MASSEY UNIVERSITY
ENGINEERING

WIRELESS DATA ACQUISITION AND MONITORING FOR HEALTHCARE SERVICE SYSTEMS

A thesis in the partial fulfillment of the requirement for the

Masters of Engineering

(Electronics and Computer Systems)

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AMIR HOSHANG KIOUMARS

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This thesis is dedicated to my brother

Hashem Kioumars

For his endless love, support and encouragement

In memory of the victims of the Feb 2011

Christchurch earthquake

"Any intelligent fool can make things bigger, more complex, and more violent. It takes a touch of genius - and a lot of courage - to move in the opposite direction."

Albert Einstein (1879 - 1955)

ABSTRACT

The aging population brings challenges to healthcare systems. To cope with the high demand on health professionals and services, the feasible solution is to engage modern technologies. Wireless communication, service robots and information technology have become the active research areas for future healthcare systems. In the field of human health, collecting and analysing the real-time data is vital. New facilities and advanced tools give health service providers and their patients more choices to readily access and use health information and collect and store real-time health data. Information technology (IT) has the potential to improve the quality, safety, and efficiency of healthcare. IT allows healthcare providers to collect, store, retrieve and transfer information electronically. Together with modern communication technologies and intelligent systems, patients are able to monitor their own vital health signs from home and communicate the results to their health providers wirelessly. This will increase the ability to address a problem before a patient requires acute care. The ability to remotely monitor vital signs of a patient in real-time using a simple, low-cost and compact device with a minimum training time is highly desirable in a society with an increasing aging population.

This research outlines the design and development of a cost effective and reliable wireless sensing device for collecting real-time health vital signs such as human body temperature and heart rate. A software system is also developed to provide two-way communications with the remote sensor device in order to receive and store the collected data by the sensor device in a central database. The literature review led to the use of ATmega micro-controller, ZigBee technology for wireless communication and the development of highly adaptable, flexible and intelligent software written in Microsoft C-Sharp (C#). A unique communication data packet is also developed and implemented to overcome the micro-controller memory limitations, improving the reliability of the communication and increasing the security of data as well as saving power. The system is able to communicate with service robots and host computers via the network of XBees.

The proposed hardware device is able to collect the human heart rate and body temperature in real-time. It is light-weight, low-cost, power efficient and maintainable. It can be wrapped around the wrist and carried with the person. It transmits the data when it is needed and stays on sleep mode to save power.

The developed software system (T-HBR, stands for temperature-heart beat rate) is capable of receiving the data from the remote device and storing the data to a central database. T-HBR allows health professionals such as general practitioners (GPs), nurses and healthcare providers to be able to collect the real-time data, see the patient's history, issue a new

prescription and send it to the patient, other GPs or nurses by e-mails or text messages. The software can be a component of an individual system or can be used within a network connected to a central database. The software system supports a high level of security by using ten different types of encryption algorithms and is also able to import data from other T-HBR software and merge them into the existing database. It is component-based software with a three-layer architecture, which allows each component of the system to be replaced separately. Such a design approach reduces the cost of maintenance and enables more functionality to be added easily.

Three papers, two published and one submitted, have been the outcome of the research in this dissertation[1]:

- **Wireless Network for Health Monitoring**
  Fifth International Conference on Sensing Technology
  28th November – 1st December 2011
  Palmerston North, New Zealand
  pp. 378-385, ISBN 978-1-4577-0166-5

- **ATmega and XBee-Based Wireless Sensing**
  Fifth International Conference on Automation, Robotics and Applications
  6th – 8th December 2011
  Wellington, New Zealand
  pp. 361-365, ISBN of 978-1-4577-0328-7

- **Wireless Health Data Acquisition**
  14th International Conference on E-Health Networking
  10th – 13th October 2012
  Beijing, China
  (Submitted)

[1] *Appendix A: Publications*

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INTELECTUAL PROPERTY STATEMENT

This research was conducted in collaboration with Dr Liqiong Tang and Massey University New Zealand. Aspects of this research, particularly the designed hardware sensor, the micro-controller codes, proposed communication methodology and the developed software system are commercially sensitive. The software codes have not been provided in the publications of this research and only abstract diagrams are used to illustrate their functionalities.

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