Detection of Cardiorespiratory Interaction for Clinical Research Applications

by

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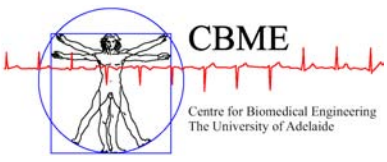

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This Thesis is dedicated to my parents for their love, encouragement and endless support.

"To laugh often and much; To win the respect of intelligent people and the affection of children; To earn the appreciation of honest critics and endure the betrayal of false friends; To appreciate beauty, to find the best in others; To leave the world a bit better, whether by a healthy child, a garden patch, or a redeemed social condition; To know even one life has breathed easier because you have lived. This is to have succeeded." -Ralph Waldo Emerson

Contents

Abstract

Human physiological systems are a widely studied topic in the field of Biomedical Engineering. There is a particular interest in the study of human cardiovascular and respiratory systems since these two systems do not act independently; there exists a strong coupling between them. Experimental studies use the concept of synchronization to demonstrate the interaction between different physiological systems. Synchronization is the appearance of some relationship between two periodic oscillators in the form of locking of their phases or adjustment of rhythms. Cardiorespiratory coordination is an aspect of the interaction between heart and respiratory rhythm that has been reported not only at rest or during exercise, but also in subjects under the influence of anesthesia and drugs. Through the quantification of cardiorespiratory coordination we can achieve a better understanding of its physiological functioning.

Some of the conventional signal-processing techniques such as power spectral density and cross-correlation analysis have shown linear dependencies between heart and respiratory rate. However, as these biological signals are inherently non-linear, non-stationary, and contain superimposed noise, the techniques mentioned above often prove to be inadequate for characterizing their complex dynamics. Therefore, to overcome these issues, it is required to develop a technique that is less sensitive to noise, robust and possibly provides additional information about the interaction between cardiac rhythms and respiration. This Thesis introduces a new and relatively simple approach for the quantification of cardiorespiratory interaction based on joint symbolic dynamics, which provides an easy interpretation of physiological data by a simplified description of the system's dynamics. Furthermore, this Thesis investigates the association between cardiorespiratory coordination and some of the physiological mechanisms, and assesses cardiorespiratory coordination as a marker of cardiorespiratory system disturbances.

Statement of Originality

This work contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Muammar Muhammad Kabir and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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24 February 2012

Signed

Date

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Thesis Conventions

The following conventions have been adopted in this Thesis:

1. **Spelling.** Australian English spelling conventions have been used, as defined in the Macquarie English Dictionary, A. Delbridge (Ed.), Macquarie Library, North Ryde, NSW, Australia, 2001.

2. **Typesetting.** This document was compiled using LaTeX2e. TeXnicCenter was used as text editor interfaced to LaTeX2e. Adobe Illustrator CS2 and Inkscape was used to produce schematic diagrams and other drawings.

3. **Mathematics.** MATLAB code was written using MATLAB Version R2007b/R2008a; URL: http://www.mathworks.com.

4. **Referencing.** The Harvard style has been adopted for referencing.

5. **URLs.** Universal Resource Locators are provided in this Thesis for finding information on the world wide web using hypertext tranfer protocol (HTTP). The information at the locations listed was current on 17 December 2009.

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