Time-frequency Description of Vibrocardiographic Signals

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***Abstract*— Frequency content of an actual vibrocardigraphic signal was investigated using three different time-frequency distribution (TFD) techniques. TFD analysis suggested that polynomial chirplet transform may provide a better estimate of the signal frequency content.**

I. Introduction

Auscultation of heart sounds is an integral component of the physical examination. Computer analysis of these sounds can provide quantitative diagnostic information that may be helpful for screening patients suspected of heart disease. The low frequency heart sounds may also be called vibrocardiographic (VCG) signals [1]. Many methods may be used for VCG analysis. The objective of this study is to test some of the available methods for estimating the TFD of VCG signals. Understanding different characteristics of VCG, including its TFD, may lead to a better understanding of heart dynamics. Furthermore, successful classification of VCG signals in health and diseased can provide possible new methods for diagnosing and monitoring heart function.

II. Materials And Methods

After IRB approval, VCG signals were measured over the chest of healthy volunteers using a light-weight (2 gm) accelerometer (PCB piezotronics, Depew, NY). The sensor was placed at the sternal border and the 4th intercostal space. Signals were digitized at a sampling frequency 3200 Hz and down-sampled to 320 Hz. Matlab (R2015b, The MathWorks, Inc, Natick, MA) was used to both acquire and process the signals. TFD was estimated using three different methods: short-time Fourier transform (STFT), continuous wavelet transform with Daubechies 4 (CWT-db4) as the mother function, and polynomial chirplet transform (PCT) [2]. The latter method aims to improve the conventional chirplet transform results when applied to signals with a nonlinear instantaneous frequency trajectory.

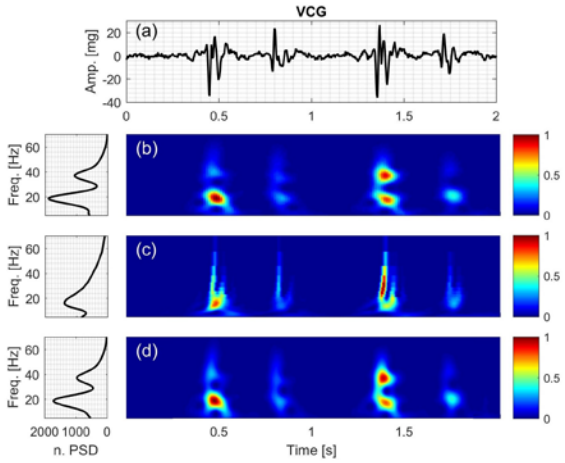
III. Results And Discussion

STFT had coarser temporal resolution compared to the other two methods, which had the same temporal resolution (Table 1). The frequency resolution for STFT and PCT was frequency independent and was 0.625 and 0.246 Hz, respectively. The spectral resolution for CWT-db4 was frequency dependent (ranging from about 0.4 to 19 Hz for frequencies of 10 to 70 Hz) with finer resolution at lower frequencies. Finer resolution is desirable as it may result in lower errors in estimation of instantaneous frequency of the signal. The STFT and PCT detected two frequencies in the VCG signal, while CWT-db4 appeared to detect one primary frequency.

TABLE I. Temporal And Spectral Resolution For Different Signals And TFD Techniques For Frequencies Between 10 and 70 Hz.

	STFT	***CWT-db4***	***PCT***
Temporal resolution (ms)	12.5	3.1	3.1
Spectral resolution (Hz)	0.625	0.452-19.048	0.246

Figure 1. VCG signal: (a) Time series. Time-frequency distribution using (b) STFT, (c) CWT-db4, (d) PCT, respectively.



IV. Conclusion

TFD of a VCG signal was estimated using different methods. The results showed that PCT had a finer resolution and detected the correct frequency components. Therefore, PCT appears to be a better choice than CWT-db4 and STFT for TFD estimation of VCG signals in the current study. More studies are needed to investigate the differences in TFD of VCG between healthy subjects and those with cardiovascular disease.

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