An Exploration of Heart Sound Intelligent Interpretation Using MRA-Envelogram Cooperated MFCC Feature Extraction and DTW Classification

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master in Electrical and Electronics Engineering

Faculty of Science and Technology
University of Macau

2013

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Abstract

AN EXPLORATION OF HEART SOUND INTELLIGENT INTERPRETATION USING MRA-ENVELOGRAM COOPERATED MFCC FEATURE EXTRACTION AND DTW CLASSIFICATION

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Nowadays, cardiovascular diseases (CVDs) become great threat to human's lives aggressively. A good way to prevent the death cause of CVDs is early discovery and interposing. This leads the research on the heartbeat signal analysis area in order to provide a cost-effective and time-saving prognostic approach for those cardiac disease victims.

Heart auscultation signal has served as an important primary symptom to identify CVDs for a long time. Heart sound (HS) analysis by auscultation and phonocardiogram (PCG), graphical interpretation of the acoustical waves of heart were routinely assessed by experienced physicians for diagnosing CVDs. However, over the years with the advent of echocardiogram (ECHO), electrocardiogram (ECG), photoplethysmogram (PPG), sphygmogram (SPG), etc., its importance as a diagnostic tool has considerably declined. But it is still one of the most primary physiological signals worthwhile to note that physicians still primarily analyze the auscultation of the heart to find signs of pathologic conditions before requesting for ECHO, ECG, etc.

In this research, a scheme for Heart Sound Intelligent Interpretation using multi-resolution analysis (MRA)-envelogram cooperated mel-scale frequency cepstral coefficients (MFCC) feature extraction and dynamic time warping (DTW)

classification is presented. MFCC algorithm which approximates closely to response of human auditory system is further applied to carry HS feature extraction. DTW is applied to measure the distance between two HS signals as classifier. Distances got through DTW can serve as an index of identifying pathological symptoms.

MFCC and DTW are cooperated with envelogram segmentation. Classification accuracy is influenced greatly by the segmentation results, which makes HS segmentation approach as a decisive step. The innovative envelogram focusing on shape of signal waveform resists influence of murmurs and segments HS events without any additional assisting channels. However, there are high frequency noises between HS beats in some cases explored from the HS benchmark database, which makes HS segmentation failed due to the slope of HS envelope changes too frequently. The components of noise are unknown, and in each case the noises are different. Thus MRA algorithm is adapted to remove such noise from HS signal in this research work thus to implement the envelogram as an anti-noise HS segmentation. MRA also prevents the influence of unnecessary frequency band to improve the performance of MFCC so that the sensitivity and specificity of the scheme increase greatly.

The outcomes of testing various HSs are presented and discussed concretely. It is observed that the MRA has improved the segmentation accuracy of HS signals by 23.2% and the pathological symptom hidden inside of HS can be efficiently detected by the proposed scheme. Obviously, such an explored advanced technology might be applied to the developing CVD diagnosis system through analysing HS and plays important role.

Key words: heart sound, multi-resolution analysis, envelogram, mel-scale frequency cepstral coefficients, dynamic time warping

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GLOSSARY

CVDs. Cardiovascular Diseases

PPG. Photoplethysmography

ECG. Electrocardiogram

SPG. Sphygmogram

PCG. Phonocardiogram

HS. Heart Sound

ECHO. Echocardiogram

S1. The First Heart Sound

S2. The Second Heart Sound

S3. The Third Heart Sound

S4. The Forth Heart Sound

AV. Atrioventricular

ICS. Intercostal Space

MS. Mitral Stenosis

TGA. The Great Arteries

AR. Aortic Regurgitation

AS. Aortic Stenosis

STFT. Short Time Fourier Transform

WT. Wavelet Transform

DWT. Discrete Wavelet Transform

FFT. Fast Fourier Transform

FT. Fourier Transform

MFCC. Mel-Frequency Cepstrum Coefficient

ANN. Artificial Neural Networks

AI. Artificial Intelligence

HMM. Hidden Markov Model

HTK. Hidden Markov Model Toolkit

GM. Gaussian Mixture Densities

DTW. Dynamic Time Warping

MRA. Multi-Resolution Analysis

DCT. Discrete Cosine Transform

WP. Wavelet Packets

FLD. Fisher's Linear Discriminant

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ACKNOWLEDGMENTS

I would like to extend my sincere appreciation to my supervisor Prof. Dong Mingchui for his support, inspiring instruction, immense patience to my study and research. His deep knowledge and corrections helped me in producing a more coherent and clear thesis as well as conference papers. Only with his patient guidance and endless support, I had the courage on my graduate studies and achieve some decent results.

I also would like to thank my co-supervisor Ms. Fu Binbin and Mr. Fei Xiaolei, Mr. Lei Waikei for their valuable advices and guidance in practical and theoretical matters throughout this research. And I thank other members of laboratory for their technical helps and friendships. As far as project is concerned, I would like to acknowledge Faculty of Science and Technology, Research Committee of University of Macao and the Science and Technology Development Fund of Macau for financial and technical supports to the research.

Last but not least, I would like to express my wholehearted gratitude to my dearest mother, my godmother and her daughter Miss He for their helps and encouragements. I can not do without their love and constant support within my life in Macau.

DEDICATION

The author wishes to dedicate this thesis to my mother.

Thanks to all she bestowed to me!