Chapter 17
A Centralized Real-Time E-Healthcare System for Remote Detection and Prediction of Epileptic Seizures

Dung V. Pham
The University of Melboune, Australia

Thas Nirmalathas
The University of Melbourne, Australia

Malka N. Halgamuge
The University of Melbourne, Australia

Bill Moran
The University of Melbourne, Australia

ABSTRACT

Epilepsy is one of the most common serious neurological disorders, affecting about 60 million people worldwide. There are currently about 220,000 Epilepsy patients in Australia, a significant proportion of whom are elderly and live in rural areas. In this chapter, we present the applications, requirements, solutions, and further research problems for a Centralized Real-time E-Healthcare System (CREHS) for Epilepsy patients in Australia, utilizing wearable wireless sensors and broadband technologies. Later, the authors propose, optimize, and validate biosensor devices to detect epileptic seizures. In addition, the chapter also provides a detailed description of the structures, features, and detailed implementation scenarios for the system.

INTRODUCTION

Epilepsy is one of the most common serious neurological disorders, after stroke, affecting about 60 million people worldwide (Zandi, 2010). According to JECA (2009), "10% of Australians will have a seizure during their lifetime, while 3–4% will be diagnosed with Epilepsy". There were about 600,000 - 880,000 Australians experiencing Epilepsy in their life time (Walker, 2007; JECA, 2009). Patients with Epilepsy suffer recurrent unprovoked seizures, which are transient neurological events caused by excessive or hyper synchronous neuronal network activity in the brain. Seizures are often associated with loss of consciousness which means that during and following a seizure, the patients are not physically capable of requesting help. Seizures carry a significant risk of mortality and

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morbidity, and may on occasions be prolonged and require emergency intervention. One of the most serious disabilities associated with Epilepsy is the unpredictability of seizures which can occur anywhere and anytime. Therefore, it would be very valuable to have an "at-home" sensor system to detect seizure occurrences and enable help or intervention to be sent to the carers. Previous work by the Royal Melbourne Hospital Epilepsy Group has demonstrated that the pattern of arm movement on EEG can used to reliably diagnose epileptic seizures (Vinton et al, 2004). More recently, a pilot study undertaken on patients undergoing inpatient video-Electroencephalography (video-EEG) monitoring has demonstrated the diagnostic accuracy and applicability of assessment based on the pattern of movements recorded with a wrist strapped accelerometer. Therefore, an obvious future application of this technology is to be applied for outpatient (Remote Detection - RMON) for diagnosis and seizure detection.

The occurrence of Epilepsy increases as people age which adds to a sharply rising health care cost for nations (Berg Insight, 2008). Australia with its ageing population also faces a significant health care crisis, and a Centralized Real-time E-Healthcare System (CREHS) for detection and prediction of coming seizures on Epilepsy patients can offer significant opportunities to reduce the cost of health care. A CRESH can significantly reduce the percentage of patients who are now kept in hospital beds for routine monitoring. A CREHS will offer the lifestyle that senior citizens seek by allowing them to lead a near normal life at home with the protection of a system and a support network of healthcare professionals keeping closely monitoring their health. If senior citizens are given a high quality care through cost-effective combination of technology and professional health care, significant savings on the cost to the national health system can be achieved. Similar to many other developed nations, Australia begins to invest in a national broadband network, it is crucial to consider leveraging such investment for further reduction in healthcare service delivery to all Australians. Recent advances in wireless sensor networking have opened up new opportunities for innovative solutions for CREHS; it could, for example be realized by attaching a range of cost-effective biomedical sensors to body-wearable sensor nodes that collect and transmit biomedical data to central processing hardware (CPH). At a CPH, the data is processed and calibrated to generate accurate data sets that are continuously analyzed to detect anomalies that are referred to a healthcare support network via the home broadband connection. This implementation across the nation could offer opportunities for innovation in healthcare through new services combining triage nursing; general practice and specialist care through a hierarchical care network. Broadband network will permit on-demand video communication between remotely located healthcare professionals and patients and allows a network of family members and healthcare professionals to play a key role in the management of healthcare of senior citizens.

In this work, we present the applications, requirements, solutions, and further research problems for a Centralized Real-time E-Healthcare System (CREHS) for detecting and predicting seizures on Epilepsy patients in Australia. The system utilizes wearable wireless sensors to detect and transmit real time EEG signal through the broadband communication network to a central signal monitoring and processing system. We also propose, optimize and validate biosensor devices to detect epileptic seizures. This will require the patient to wear a body sensor system consisting of an accelerometer, gyroscope and magnetometer which are collectively used to measure body, and specifically hand, movements. In addition, the facial expressions, words and movements of the patient are monitored by video cameras incorporating microphones. Multiple, high quality, real-time video and audio stream from multiple patients are sent by sharing same broadband link. Finally, compressed data is sent to the neurologist