Developing Custom Signal Processing Algorithm with LabView FPGA and Compact RIO to Detect the Aortic Stenosis Disease

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Abstract

FPGAs provide an ideal template for run-time reconfigurable (RTR) designs. Only recently have RTR enabling design tools that bypass the traditional synthesis and bit stream generation process for FPGAs become available. Heart auscultation which is the interpretation of sounds produced by the heart is a fundamental tool in the diagnosis of heart disease. It is the most commonly used technique for screening and diagnosis in primary health care. This study aims at utilizing the discrete wavelet packet transforms in early detection of an Aortic Stenosis (AS) using heart sound data collected at Sussex University Hospital in England. From the data analysis, a criteria has been proposed for the detection of the AS disease from the heart sound data.

1. Introduction

Development of auscultation techniques for the diagnosis of heart disease and disorders is still growing. Experience gives the cardiologists the ability to detect abnormalities such as the presence of murmurs, which may indicate a pathological condition. The description of murmurs is an important task and, when auscultation is carried out, the cardiologist's notes are the sole record of the patient's condition. These facts are subjective and can be interpreted in different ways. In order to eliminate subjectivity a signal processing method is needed for the representation of the first heart sound S1, second heart sound S2 and murmurs. Since 1991, many researchers have shown that continuous wavelet analysis can provide an adequate representation of the primary heart sounds. For most applications, however, the goal of signal processing is to represent the signal efficiently with fewer parameters. This paper considers the representation of murmurs by exploring the use of discrete wavelet packet transform (DWPT) using the wavelet base Daubechies 'db4'.

The paper is structured as follows. Section 2 presents background information about heart sound auscultation. An overview of wavelet analysis is given in Section 3. Description of reconfigurable I/O (RIO) technology, Field-Programmable Gate Arrays (FPGAs), the data and the methodology used in the analysis are discussed in Sections 4 and 5.

Description of the data and the methodology used in. Section 6 discusses the results obtained. Finally, Section 7 concludes the paper.

2. Heart sound and auscultation

The technique of listening to the sounds produced by organs and vessels of the body is called auscultation. Phonocardiography (PCG) consists of the registration of the vibrations originating in the heart and associated blood vessels in order to obtain a visual record of the phenomena. Many studies attempted to extract features from heart sounds in order to understand their mechanisms as well as aiding in diagnosis. The techniques for recording and analysis have been changing as new electronic devices and signal processing techniques have become available.

The heart sounds are those generated as a result of mechanical vibrations due to contraction and relaxation of the heart cavities. The heart sounds have been described and classified, basically in terms of duration and pitch, in order to identify them. The first and the second heart sounds are related to complete closure of the Atrioventricular (AV) and semilunar valves, respectively (Figure 1a). The first heart sound (S1) marks the beginning of mechanical systole. It consists of two intense high-frequency bursts of vibrations at the time of the AV closure and a few variable low-intensity vibrations [1]. The two components are known as M1 and T1 corresponding to the mitral and tricuspid components. The second heart sound (S2) marks the beginning of mechanical diastole. It consists of two high-frequency components that relate to the closure of the aortic and pulmonic valves, A2 and P2 respectively. The detection of the two components, their intensity, and time relation provide valuable diagnostic clues [1-3].