Hardware Accelerated Nios II Implementation of Hilbert Huang Transform

基於 Nios II 軟核處理器的希爾伯特黃變換硬體加速實現

by

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Master of Science in Electrical and Electronics Engineering

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

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Approved by _____
Supervisor

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Abstract

HARDWARE ACCELERATED NIOS II IMPLEMENTATION OF HILBERT HUANG TRANSFORM

by Wang Lei

Thesis Supervisor: Prof. VAI Mang I & Dr. MAK Peng Un
Master of Science in Electrical and Electronics Engineering

Today, more and more people are caring about their health, so biomedical research is much more important for human being. Biomedical signal processing is one of the most important research areas in biomedical engineering, but most of the biomedical signals are nonlinear and non-stationary signals. And the traditional methods like Fourier transform are limited to the priori assumption that the signals being processed should be linear and stationary, which is a restriction for biomedical signal processing. In 1998, N. E. Huang proposed a novel algorithm which named Hilbert Huang Transform, this algorithm is very good at processing nonlinear and non-stationary signals, and it already has a lot of applications on biomedical engineering. But the huge computation cost is a bottleneck to implement those applications with real-time processing.

This thesis presents a “Fast Instantaneous Frequency Analyzer Based on Hilbert transform”, the system can analyze nonlinear and non-stationary signals such as biomedical signals in time-frequency domain with a 3D spectrum. It clearly demonstrates the process of nonlinear and non-stationary signal during changing. And this thesis also proposes a method to use the concept of System On Programmable Chip to combine the soft-core processor with hardware functions to implement the acceleration for Hilbert Huang Transform. After evaluation, this method is proved to be effective.

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LIST OF ABBREVIATIONS

ADC. Analog to Digital Convertor

ALU. Arithmetic Logic Unit

BCI. Brain Computer Interface

CLB. Configurable Logic Block

DAC. Digital to Analog Convertor

DSP. Digital Signal Processor

ECG. Electrocardiogram

EEG. Electroencephalogram

EMD. Empirical Mode Decomposition

FA . Full Adder

FFT. Fast Fourier Transform

FPGA. Filed Programmable Gate Array

GSFC. Goddard Space Flight Center

HDL. Hardware Description Language

HHT. Hilbert-Huang Transform

HHT-DPS. HHT Data Processing System

HSA. Hilbert Spectral Analysis

IA. Instantaneous Amplitude

IF. Instantaneous Frequency

IFFT. Inverse Fast Fourier Transform

IMF. Intrinsic Mode Functions

LAB. Logic Array Block

LE. Logic Elements

LUT. Look-up Tables

MMU. Memory Management Unit

MPU. Memory Protection Unit

NASA. National Aeronautics and Space Administration

PC. Personal Computer

PPG. Photoplethysmogram

PTT. Pulse Transit Time

SDRAM. Synchronous Dynamic Random Access Memory

SOPC. System On Programmable Chip

SRAM. Static Random Access Memory

ACKNOWLEDGMENTS

I am grateful to the many people who have given me the possibilities to complete this research and thesis.

First of all, I must express my special thanks to my supervisors Prof. Vai Mang I and Dr. Mak Peng Un, not only for their valuable guidance, support and comments to my research work and university life, but also introducing me to this wonderful biomedical engineering and digital signal processing world. Without them, I never know anything about this field.

My appreciation also to all of my teachers in Biomedical Engineering Joint-Research Group including Dr. Chao Sam, Dr. Mak Pui In, Dr. Wan Feng and Dr. Wong Fai, for both of their guidance in regular meetings and the support in university life. And I am deeply indebted to Dr. Mak Pui In for participating in my defense committee. I have to thank my BME lab-mates and classmates including but not limited to Mr. Ieong Chao In, Mr. Chan Chang Hao, Mr. Zhang Tan Tan, Mr. Mou Pedro, Mr. Pun Sio Hang, for taking care of me these days.

Last but not the least, I sincerely thank my family. Without their unlimited love and support, everything is impossible.