user interface.

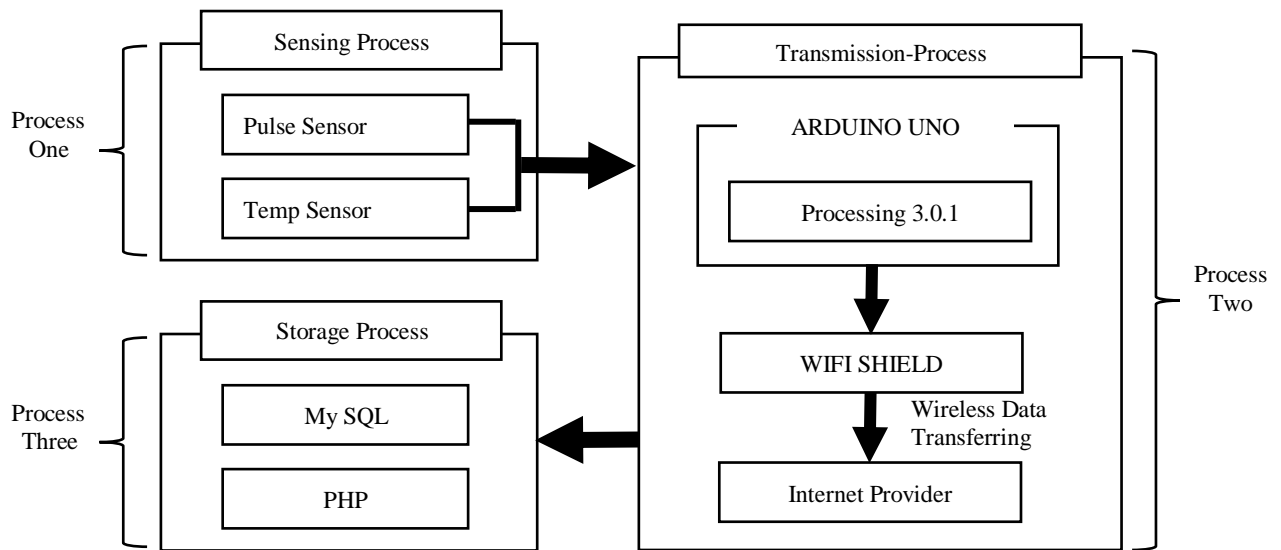


Fig. 2. Procedures for System Implementation and Testing

3.2 Testing

The proposed healthcare monitoring system was evaluated using the results obtained from 10 persons with different ages, gender, and situations (see Table 1). Table 1 specifies that the standard HP readings were adopted from Medical News Today (Nordqvist, 2010).

The physiological parameters of the human body are normally affected by several factors, such as exercise, body position (for instance, the body position for a short while

after standing up quickly), body temperature, and emotions (such as anxiety and arousal). As can be seen in Table 1, the most results lie within the standard HP values, except for those in test numbers 6 and 7. The system recorded HP value lower than the standard HP, and these results are normally based on the situation of the patients (Nordqvist, 2010). In addition, the proposed system reported results that all lie within the standard values.

Table 1
Results of the Healthcare Monitoring System.

Test No	Age	Gender	Temp	Measured HP	Standard HP
1	11 years	Male	37	93	60-100
2	16 years	Female	37	80	60-100
3	20 years	Male	36	98	100-150
4	25 years	Female	37	95	95-162
5	29 years	Male	37	96	95-162
6	41 years	Female	37	86	90-153
7	45 years	Female	37	85	90-153
8	53 years	Male	37	84	83-140
9	65 years	Female	37	78	78-132
10	67 years	Female	37	87	78-132

3. Results and Discussion

The experiment carries out with a commercial device and accordingly we presented an evaluation method based on signal quality and analysed and tracked the performance of the proposed system in measuring and monitoring the physiological parameters of the patients in real-time settings (see Fig. 3). The HP value recorded by the system is lower than the standard HP and this normal value is based on the situation of the patient. In addition, the system reported results that all lie within the standard values.

4. Comparison of the Existing Solutions and the Proposed System Based on Performance Metrics

Many attempts have been made by the researchers on developing wireless biomedical sensors for healthcare monitoring systems. They mainly focused on improving technical solutions that address problems and challenges in healthcare delivery or ubiquitous healthcare service provisioning such as cost and quality of services, limited access to different services, an increasing the population of elderly (Ogunduyile et al., 2013). However, accurately predicting the future of any healthcare domain is a complicated task. Hence, delivery of healthcare services to

members of the global aging population poses major challenges. Moreover, delivery of these services is affected by different situations that require cost cutting for healthcare services. Table 2 analysed and tracking performance evaluation and presents a critical review of previous studies and the proposed system in healthcare monitoring systems with WSN and highlights their main findings, application, and communication. In addition, these studies were classified based on the measured physiological parameters of the patients. These parameters include Heart Rate (HR), Blood Pressure (BP), and Temperature (Temp).

Most previous studies that measured the physiological parameters of patients used monitoring systems to measure and tracking physiological variables such as HP, BP, and temperature. Two studies are measured HP, BP, and temperature together that proposed by Akshay and Krishna (2016) and Almadani et al. (2015). In terms of communication, there are wireless, wired, Bluetooth, internet based, and webcam communication. Four previous studies conducted a real-time monitoring system like Akshay and Krishna (2016), Mohamed and Khairul Azami (2015), Fernando Cornelio et al. (2014), and Ogunduyile et al. (2013).

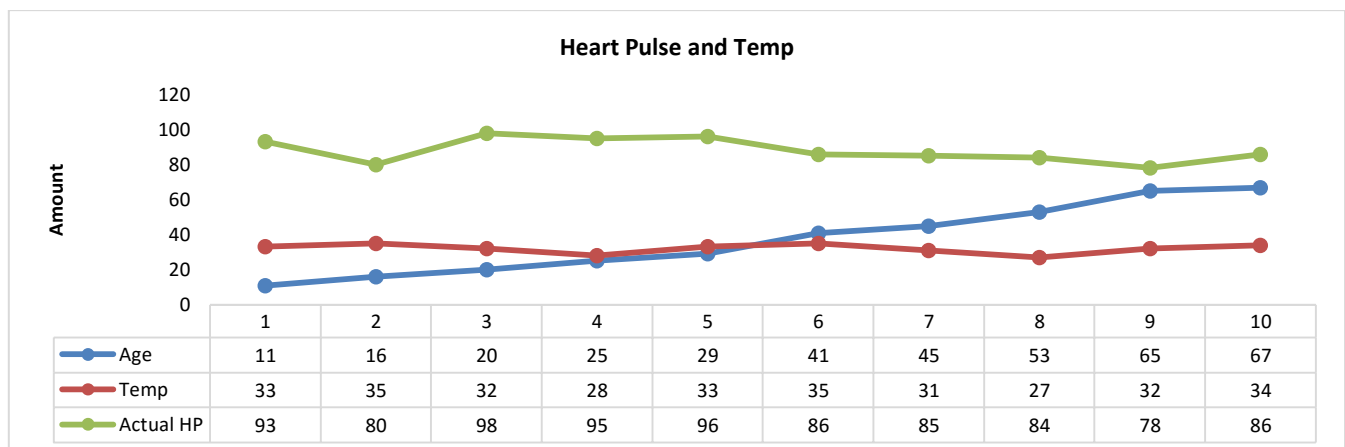


Fig. 3. The Results of HP and Temp for 10 Persons with Different (Age, Gender and Status).

5. Conclusions and Future Work

Many studies have been conducted to develop technologies for healthcare delivery systems. These developments are useful especially in our aging world in which ubiquitous monitoring of health under minimal physical interaction between doctors and their patients is required. These technologies reduce costs and are expected to improve the delivery of healthcare services. Hence, future challenges can be solved via WSNs which can assist in addressing some of the challenges in healthcare delivery

by facilitating the use of medical equipment, advancing at home healthcare, and displaying health information and wellness status via healthcare monitoring systems to both providers and patients. This paper presented a system architecture for remote healthcare monitoring using HP and temperature sensors. The proposed system measured a patient's physiological parameters, namely, HP and temperature. The results showed that the proposed system has potential to be implemented as a decision support system in healthcare. In the future study we plan to develop the system to measure Oxygen in the blood and breathing.

Table 2
Comparison of the Previous Studies for Healthcare Monitoring Systems.

Author	Application	Physiological Parameters			Communication	Benefits (Main Findings)
		HR	BP	Temp		
Ometto, 2011	Healthcare monitoring system of elderly patients at home	✓	✗	✗	WBSN	Presenting non-invasive device which is monitoring physiological parameters of the patient like electrocardiogram (ECG), Heart Rate (HR).
Poh et al., 2011	Healthcare measuring service using a webcam	✓	✓	✗	Webcam	Measuring different physiological data.
Mehta et al., 2012	Healthcare monitoring for diverse vitals of the patients by a doctor.	✓	✗	✓	Internet based	Using low-cost webcam technology to assist doctor Tele-monitoring for diverse vitals of the patient via remotely and dynamically.
Ogunduyile et al. 2013	Providing healthcare services via Monitoring physiological data of the patients.	✓	✓	✗	WSN	Providing healthcare services for patients via monitoring physiological data of the patients in a real-time environment.
Aminian, 2013	Monitoring critical variables and parameters of patients continuously in the hospital	✗	✓	✗	WBSN	Increasing and improving the quality of the patient's life by detecting abnormal conditions and reducing the energy consumption via proposed a monitoring system for multiple patients' bodies.
A. Triantafyllidis et al., 2014	Mobile-based home monitoring system in home condition	✓	✗	✗	Bluetooth	Providing self-monitoring for heart failure of the patients daily at home conditions.
Gaoan and Zhenmin, 2014	Can be used for long-term health support or emergency circumstance	✓	✗	✗	WSN	Measuring and tracking heart rate, and achieved series of valuable data by a low-cost mobile acceleration sensor which based on wavelet transform.
González et al., 2014	Supporting nurses and physicians for remote patient monitoring	✓	✗	✓	Wi-Fi	Presented a novel alternative system to measuring heart rate and body temperature for patient care in real-time settings.
Tamura et al., 2015	Homecare Patient	✗	✓	✗	Wired	Testing and monitoring the physiological parameters to Improving a team-based healthcare as well using a rehabilitation training system.
Mahgoub and Khalifa, 2015	Remote patient monitoring system	✗	✓	✓	GSM Shield	Measuring Oxygen saturation and body temperature of the patient remotely in the real-time setting system.
Almadani et al., 2015	E-Ambulance framework	✓	✓	✓	Wireless	Presented E-Ambulance model by providing paramedic staff with automatic responses of warnings and suggestions inside an ambulance.
Akshay and Krishna, 2016	Health check-up at village	✓	✓	✓	USB	A real-time system for healthcare improvement services via measured health check-up facility (physiological parameters).
Proposed System	Healthcare monitoring system of patients at home	✓	✗	✓	Wi-Fi	Measuring and monitoring physiological parameters of the patients in real-time settings.

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