



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
Adelaide, South Australia

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

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Contents

Abstract	vi
Declaration	vii
Acknowledgement	viii
Publications	ix
List of Figures	ix
List of Tables	xix
Glossary	xxii
1 Introduction	1
1.1 Introduction	2
1.2 Brief Description of the Heart	4
1.3 Heart Sounds	7
1.3.1 The First Heart Sound	8
1.3.2 The Second Heart Sound	8
1.3.3 The Third and Fourth Heart Sounds	9
1.4 Electrical Activity of the Heart	9
1.5 Literature Review	11
1.5.1 Time-Frequency and Time-Scale Decomposition Based De-noising	11

CONTENTS

1.5.2	Other De-noising Methods	14
1.5.3	Time-Frequency and Time-Scale Analysis	15
1.5.4	Classification and Feature Extraction	18
1.6	Scope of Thesis and Justification of Research	23
2	Equipment and Data Acquisition	25
2.1	Introduction	26
2.2	History of Phonocardiography and Auscultation	26
2.2.1	Limitations of the Human Ear	26
2.2.2	Development of the Art of Auscultation and the Stethoscope	28
2.2.2.1	From the Acoustic Stethoscope to the Electronic Stethoscope	29
2.2.3	The Introduction of Phonocardiography	30
2.2.4	Some Modern Phonocardiography Systems	32
2.3	Signal (ECG/PCG) Acquisition Process	34
2.3.1	Overview of the PCG-ECG System	34
2.3.2	Recording the PCG	34
2.3.2.1	Pick-up devices	34
2.3.2.2	Areas of the Chest for PCG Recordings	37
2.3.2.2.1	Left Ventricle Area (LVA)	37
2.3.2.2.2	Right Ventricular Area (RVA)	38
2.3.2.2.3	Left Atrial Area (LAA)	38
2.3.2.2.4	Right Atrial Area (RAA)	38
2.3.2.2.5	Aortic Area (AA)	38
2.3.2.2.6	Pulmonary Area (PA)	39

CONTENTS

2.3.2.3	The Recording Process	39
2.3.3	Recording the ECG	39
2.3.4	The WIN-30D Analog to Digital Converter	41
2.4	Data Records	42
2.5	Chapter Summary	44
3	Theory of De-Noising Methods	45
3.1	Introduction	46
3.2	The Wavelet Transform and De-noising	46
3.2.1	Fourier Analysis	46
3.2.2	Short Time Fourier Transform (STFT)	48
3.2.3	The Wavelet Transform (WT)	49
3.2.3.1	Wavelet Families and Properties	54
3.2.4	The Wavelet De-Noising Procedure	55
3.2.4.1	Soft or Hard Thresholding	57
3.2.4.2	Threshold Selection Rules	58
3.2.4.3	Threshold Rescaling Methods	59
3.3	Wavelet Packets (WP) and De-Noising	60
3.3.1	Wavelet Packet Generation	61
3.3.2	Wavelet Packet Atoms	62
3.3.3	Organising Wavelet Packets in Trees	62
3.3.4	Choosing the Best Decomposition	63
3.3.5	De-Noising with Wavelet Packets	63
3.4	Use of the Matching Pursuit Method to De-noise Signals	64

CONTENTS

3.4.1	Numerical Implementation of the Matching Pursuit with Gabor Dictionaries	66
3.5	De-noising Using Averaging	67
3.5.1	Heartbeat Segmentation Algorithms	68
3.6	Chapter Summary	69
4	PCG De-noising Study	71
4.1	Introduction	72
4.2	Estimation of Noise in Recorded PCGs	72
4.3	Measurement of Noise Removal from PCGs	75
4.4	Optimised Wavelet De-noising	76
4.5	Wavelet De-noising	87
4.6	Wavelet Packet De-noising	93
4.7	Averaging	98
4.8	Matching Pursuit	100
4.9	Results and Discussion	108
4.10	Chapter Summary	113
5	PCG Data Analysis	115
5.1	Introduction	116
5.2	Phase Space and Hilbert Transform Diagrams	116
5.2.1	Phase Space Diagrams	116
5.2.2	Hilbert Transform Diagram	118
5.2.3	Comparison of Phase Space and Hilbert Transform Diagrams	119
5.3	Use of the HT to Calculate Instantaneous Signal Parameters of the PCG	127

CONTENTS

5.4	Phase Synchronisation	135
5.4.1	ECG-PCG Phase Synchronisation, The Cardiosynchrogram	137
5.5	Chapter Summary	139
6	Conclusion and Future Directions	141
6.1	Introduction	142
6.2	Summary	142
6.3	Discussion and Conclusions	143
6.3.1	PCG De-noising	143
6.3.2	PCG Data Analysis	146
6.4	Future Research Directions	148
A	Escope Specifications	153
B	Some Data From Patient Recordings	155
C	Information on the Design of the PCG/ECG System	165
D	Moment of Velocity	169

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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PUBLICATIONS

List of Figures

1.1	This diagram shows the systemic and pulmonary circuits of the heart. . . .	6
1.2	An electrocardiogram trace showing the three deflection waves and the intervals, modified from Marieb (1991).	10
2.1	Relative frequency ranges from Selig (1993)	27
2.2	Timeline of the evolution of the acoustic stethoscope. Modified from Selig (1993).	29
2.3	ECG-PCG system block diagram, modified from Maple (1999).	35
2.4	The Escope from Cardionics is an electronic stethoscope that is used to record heart sounds.	36
2.5	Areas of the chest for PCG recordings (Luisada 1980, Tinati 1998).	38
2.6	Positioning of the ECG electrodes.	40
3.1	Comparison of a signal represented in different domains with (a) corresponding to the Fourier transform representation, (b) representing the short time Fourier transform, and (c) the wavelet transform	46
3.2	Heartbeat in time domain, frequency domain, time-frequency domain, and time-scale domain	47
3.3	Examples of wavelets used in this study	50
3.4	This figure illustrates how the CWT is calculated.	52
3.5	How the DWT and WPs decompose a signal.	53

LIST OF FIGURES

3.6	Example of applying optimised wavelet de-noising to a signal while varying the threshold selection rules.	59
3.7	Wavelet packet tree (Misiti, Misiti, Oppenheim & Poggi 1996)	62
4.1	Power spectrum (in decibels per Hertz) of the instrumental background noise estimate.	73
4.2	Amplitude of power spectrum of the instrumental background noise estimate.	73
4.3	Power spectrum (in decibels per Hertz) of the noise estimate for the instrumental and physiological background noise taken during the diastolic phase of the PCG for several patients.	74
4.4	Amplitude of power spectrum of the noise estimate for the instrumental and physiological background noise taken during the diastolic phase of the PCG for several patients	74
4.5	The mean power spectrum (in decibels per Hertz) of the noise estimate for the instrumental and physiological background noise taken during the diastolic phase of the PCG for several patients.	74
4.6	The mean amplitude of power spectrum of the noise estimate for the instrumental and physiological background noise taken during the diastolic phase of the PCG for several patients	74
4.7	This figure shows wavelet de-noising results (as an SNR in dBs) while varying the wavelet used for different levels of white noise added to a three PCG samples.	77
4.8	This figure shows how much information (as an SNR in dBs) was lost when applying optimised wavelet de-noising to three clean heart sound samples while varying the wavelet.	79
4.9	This figure shows how much information was lost from optimised wavelet de-noising results applied to a three clean PCG samples while varying the level of decomposition	80

LIST OF FIGURES

4.10	The effect of varying the level of decomposition for optimised wavelet de-noising applied to the heart sound recording of patient 15 for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	81
4.11	The effect of varying the level of decomposition for optimised wavelet de-noising applied to the heart sound recording of patient 10 for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	82
4.12	The effect of varying the level of decomposition for optimised wavelet de-noising applied to the PCG of patient 12 for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	83
4.13	This figure demonstrates that hard thresholding can cause discontinuities in a signal.	84
4.14	This figure is a comparison of the different threshold rescaling methods used by optimised wavelet de-noising.	85
4.15	Best SNR results before de-noising versus after optimised wavelet de-noising for three trials.	86
4.16	Wavelet de-noising results (as an SNR in dBs) for different levels of white noise added to 3 different PCGs.	88
4.17	How much of the original signal content remains (expressed as an SNR in dBs) after wavelet de-noising is applied to 3 “clean” PCGs.	89
4.18	Effect of varying the level of decomposition for wavelet de-noising of a PCG (Trial 1) for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	90
4.19	Effect of varying the level of decomposition for wavelet de-noising of a PCG (Trial 2) for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	90
4.20	Effect of varying the level of decomposition for wavelet de-noising of a PCG (Trial 3) for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	91

LIST OF FIGURES

4.21 Degree of information loss from the wavelet de-noising process (SNR in dBs) when it was applied to a three clean PCG samples while varying the level of decomposition.	92
4.22 Wavelet packet de-noising results (as an SNR in dBs) for different levels of white noise added to a 3 different PCGs.	93
4.23 This figure shows how much of the original signal content remains (expressed as an SNR in dBs) after wavelet packet de-noising is applied to 3 “clean” PCGs.	94
4.24 Effect of varying the level of decomposition for wavelet packet de-noising of a PCG (Trial 1) for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	95
4.25 Effect of varying the level of decomposition for wavelet packet de-noising of a PCG (Trial 2) for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	95
4.26 Effect of varying the level of decomposition for wavelet packet de-noising of a PCG (Trial 3) for various wavelets with additive white noise at levels of 1 dB and 10 dBs.	96
4.27 The degree of information lost when the wavelet packet de-noising process (measured in SNR in dBs) was applied to three clean PCG samples while varying the level of decomposition.	97
4.28 Four similar characteristic heartbeats recorded from a single subject with a normal heart at four different times.	98
4.29 The SNR after adding white noise to a series of heart sound cycles versus the SNR after averaging these series of heart sound cycles to obtain a characteristic heartbeat and reduce noise.	99
4.30 This figure shows (a) a clean heart sound cycle (from patient 15), (b) the heart sound cycle with 1 dB additive white noise, and (c) the additive white noise.	100

LIST OF FIGURES

4.31	This figure shows the reconstruction of the heart sound cycle (from patient 15) shown in Figure 4.30 (b) after matching pursuit de-noising.	101
4.32	Plot of the decay parameter against the number of time-frequency atoms used by the MP method for the heart sound cycle (from patient 15) shown in Figure 4.30.	102
4.33	Plot of the decay parameter against the number of time-frequency atoms used by the MP method for another heart sound cycle (from patient 10).	103
4.34	Plot of the decay parameter against the number of time-frequency atoms used by the MP method for the another heart sound cycle (from patient 12).	104
4.35	This figure shows the decay parameter and the SNR plotted against the number of time-frequency atoms after MP de-noising is applied to a heart sound cycle (patient 10) with different amounts of additive white noise.	105
4.36	This figure shows the decay parameter and the SNR plotted against the number of time-frequency atoms after MP de-noising is applied to a heart sound cycle (from patient 15) with various amounts of additive white noise.	106
4.37	This figure shows the decay parameter and the SNR plotted against the number of time-frequency atoms after MP de-noising is applied to 3 different characteristic heartbeats.	107
4.38	Here is an example of the various de-noising methods all applied to the same noisy heart sound recording.	109
4.39	Typical SNR values after applying the various de-noising techniques with different amounts of noise.	111

LIST OF FIGURES

4.40	This graph shows the SNR after adding white noise to a PCG with a number of heart sound cycles versus the SNR after de-noising the signal. Various methods are tried: optimised wavelet de-noising only, averaging only, and optimised wavelet de-noising combined with averaging. The optimised wavelet de-noising combined with averaging was the most successful de-noising method.	112
5.1	This figure is an aid for explaining phase space diagrams.	117
5.2	This figure is an aid for explaining Hilbert Transform diagrams.	120
5.3	White Noise	121
5.4	Derivative of the White Noise	121
5.5	Hilbert Transform diagram of the White Noise	121
5.6	Snapshot of the White Noise, Derivative of the Noise, and Hilbert Transform of the Noise	121
5.7	Phase Space Diagram of the White Noise	122
5.8	Hilbert Transform of the White Noise	122
5.9	(a) FFT of the white noise, (b) FFT of the derivative of the white noise and (c) FFT of the Hilbert Transform of the noise	122
5.10	The characteristic heartbeat of four patients. Patients 10 and 15 are normal subjects whereas Patients 3 and 8 have heart murmurs.	124
5.11	The phase space diagrams of four patients where the PCG is plotted against its' derivative. Patients 10 and 15 are normal subjects whereas Patients 3 and 8 have heart murmurs.	125
5.12	The Hilbert Transform diagrams of four patients where the PCG is plotted against its HT. Patients 10 and 15 are normal subjects whereas Patients 3 and 8 have heart murmurs.	126
5.13	Plots of the instantaneous frequencies of a characteristic heartbeat before and after de-noising.	128

LIST OF FIGURES

5.14	The instantaneous amplitude of 4 characteristic heartbeats recorded at different times from the same normal patient. They are all fairly similar demonstrating that this technique is reproducible.	129
5.15	Instantaneous amplitude of normal heart sound cycles and pathological heart sound cycles.	130
5.16	Instantaneous frequency of normal heart sound cycles and pathological heart sound cycles.	131
5.17	Moment of velocity of normal characteristic heartbeats and pathological characteristic heartbeats.	132
5.18	Complex PCG trace first with additive white noise and secondly without noise.	133
5.19	This figure shows a complex PCG trace of four different characteristic heartbeats. Patients 10 and 15 are normal subjects whereas Patients 3 and 8 have heart murmurs.	134
5.20	This figure demonstrates how the phase stroboscope known as a synchrogram functions.	136
5.21	The four charts are cardiosynchrograms where the ECG R wave is used as a stroboscopic point to examine the phase of the PCG to see if there is any phase synchronisation occurring.	138
B.1	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #1	156
B.2	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #2	157
B.3	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #3	157
B.4	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #4	158

LIST OF FIGURES

B.5	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #5	158
B.6	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #6	159
B.7	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #7	159
B.8	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #8	160
B.9	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #9	160
B.10	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #10	161
B.11	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #11	161
B.12	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #12	162
B.13	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #13	162
B.14	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #14	163
B.15	5 Second Sample of ECG/PCG Recording and Characteristic Heartbeat From Patient #15	163
C.1	PCG/ECG System Circuit Diagram (Hall 1999)	166
C.2	PCG Filter Frequency Response (Hall 1999)	167
C.3	ECG Filter Frequency Response (Hall 1999)	167
C.4	ECG/PCG System PCB Layout (Hall 1999)	168

LIST OF FIGURES

D.1 Coordinate system used in context of defining angular momentum, modified
from Beer & Johnston (1999) 170

D.2 Signal and Hilbert Transform analytic plane 170

LIST OF FIGURES

List of Tables

1	Glossary	xxiii
1.1	Some basic heart sound characteristics (Ewing 1989)	7
2.1	WIN-30D Characteristics. Information from Hall (1999)	42
2.2	Patient Information	43
3.1	Summary of the properties of various wavelet families.	56
3.2	Threshold selection rules	58
3.3	Noise model options and corresponding models	60
4.1	Wavelet and decomposition level which obtained best de-noising results after adding a known amount of noise to three different characteristic heartbeats and then applying optimised wavelet de-noising. (coif = Coiflet, db = Daubechies, sym= Symlet)	78
4.2	Typical SNR results after optimised wavelet de-noising using four threshold selection rules.	84
4.3	This table lists the best results (using SNR measured in dB) of all the combinations tried for wavelet de-noising with varying amounts of white noise added.	92

LIST OF TABLES

4.4	This table lists the best results (using SNR measured in dB) of all the combinations tried for wavelet packet de-noising with varying amounts of white noise added.	94
4.5	Comparison of typical results for various de-noising methods for three different PCGs which had 1 dB of additive white noise. The results are given as the SNR in dBs of the original clean PCG and the de-noised version. . .	108
4.6	Comparison of typical results for various de-noising methods for three different PCGs which had 5 dBs of additive white noise. The results are given as the SNR in dBs of the original clean PCG and the de-noised version. . .	108
4.7	Comparison of typical results for various de-noising methods for three different PCGs which had 10 dBs of additive white noise. The results are given as the SNR in dBs of the original clean PCG and the de-noised version.	109
4.8	Comparison of typical results for various de-noising methods for three different PCGs which had 20 dBs of additive white noise. The results are given as the SNR in dBs of the original clean PCG and the de-noised version.	110
A.1	This gives the specifications for the Escope, the electronic stethoscope, used to record the phonocardiograms (Cardionics 1999).	154

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

LIST OF TABLES
