

CHAPTER 1 – INTRODUCTION

1.1 Background

Cardiovascular diseases (CVDs) can happen in both young and old population (Auer et al., 2012; Feng, Wang, Liu, Luo, & Huang, 2018; Maron et al., 2014) and is usually indicated by irregular heartbeats, or on medical terms, cardiac arrhythmia. Thus, electrocardiogram (ECG) abnormality detection plays a significant role in the detection of potential diseases. Since arrhythmia does not emerge in a short time, but instead over some period in between normal ECG signal, the diagnosis using ECG in the hospitals is limited.

Additionally, the traditional ECG monitoring system confines the individuals with large instruments and wired connection. The idea of wearable ECG with wireless sensors that could monitor the cardiac activity continuously in real-time is a more convenient approach. In this case, the monitoring and detection process will not influence the daily life of the users. Moreover, these sensors can generate and process a large amount of data efficiently (Pandeya, Voorsluys, Niua, Khandoker, & Buyya, 2012; Walsh, Topol, & Steinhubl, 2014) that might be less infeasible to be inspected by a cardiologist or a clinician.

Emerging technologies furthering the reach of medical diagnosis into smart wearables require advanced sensing, control, and analytical capabilities. The state-of-the-art for automatic ECG classification includes embedded atrial fibrillation detector based on irregular heartbeats. A novel chest-strap wearable device for real-time atrial fibrillation (AFib) detection (Iskandar, 2017) was developed in 2017 by Iskandar (unpublished work), which happened to be the hosting device for the research in this thesis. That being stated, this research aims to improve the firmware algorithm of the wearable ECG devices as well as implement the wearable device for clinical usage in a hospital. The improvements include furthering the scope of detection – detection of irregular heartbeats, premature ventricular contraction (PVC), premature atrial contraction (PAC), supraventricular tachycardia (SVT) and ventricular tachycardia (VT).

Beside the wearable heart rate monitors based on ECG signal using electrodes mentioned above, there are also some wearable heart rate monitors based on blood pulse using LED sensors. The benefit of measuring heart rate based on ECG, rather than the heart rate sensor using an optical LED light source-sensor, is the accuracy. ECG signal represents the electrical activity of the heart pumping motion itself and not the pulse of the pumped blood. However, there are several challenges for ECG assessment approaches. Firstly, the contamination in the ECG signal by various kinds of noise and physiological artefact, such as baseline wanders, power line interference/electrical noise, and muscle contraction.

ECG acquisition with the current trend of cardiac arrhythmia detection plays a vital role in diagnosing most of the cardiac diseases, thus increasing people's awareness and preventive measures towards cardiac diseases while assisting cardiac doctors in the diagnosis.

1.2 Research Problems

The problems underlying this study are as follows:

1. Cardiac arrhythmia signals often pass undetected in clinical tests.
2. Current devices mostly focus on atrial fibrillation detection based on irregular heart rate analysis.
3. There are difficulties to interact or consult directly with doctors in case of cardiac arrhythmias.

1.3 Research Objectives

1. To develop software for the wearable ECG monitor that can characterise various parameters of ECG signal.
2. To detect and recognise several diagnoses of cardiac arrhythmias based on ECG signals as in clinical standards using an embedded device.
3. To provide fast and simple ECG monitoring aids that helps both medical doctors and patients, especially in dealing with cardiac arrhythmias.

1.4 Significance of Study

The study is significant for three reasons, notably:

1. In recent years, various health-related problems are propagated enormously due to the drastic change in the lifestyles of the population across the world. Especially in the 21st century, cardiovascular diseases (CVDs) have become the leading cause of mortality. This device will help increase people awareness of heart diseases.
2. The wearable ECG is convenient to use and able to monitor the cardiac activity continuously in real-time without influencing the daily life of the users.
3. The result from the device can be carried out into a smartphone application installed on mobile devices that can be used to inform the doctors.

1.5 Research Questions

Question #1: How to recognise ECG signal parameters, such as the Q-wave, S-wave, and irregular heart rate?

Question #2: How to construct the algorithm on an embedded software based on ECG signals to detect several cardiac arrhythmias in real-time?

Question #3: How to develop a visual platform to provide doctors with patients' condition and emergencies and provide patients with ease of consultation?

1.6 Hypothesis

Hypothesis #1: This software can recognise ECG signal parameters and generate further parameters, such as QRS-width and RR-interval.

Hypothesis #2: This wearable ECG device can detect several cardiac arrhythmias in real-time, especially those commonly appears in daily life.

Hypothesis #3: The complementary mobile application can provide visual aids to the patients and doctors in case of cardiac arrhythmias.