Chapter 6
A J2ME Mobile Application for Normal and Abnormal ECG Rhythm Analysis

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ABSTRACT

Cardiovascular disease has become the world's number one killer. The prevalence of cardiovascular disease has caused many unnecessary premature deaths and imposed substantial burden to healthcare systems. Many continuous heart monitoring systems have been proposed with the aim to issue early stage warning for a possible forthcoming heart attack by utilising advanced information and communication technologies. Nevertheless, there is still a significant gap between the usability and reliability of those systems and the requirements from medical practitioners. This chapter presents our recent development of a mobile phone based ECG real-time intelligent analysis system. By fully employing the computational power of a mobile phone, the system provides local intelligence for ECG R wave detection, PQRS signature identification and segmentation, and arrhythmia classification. Because those processing can be performed on realtime, an early status warning can be issued promptly to initiate further rescue procedures. As an application of e-commerce in healthcare, a telecaridiology system like this is of great significance to support chronic cardiovascular disease patients.

INTRODUCTION

Recently, the patients suffering from cardiovascular disease (CVD) have been undergoing a rapid increase world widely due to the lifestyle change and the aging of population. For many nations such as USA, Australia, European nations, Canada and China, various CVDs are the number one killer while the cerebrovascular diseases (CBD) such as stroke are the number two killer (Roberts, 2006). The

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prevalence of CVD has risen by 18% over the last decade and is expected to continue to rise over the coming decades due to an expected increase in the elderly population (AIHW, 2004a). In Australia, 37% of the total death in 2001 was caused by cardiovascular diseases and CVD affected total 3.67 million Australian people which is about 18% of national population (AIHW, 2004b). Among Australians having heart attacks, about 25% die within an hour of their first-ever symptoms and over 40% will be dead within a year (Access Economics Report, 2005). CVD together with CBD are also the leading causes of long term disability in adults (Access Economics Report, 2005). They impose a big burden on patients' families as well as the national healthcare system due to the high costs of care, the resulted lower quality of life, and the premature death. Chronic CVD patients are at high risk of having heart attacks and the majority of such heart attacks take place in out-of-hospital environment where the emergence services cannot be available immediately. Therefore, there is an urgent need to develop a personal monitoring and alarming system which can effectively detect early indications of a heart attack and issue timely warning signals for calling for rescue efforts.

Since last decade, we have witnessed the explosive expansion of the use of mobile phone. Now, mobile phone is one of the most pervasively used single electronics devices in the world. For example, Australia has more subscribed mobile phone handsets than its total population (ACMA Report, 2009). The ever increasing computation power of a mobile phone plus its great mobility make it an ideal pervasive computing platform for telehealth monitoring. Although handheld devices such as mobile phone have been widely proposed to use in various telemedicine applications, they are generally utilized as the wireless data transmission tools. The power from the mobile computing devices has not been fully harnessed. On the other hand, many ambulatory and medical monitoring systems need the acquired vital physiological data be processed in real-time so as to generate the much needed precaution and alarming signals. For such applications, the acquired physiological data should be processed locally, rather than sent to a remote server via a GPRS or 3G mobile telephony network systems, to avoid transmission delay and reduce transmission cost. In order to develop the local intelligence, some limitations pertinent to handheld computing devices need to be addressed. Those limitations include the bottleneck of the bandwidth for large amount of stream data continuous transmission, the partial support of the full extended ASCII set, the limited hardware resources such as processor speed and memory amount, and the restricted programming environment such as no directly support of floating point and no multi-dimensional array support for many mobile phone handsets (Sufi et al., 2006).

This chapter presents a realtime stream data mining system for one human vital physiological signal, the electrocardiogram (ECG) on compact mobile phone handsets. This lightweight data mining system is able to extract information which is important to medical practitioners to make clinical diagnosis and treatment decision. The first part of the chapter is a brief introduction of ECG signal and the general steps of clinical analysis of this crucial electrophysiological signal. The current mobile cardiac monitoring development efforts are also briefly reviewed in this section. It is followed by an introduction to J2ME, the development platform used in this research. The key analysis techniques employed in this research which include the time series analysis, the discrete wavelet transform (DWT) and a naive Bayesian classifier are elaborated in this section. The frequency domain analysis of the recorded heart rhythm such as power spectrum density can be performed by implementing the fast Fourier transform (FFT) algorithm on a mobile phone handset. However, it is the discrete wavelet transform, a time-frequency analysis method that shows it superiority over Fourier transform to display the high frequency details of an ECG waveform in different scales and suppress the low