

An Exploration on Real-time Cuffless Blood Pressure
Estimation for e-Home Healthcare

by

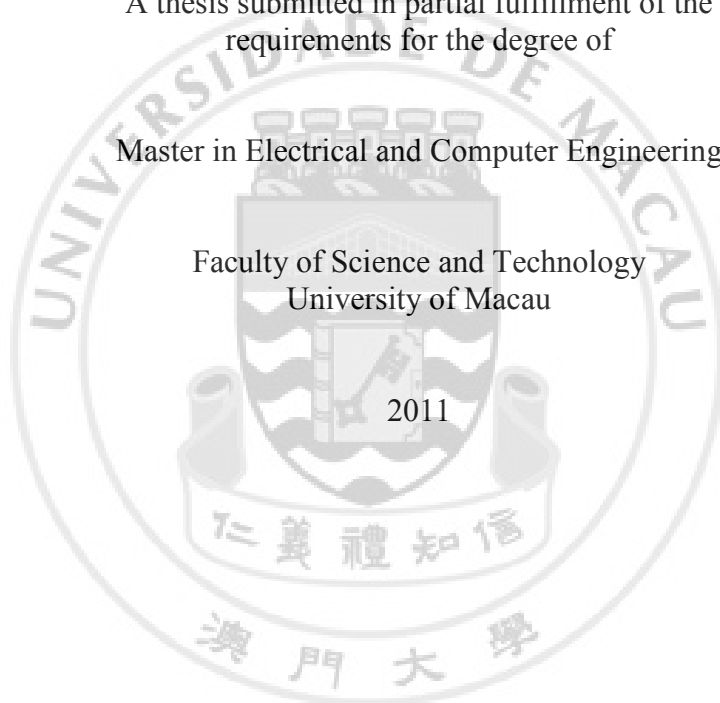
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requirements for the degree of

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Supervisor

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Abstract

AN EXPLORATION ON REAL-TIME CUFFLESS BLOOD
PRESSURE ESTIMATION FOR E-HOME HEALTHCARE

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It was apparent to all that blood pressure (BP) is one of the most important physiological parameters relevant for medical diagnostics, prevention as well as therapy strategies. High BP, i.e., hypertension is the greatest risk factor for cardiovascular diseases, including cardiac failure, coronary artery disease, and peripheral vascular disease. The late implications are often thrombosis and embolism, which may cause cerebral ischemia (stroke) or cardiac ischemia (heart attack). Thus, the online monitoring and early warning message to BP are vitally important to protect sudden heart disease and save human's life. Conventional noninvasive BP measurement via cuffed sphygmomanometers only provides a snapshot value, causes circulatory interference and uncomfortable sense at the measurement position due to wearing ballonet. However, long time monitoring can provide BP variation curve which indicates heart status and variation tendency. Thus, continuous monitoring of BP used in portable clinic devices is vitally important and highly cost effective in order to detect the damage of cardiovascular system and treat them as early as possible.

Using traditional sphygmomanometers to frequently measure BP, the encircling band-type cuff around the arm often makes subject feel uncomfortable due to necessary arm occlusion, thus long term BP measurement is limited because of pain caused by blood pooling or venous congestion in the distal portion of the measurement site. BP includes three parameters: systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP). As we know, by

measuring SBP and DBP one can detect hypertension and help to obtain parameters related to cardiovascular system. MAP is also important for getting an idea about cardiovascular system due to its close relationship to cardiac output, systemic vascular resistance and central venous pressure. Therefore, this research focuses on developing a real-time MAP estimation system which can be easily operated under comfortable condition, to provide complete information for CVD diagnosis.

It is summarized from a thorough literature review that pulse transit time (PTT) based method is competitive owing to its potential in realizing ambulatory BP monitoring scheme for e-home healthcare. Theoretically, this method is based on the relationship between BP and PTT and has a long development history for this relationship. It has been explored to realize cuffless blood pressure estimation in recent years, but there still exist problems concerning its practical applications, which can be categorized as three parts: 1) most researchers didn't construct a system which can automatically adjust electrocardiogram & pulse waveform and real-time extract their feature points, finally realize real-time PTT & MAP estimation; 2) constructing a convenient calibration method which can be easily operated under comfortable condition is another bottleneck problem; 3) to increase the accuracy of BP estimation is also a bottleneck problem in real application of PTT based method.

In this thesis research, an automatic sphygmogram (SPG) fast sampling scheme with signal conditioning circuit and relevant software for realizing signal amplitude & baseline-shift self-adjustment and distortion control are proposed. Due to existing external disturbance during pulse signal sampling, a close-loop control is constructed between computer and micro control unit based on the principle of Edifier Intelligent Distortion Control, so that to help home user quickly acquire the self-adjusted stable pulse signal with less distortion.

To realize the real-time feature point detection, SPG and ECG waveforms are collected to take feature point detection each few seconds. Due to existing THE feature points mis-detection and possible loss of relative SPG or ECG waveforms within that few seconds, a real-time PTT estimation scheme with several rules defined

to detect adjacent peak points of ECG & SPG but from different pulses is constructed, such that to reduce PTT calculation error.

The research finding by Chinese University of Hong Kong on using contact force to affect PTT and transmural pressure of fingertip is adopted and developed as an external cuff pressure based calibration method, which uses three groups of external cuff pressure on arm arterial to find out the coefficient value in BP-PTT relationship. The prototyping system is constructed and tested, the testing result is compared with another prevalent calibration method called hydrostatic pressure based method, which indicates that the operation procedure of our calibration method is easier and comfort, its accuracy for MAP estimation is comparable with that of hydrostatic pressure based method.

Key words: Blood Pressure, Real-Time, Pulse Transit Time Based Method, Close-loop Control, Pulse Transit Time Calculation, External Pressure Based Calibration Method

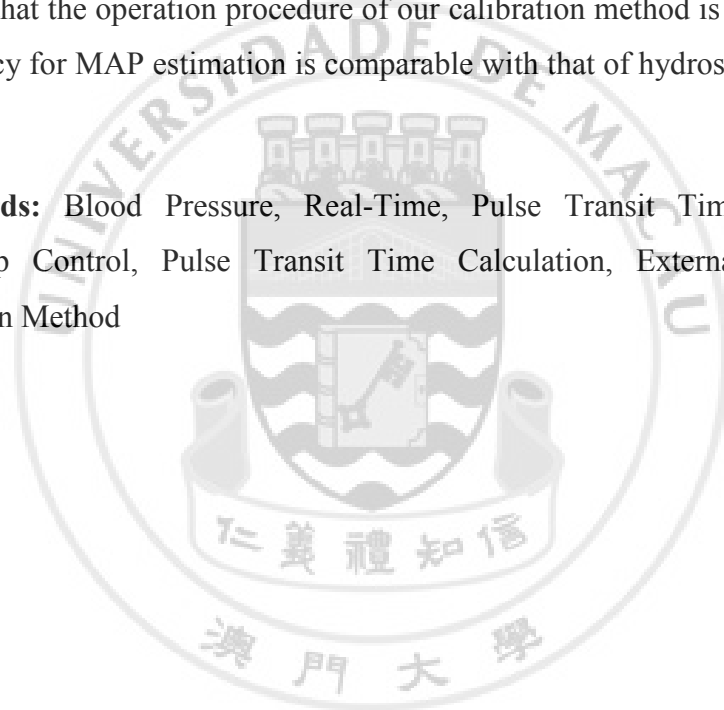


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GLOSSARY

CVDs. Cardiovascular Diseases

BP. Blood Pressure

SBP. Systolic Blood Pressure

MAP. Mean Arterial Pressure

DBP. Diastolic Blood Pressure

PPG. Photoplethysmography

ECG. Electrocardiogram

SPG. Sphygmogram

PTT. Pulse Transit Time

ADC. Analog-to-Digital Converter

MCU. Micro Control Unit

PC. Personal Computer

USB. Universal Serial Bus

E.I.D.C. Edifier Intelligent Distortion Control

USARTs. Universal Synchronous Asynchronous Receiver Transmitter

HPF. High Pass Filter

SNR. Signal to Noise Ratio

LPF. Low Pass Filter

THD. Total Harmonic Distortion

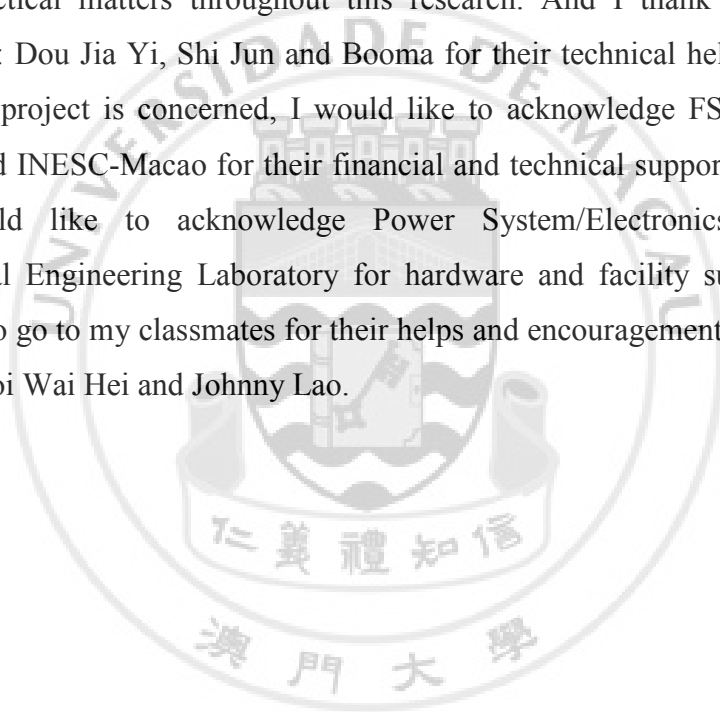
PCG. Phonocardiogram

PEP. Pre-ejection Period

SD. Standard Deviation

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DEDICATION

The author wishes to dedicate this thesis to my parents and Ms. Amy Zhang

Thanks for their support all the time!

