CBME
Centre for Biomedical Engineering
Adelaide University

Signal Processing Techniques for Phonocardiogram De-noising and Analysis

by

Sheila R. Messer

B.S., University of the Pacific, Stockton, California, USA

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ADELAIDE UNIVERSITY
AUSTRALIA

SUB CRUCE LUMEN

Adelaide University
Adelaide, South Australia

Department of Electrical and Electronic Engineering
Faculty of Engineering, Computer and Mathematical Sciences

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Abstract

The focus of this thesis is the de-noising and representation of phonocardiograms for subsequent analysis. The PCG has been proven to be a clinically significant diagnostic tool while being inexpensive, non-invasive, reliable and cheap. However, the PCG is corrupted by noise from a number of sources including thoracic muscular noise (Zhang, Durand, Senhadji, Lee & Coatrieux 1998), peristaltic intestine noise (Zhang, Durand, Senhadji, Lee & Coatrieux 1998), respiratory noises, foetal heartbeat noise if the subject is pregnant, noise caused by contact with the instrumentation and ambient noise. Thus, there is a need to de-noise the PCG signal. Because it is a complex, non-stationary signal, traditional methods of de-noising are not appropriate. Phonocardiogram de-noising techniques, which are explored, include wavelet de-noising, optimised wavelet de-noising, wavelet packet de-noising, the matching pursuit technique, and averaging. The time-frequency and time-scale de-noising methods performed roughly equally while removing significant amounts of noise from the signal. However, optimised wavelet de-noising performed slightly better than the other methods; thus, optimised wavelet de-noising in conjunction with averaging is recommended to be used in appropriate cases. Once the PCG has been de-noised, different methods of extracting features from the PCG and classifying the PCG according to this information were explored. The use of phase space diagrams, HT diagrams, instantaneous signal parameter extraction, and phase synchronisation between the ECG and PCG were investigated, but these investigations were limited by the quantity and quality of data available. The results presented are only indicative results, but they demonstrate that further work to investigate the use of these techniques with larger amounts of data would be worthwhile. Recommendations for future research in the area of phonocardiogram de-noising and classification are provided.

Statement of Originality

I hereby declare that this work contains no material which has been accepted for the award of any degree or diploma in any university or other tertiary institution 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.

I give consent to this copy of my thesis, when deposited in the University Library, being available for loan and photocopying.

Sheila Renee Messer

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Publications

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Glossary

A/D	Analogue to Digital
ALE	Adaptive Line Enhanced
AR	Auto-regressive
CBME	Centre for Biomedical Engineering
CWT	Continuous Wavelet Transform
dB	Decibel
DWT	Discrete Wavelet Transform
ECG	Electrocardiogram
EHG	Electrophysterography
FFT	Fast Fourier Transform
FT	Fourier Transform
HRV	Heart Rate Variability
HT	Hilbert Transform
IDWT	Inverse Discrete Wavelet Transform
MP	Matching Pursuit
NRMSE	Normalised Root-mean-square Error
PC	Personal Computer
PCB	Printed Circuit Board
PCG	Phonocardiogram
QRS	QRS Complex–Waves on the ECG
S1	First Heart Sound
S2	Second Heart Sound
S3	Third Heart Sound
S4	Fourth Heart Sound
SA	Sinoatrial
SNR	Signal-to-noise-ratio
SPL	Sound Pressure Level
STFT	Short Time Fourier Transform
WD	Wigner Distribution
WP	Wavelet Packet
WT	Wavelet Transform

Table 1 Glossary