Wireless Sensor Networks in Health Care Applications

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Introduction

The World Journal of Medical Education and Research (WJMER) (ISSN 2052-1715) is an online publication of the Doctors Academy Group of Educational Establishments. Published on a quarterly basis, the aim of the journal is to promote academia and research amongst members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from around the world. The principal objective of this journal is to encourage the aforementioned, from developing countries in particular, to publish their work. The journal intends to promote the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting edge technology and those who need to innovate within their resource constraints. It is our hope that this will help to develop medical knowledge and to provide optimal clinical care in different settings. We envisage an incessant stream of information flowing along the channels that WJMER will create and that a surfeit of ideas will be gleaned from this process. We look forward to sharing these experiences with our readers in our editions. We are honoured to welcome you to WJMER.

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Wireless Sensor Networks in Health Care Applications

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Abstract
The objective of this work is to focus on health-related applications of wireless sensor network and to enhance the performance of the sensor networks by considering security and privacy as important metrics. There is a rapid need to provide constant care and support to the disabled and elderly which has become the foremost challenge of the scientific community. Dependence is a situation in which a person needs important assistance from others to perform their daily activities such as essential mobility, object and people recognition or domestic tasks. The significance of developing new ways for providing care and support for the elderly is underscored by this trend, and the creation of secure and adaptable environment for monitoring become vital. In this review, various healthcare applications using wireless sensor networks are studied. This study reveals that security and privacy are important measures for sensor networks.

Key Words
Wireless medical sensor networks; Intra Ocular Pressure; Personal Digital Assistance; Triaxial accelerometer; intraocular space.

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1. Introduction

Currently, healthcare using wireless medical sensor networks (WMSN) is one of the most important applications of wireless sensor networks. Wearable medical devices in sensor networks and emerging applications will improve general living standard in under-served populations with the advances of wireless and mobile communication technologies. Remote health monitoring is emerging as a key area of research that integrates wireless telecommunications, sensing, and health care. Low-cost sensor nodes, with local sensing and processing have short-range wireless communication capabilities. Healthcare application uses wireless medical sensor networks (WMSNs) for patient monitoring in real-time senses the patient's body data and transmits it to the professionals by embedding inexpensive sensors at the body of patients. A medical device interfaced with a sensor communicates its data to a sink .The sink is connected to smart phone that communicates the data through wireless network to the hospital.

2. System Architecture

The system architecture of wireless sensor networks is in Figure 1 Sensor nodes are responsible for collecting physical information and sends it to a sink node, which receives the information gathered by the network and delivers it to the end-user.

2.1. Healthcare Sensor Network Model

The healthcare architecture has three active entities, namely, user/professional, medical sensors and base station/gateway. A Wireless Sensor Network (WSN) consists of individual sensor nodes that are able to sense the environment, collect physical parameters, perform data processing, and transmit data to a sink. The patient vital signs are queried and monitored within the hospital ward room using smart phone and laptop.

2.2. Hardware Architecture

The proposed architecture of the WBSN node has three main blocks which performs sensing, processing and transmitting the data to a PC.

The processing capability is provided by a low-power microcontroller and analog-to-digital converter and processing unit controls the communication power by minimizing the interference with other electronic instruments in the hospital or home. Figure 2 illustrates the sensor network model.

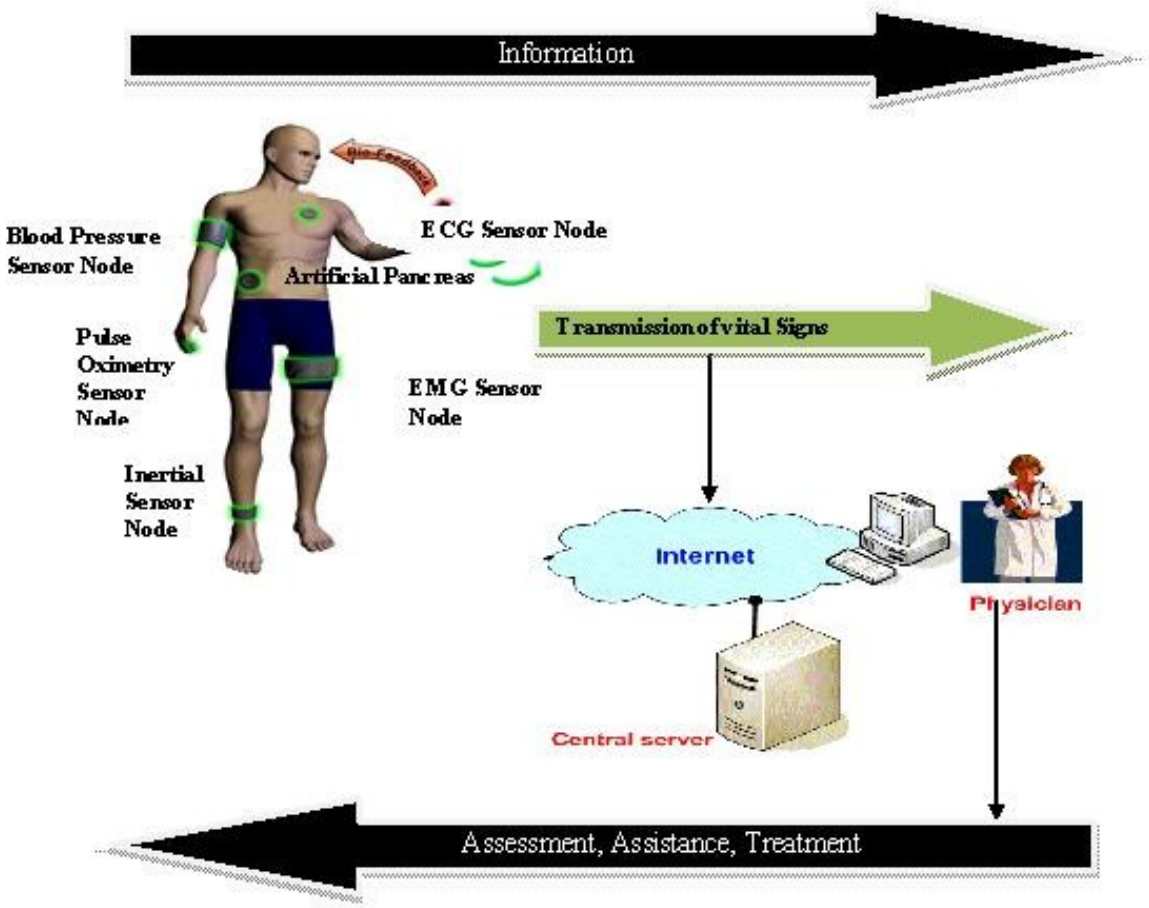

Figure 1: Sensor Network in Health Care Applications

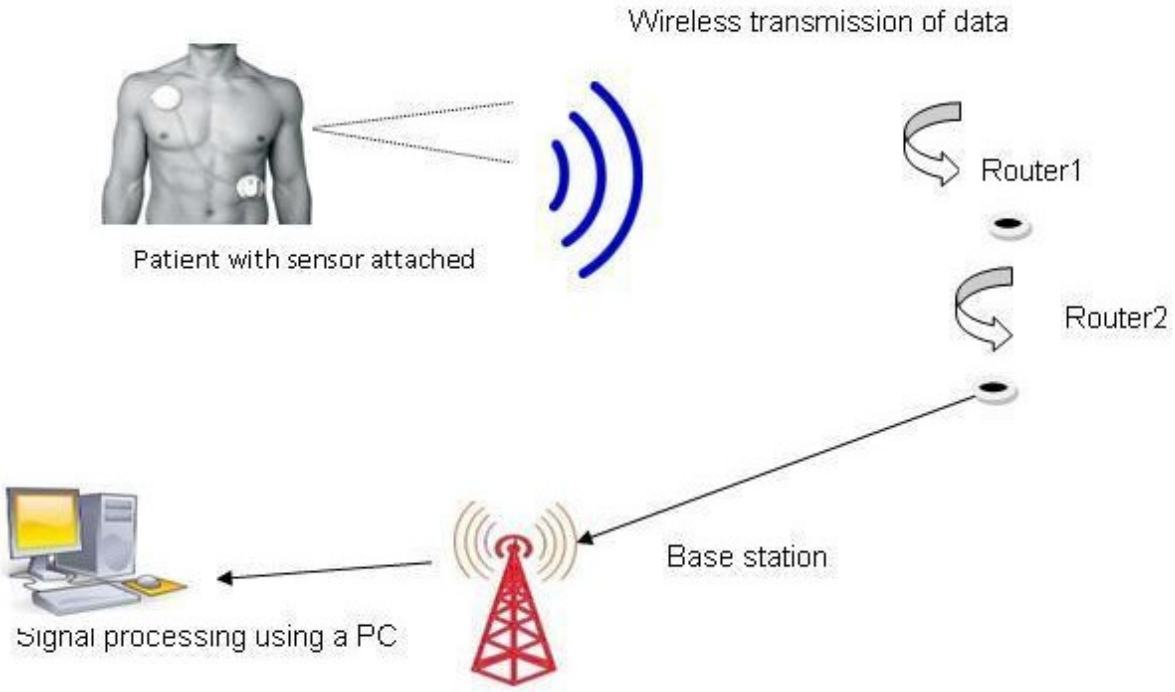

Figure 2: Hardware Architecture

3. Medical applications of wireless sensor networks:

Wireless devices have invaded the medical area with a wide range of capability. There are several health monitoring applications in which wireless sensor network will play a significant role[1]. They are illustrated below:

3.1. Chronic Disease Monitoring

Chronic diseases include stress, diabetes, asthma, heart diseases, cancer and sleep disorders. Asthma is defined as a chronic hypersensitivity of the bronchial airways. Oletic (2009[2]) described the employment of low power wireless sensor networks paired with smart phone technologies focusing on allergic asthma by retaining the disease in a controlled state by continuous monitoring of respiratory function. The wireless body sensors described by Falck et al (2006[3]) enable health monitoring of chronically ill patients by improving the treatment of chronic obstructive pulmonary disease and enhancing the ambulatory chemo therapy of women suffering from breast cancer. Boilot et al (2002[4]) described an array of 32 polymer carbon black composite sensors used to identify species of bacteria responsible for eye infections.

3.2. Personal Wellness Monitoring

Personal Wellness Monitoring monitors the health of elderly, their emotions, daily activity and behaviour. It helps in deducing the elderly wellness indices by informing the health care providers about the real-time activity behaviour and human emotion identification through telecare system[5] . Ahmed et al (2012[6]) illustrated the behaviour of the people suffering due to epileptic seizures can be monitored with the help of body sensors by detecting abnormal brain activity. The Ultra Wide Band (UWB) microwave carrier impulse radar has been used to track the human respiratory rate with both the mechanical chest phantom and human subject measurements [7]. An implantable pressure sensor for continuous wireless measurement of Intra Ocular Pressure (IOP) used in direct hydraulic contact with intraocular space provides IOP measurements in real time [8].

3.3. Fall Detection and Report Monitoring

Fall induced injuries among elderly people have become important. Huang et al (2010[9]) described a fall detection system using a wearable sensor and a head mounted triaxial accelerometer which captures the movement of human body. Taleb et al (2009[10]) proposed an elder monitoring and emergency detection, ANGELAH (Assisting ELders At Home) framework which integrates sensors and actuators for monitoring elder people.

3.4. Mobility Monitoring for Patients at Home

Continuous monitoring of ambulatory patients at home by means of resource-limited sensors described by Gonzalez et al (2011[11]) which are used for vital sign collection of patient. When the patient moves, the sensor network coordinator forward vital signs data through one of the wearable sensor nodes. Jeong et al (2007[12]) described sensors and a sensor system that can be used to monitor activity volume and recognizes emergent situations such as falling through analysing activity patterns in daily life is presented. Tseng et al (2007[13]) illustrated an integrated physical fitness testing system (iFit) to evaluate the physical fitness of older adults through a wireless sensor network that will enable users' fitness state.

3.5. Vital Sign Monitoring

Vital sign monitoring system involve monitoring blood glucose level, blood pressure, electrocardiograph (ECG) patterns, heart rate, respiration rate, blood oxygen saturation, electromyography (EMG), photoplethysmography (PPG) etc. Sheng et al (2009[14]) explained a continuous, non-invasive blood pressure monitoring system detects blood pressure with photoplethysmography sensors to obtain the pulse transit time. Fisal et al (2010[15]) described the monitoring of ECG data concerns with the development of ECG sensor board which consists of ECG electrodes and signal amplifying circuits.

Rotariu et al (2012[16]) illustrated the continuous measurement of heart rate using sensor node which has an ECG based heart rate detector attached on the patient. Lee et al (2010[17]) described wireless bio -signal transmitter, monitors the user's health using a photoplethysmography (PPG) sensor for detecting pulse wave signals. A wearable ECG sensor proposed by Nemati et al (2012[18]) measures heart rate. A compressed sensing data methodology is proposed by Zhang et al (2013[19]) to recover EEG signal using EEG sensors. Shin et al (2011[20]) described an Infrared motion sensor used to measure the motion signals and values such as activity, mobility and non response interval level of heart rate.

Andre et al (2010[21]) proposed the monitoring of sleep-disordered breathing activity and breathing rhythm of athletes using a capacitive micro sensor. Tamura et al (2011[22]) analysed the monitoring and evaluation of systolic blood pressure changes using sensors. Merritt et al (2009[23]) proposed a prototype textile-based capacitive-sensor respiration belt used for measuring respiration rate. HaomingLi et al (2011[24]) discussed a wireless ECG system which synthesizes 12-lead ECG signals for cardiac

monitoring. Shahriyar et al (2009[25]) focused on Intelligent Mobile Health Monitoring System which provides medical information through mobile devices based on the information collected by sensors. Klack et al (2011[26]) is meant for patients with end-stage heart failure implanted with mechanical circulatory support devices. Hulsbusch et al (2009[27]) illustrated the weight and activity with blood pressure monitoring system used for preventing, monitoring and treatment of heart diseases on daily basis for Congestive heart failure.

3.6. Infant Monitoring

Dasoqi et al (2009[28]) proposed an infant monitoring system based on highly sensitive microphone circuit and wireless networking hardware. Singh et al (2010[29]) described sensor nodes which have been designed for temperature monitoring of infants. Fletche et al (2012[30]) described a new technology for long-term monitoring of autonomic nervous system and motion data from active infants, children, and adults.

4. Discussion

The seven applications of biomedical sensors in various areas of healthcare are described above. Different metrics which evaluates wireless sensor networks include lifetime, coverage, cost and ease of deployment, response time, temporal accuracy, security, privacy, reliability, speed and effective sample rate. Enhancing the performance of one metric may stipulate the decrease in performance of another metric. Among all the above metrics, privacy and security in wireless sensor networks in health care perspective is vital. The health related data must always be secured. Some of the attacks in wireless sensor networks are due to inconsistent routing of data packets, eavesdropping, modifications and forging of alarms on medical data, denial of service, location and activity tracking of users, physical tampering with devices jamming attacks etc. Security has to be provided for all the above attacks for the sensor devices because these devices are less prone to security. The health related data are always private in nature. Privacy issue arises due to personal belief, social/cultural environment and public/private causes. A serious threat to the life of an individual happens due to above issues. So these two issues must be mainly considered in future work. The metrics for all the applications in the existing work are discussed in Table 1.

Existing Work	Metrics Used				Drawbacks
	Accuracy	Cost	Speed	Reliability	
Chronic Disease Monitoring [2,3,4]					Privacy, Security
Personal Wellness Monitoring [5,6,7,8]					Privacy, Security
Fall detection and report monitoring [9,10]					Privacy, Security
Mobility monitoring for patients at home [11,12,13]					Privacy, Security
Vital Sign Monitoring [14-27]					Privacy, Security
Infant monitoring [28,29,30]					Privacy, Security

Table 1: Comparison of related work in wireless sensor network

5. Conclusion

All the applications discussed here principally uses different types of biomedical sensors to monitor the physiological signals of patients to detect chronic diseases, fall detection, monitoring vital signs, infant monitoring and wellness monitoring. Though many issues prevail in the development of all existing applications, the most significant ones are security and privacy. Future research should focus on mitigating these issues for wireless sensor networks in healthcare.

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