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Analysis of Non-Contact Multichannel Recording of Cardiac Vibration: Visual Seismocardiogram

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Abstract. Seismocardiography (SCG) is the recent research focus for cardiac monitoring and diagnosis. Contact based single channel accelerometer recordings suffer from limitations due to sensor placements and propagation delay. This work uses the airborne ultrasound device named Surface Motion Camera (SMC) for non-contact multichannel recording of the chest surface vibrations and proposes visualization techniques (vSCG) to enable simultaneous evaluation of both time and spatial variations of the vibrations. Recordings are performed on 10 healthy volunteers. The time propagation of vertical scans and 2D vibration contour maps at specific cardiac events are shown. These allow for a reproducible way for in-depth analysis of cardio mechanical activities, as compared to single channel SCG.

Keywords. Non-contact cardiac monitoring, airborne ultrasound, seismocardiography

1. Introduction

Multichannel SCG [1] provides additional insights into the cardiac mechanics while mitigating the problems in single channel recordings. Use of contact type multichannel accelerometers [2] requires precise sensor placements and causes patient discomfort. An airborne ultrasound based device named SMC is proposed to be efficient for non-contact multisite SCG recording [3]. Such multichannel recording requires proper data visualization to enable detailed analysis and better reproducibility. Here, we show two such techniques, referred to as visual SCG (vSCG), for multichannel data visualization from the SMC device in both time and spatial domain.

2. Methods

Surface vibrations are recorded from the chest of 10 healthy adult male subjects using SMC device described in [3], along with simultaneous single lead ECG. The device comprises of multi-channel transmitter-receiver systems working in echographic mode. Measurement zone covers 40x30 cm^2 area on the chest with a spatial resolution of 1cm. Two visualization approaches are applied on the preprocessed data - 1) Color coded map of time variations of the vertical scans along specific lines on the chest 2) Contour distribution of vibrations on the chest at specific time events.

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3. Results

Figure 1 (a) shows the time variation maps along two vertical lines, crossing the sternum and heart apex, for a single cardiac cycle along with the simultaneous ECG and xiphoid SCG. These signature variations allow easy visual identification of the cardiac events, as compared to peak detections required for single channel SCGs. As seen from the figure, the mitral closing (MC) and the Aortic opening (AO) events are detected earlier than the Xiphoidal SCG due to the elimination of the propagation delays, thus allowing more accurate event detections. The patterns observed are similar for all subjects. In addition to commonly defined SCG fiducial points, additional location specific features can also be observed. Figure 1 (b) shows the spatial distribution of the vibrations at specific time instants for different subjects. These maps enable the analysis of the origin and distribution of vibration patterns on the chest, which can be important identifiers for disease diagnosis.

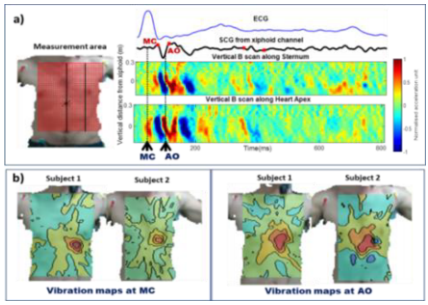

Figure 1. Visual Seismocardiogram (vSCG). a) Time variation along vertical scans b) Spatial distribution of chest surface vibrations at fiducial events- Mitral valve closing (MC) and Aortic valve opening (AO).

4. Discussion and Conclusions

This work proposes visualization techniques for efficient analysis of the multichannel SCG data, thus providing better insights into the cardiac-mechanics. Future studies will explore the utility of this technique as a complementary tool for non-contact cardiac diagnosis. Unlike the previous works on multichannel SCG [2], [3], this work provides effective visualization to analyze both the spatial and temporal variations in the cardio mechanics. The advantages over single channel recordings are also highlighted.

References

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