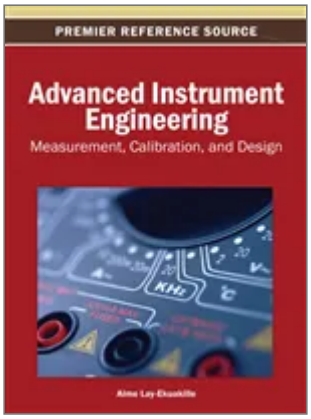

Seismocardiogram and Ballistocardiogram Sensing ⊗

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Abstract

The paper describes the latest development in seismocardiography and ballistocardiography, including sensors with or without mechanical contact with the body, for cardiac functions monitoring in common daily activity. The authors discuss the information related with the seismocardiogramn (SCG) and ballistocardiogram (BCG) and the work on SCG and BCG modeling. The latest advances reported on the devices aiming at BCG and SCG cardiovascular system evaluation are covered, highlighting their key features and novel concepts. The authors also underscore the applications of ElectroMechanical film (EMFi) sensors, MEMS accelerometers and radar sensing technology for vital signs monitoring. Discussion on the current developments and future improvements are included in the paper.

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1. Introduction

Health information obtained by non-invasive and unobtrusive measurement devices allows painless and stress free online patient monitoring without the important constraints that characterize classical devices that need wired connections and complex monitoring procedures. Taking into account these paramount advantages, many research groups developed non-invasive solutions for health monitoring based on the technological progress in microelectronics, embedded processing and data communications. Thus, over several decades, a great variety of electronics and computer technologies have been developed to assist clinical practices for cardiac performance monitoring and heart disease diagnosis.

Heart diseases have been the most important cause of death globally and are a major cause of disability. Heart diseases also result in substantial health-care expenditures. The demand for practical health care requiring diseases risk detection in daily life, in unrestricted conditions, has been leading to increasing innovation in portable systems with reduced size, weight and power consumption. Ballistocardiography (BCG) and seismocardiography (SCG) provide potential solutions to unobtrusive heart function monitoring because they do not require the contact of electrodes with the body during signal acquisition. The non-invasive and non-obtrusive characteristics of BCG and SCG sensing systems make them interesting solutions for long time monitoring of the cardiac activity. Seismocardiography (SCG) is an emerging, non-invasive technique developed for recording and analysing cardiac vibratory activity as a measure of cardiac contractile functions (Salerno & Zanetti, 1990, 1991; Zanetti, Poliac, & Crow, 1991) while ballistocardiography (BCG) is a technique for producing a graphical representation of the reaction of the body to cardiac ejection forces or the reaction of the body to the blood mass ejected by the heart with each contraction associated with arterial circulation (NASA, 1965; Scarborough & Baker, 1957; Gubner, Rodstein, & Ungerleider, 1953). Both these exams are able to measure directly or indirectly the mechanical functionality of the heart and hemodynamic parameters (Salerno & Zanetti, 1990, 1991; Zanetti, Poliac, & Crow, 1991; NASA, 1965; Scarborough & Baker, 1957; Gubner, Rodstein, & Ungerleider, 1953; Starr & Wood, 1961). Changes and abnormalities in the BCG and SCG have been correlated to various cardiac diseases.

A comparison between seismocardiography and ballistocardiography design and implementation to sense subjects' cardiac activity is presented here. We discuss the information related with seismocardiogram and ballistocardiogram and the work on SCG and BCG modeling. The latest advances reported on the devices aiming at BCG and SCG cardiovascular system evaluation are covered in the subsequent sections, highlighting their key features and novel concepts. We also underscore the applications of EMFi sensors, MEMS accelerometers and radar sensing technology for vital signs monitoring.

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