Chapter 4
Classification and Compression of ECG Signal for Holter Device

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ABSTRACT

ECG signal processing for holter monitoring of heart patients is still exploratory. Many signal processing techniques have been evolved for classification and compression of ECG signal. Despite an increase in research in this area, many challenges remain in designing an efficient classification and compression algorithm for ECG signal. These challenges include classification accuracy, good compression ratio with acceptable diagnostic quality etc. This chapter addresses a classification and a compression algorithm based on discrete wavelet transform. Classification algorithm uses discrete wavelet transform based feature to classify abnormal heart beat from ECG signal. Support vector machine is used as a classifier to detect abnormal heartbeat. The compression algorithm utilizes discrete wavelet transform and run-length encoding as a compression tool. Proposed classification and compression algorithms can be employed in monitoring of cardiac patients using holter device.

INTRODUCTION

Heart muscles generate tiny electrical impulses which can be recorded by electrodes by placing it on patient's body surface. This recording is called electrocardiogram (ECG) which is a non-invasive clinical tool in the field of cardiology. It is widely used by cardiologists for diagnosis of heart diseases. ECG waveform of a normal cardiac cycle is depicted in Figure 1 which consist P-wave, QRS-complex and T-wave (Chen *et. al*, 2014). Depolarization of atrium produces P-wave. Depolarization of right atrium reflects first half of the P-wave while latter half of the P-wave indicates depolarization of left atrium. Q-wave, R-wave and S- wave are collectively known as QRS-complex.

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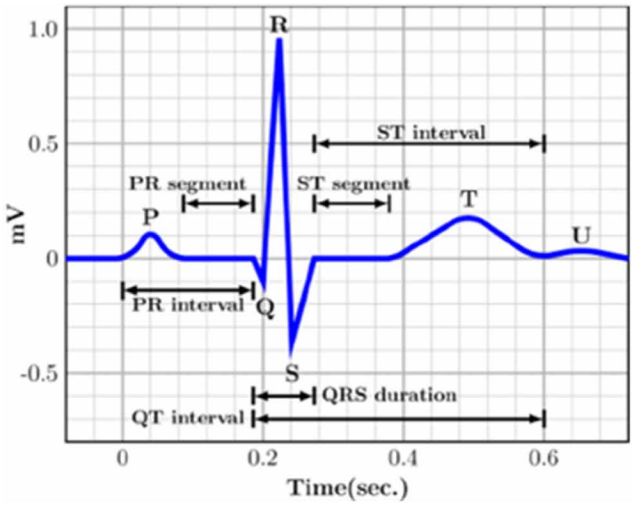
Figure 1. ECG waveform of normal cardiac cycle



It is generated by left and right ventricular depolarization. Ventricular re-polarization generates T-wave. Cardiologists diagnose heart diseases on the basis of different features of ECG waveform which includes amplitudes of PQRST waves and time intervals between different segments. ECG signal is recorded for several hours in holter monitoring of cardiac patients.

Holter Monitor

In pathological ECG test, ECG is recorded for very short duration. For a cardiac patient, it is possible that abnormal heart rhythm may come and go. In general, cardiologist cannot detect abnormal behavior of heart by observing short duration of pathological ECG record. Therefore long time monitoring of cardiac patient is necessary. Holter monitor provides this facility to cardiologist using which observation of heart function is possible on long-term basis. It also helps the cardiologist to determine medicine is working properly or not on cardiac patients. Holter monitor is a battery operated, small device which is used to record ECG signal for 12 hours to 48 hours continuously during normal daily routine of a cardiac patient. Holter monitoring is also called ambulatory ECG monitoring.

Classification of Heartbeats

Classification of heartbeats plays a major role to detect abnormal heartbeat during monitoring of heart patients. Many heartbeat classification techniques have been developed based on its features. These features include morphological features (De Chazal *et. al*, 2004), segmentation based features (De Chazal *et. al*, 2004) and frequency domain features (Romero *et. al*, 2001, De Chazal *et. al*, 2004). The technique of classification of heartbeats started two decades before using artificial neural network as a classifier (Hu *et. al*, 1992). At present classifier such as support vector machine (SVM) (Osowski *et. al*, 2004), hidden Markov model (HMM) (Coast *et. al*, 1990, Kolekar *et. al* 2004), artificial neural network (Hu *et. al*, 1992, Hu et. al, 1997, Barro *et. al*, 1998), self organizing maps (Lagerholm *et. al*, 2000) are widely used for classification of ECG heartbeats. A classification technique based on discrete wavelet transform