Chapter 9
Digitization of Paper Electrocardiogram: A Review

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ABSTRACT

In order to diagnose a possible cardiac disorder, ECG (electrocardiogram) signals are usually recorded on standard grid papers in hospitals. Many efforts have been made to advance the technology in order to improve the diagnosis and management of cardiovascular disease. There is a need to convert the existing ECG records into digital forms, as it is the most efficient method to store and analyze ECG attributes for clinical uses. The main purpose of this chapter is to review the existing algorithms for digital conversion of paper ECG. It discusses the various challenges and a systematic study on different methods that have been used so far to convert paper ECG records into digitized form so that they can be retrieved efficiently. Initial challenge involved in the digitization process is gridline removal. In this process, information of ECG signal is also removed. None of the existing methods provide flawless gridline removal. The paper ECG used in hospitals differs in shape, size, formats, so the main challenge in digitization process is to achieve a worldwide ECG format.

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INTRODUCTION

Technologies that are used to compute human behavior or physical features are known as Biometrics such as iris, face, fingerprints, retina, hand geometry, voice or signatures and using such measures to detect and recognize individuals. Biometric act as an acrimonious alternative for identity verification such as passports, driving licenses, ID cards or PIN numbers in authentication. No need to bring any type of additional ID documents by the user because biometrics uses unique physical traits for authentication purpose. Biometric credentials cannot be forgotten, lost, easily cloned or guessed like other traditional authorization systems such as passwords, ID cards or personal identification numbers (PINs). Usual biometric systems involve a nomination and verification/identification phase. In enrollment process "live samples" of a person's biometric is acquired for identification purpose, followed by processing process and after that stored as templates. In verification process captured biometric samples are matched to the enrolled template, which is stored so as to verify/identify user identity (Lumini et al., 2017, Merone et al., 2017, Hejazi et al., 2016).

First fundamental fingerprint recognition system was presented in early 20 century. In search of new biometric modalities, research community spent too much energy to get any behavioral or physical trait which assure the conditions of universality, varying with time, discriminate between the population, readily collectable and difficult to cheat/reproduce. On the basis of above criteria several distinctive symptoms are identified, such as physiological (e.g. fingerprint, face, and iris), behavioral (e.g. signature, voice, gait), soft (e.g. gender, height and ethnicity) and medico-chemical (e.g. ECG, DNA) (Lumini et al., 2017, Sidek et al., 2014).

Unlike traditional biometric modalities, for authentication purpose the heart is likely a most safe for biometric modality since it is confined in the structure of the body, making it difficult for the opportunists to forge, change, replicate, mimic etc. The electric signal produced by the heart can be captured in a non-invasive way from the body's surface using ECG sensors. Most of the available devices for ECG acquisition in developing and underdeveloped countries use Paper-ECG. To create a country wide database for citizen identification/ verification, it is required to develop techniques for digitization of these ECG's available in paper form (i.e. Paper-ECG) (Islam et al., 2017, Gutta et al., 2016).

Human Heart

The Human Heart is a muscular organ having four chambers that are located just to the left of the midplane of the thoracic cavity. The superior two chambers, i.e. atria are divided by a wall like structure known as interatrial septum. The inferior two chambers, i.e. ventricles are divided by a similar structure known as the interventricular septum. The relaxing or filling phase of a cardiac chamber is known as diastole; the contracting or pumping phase is known as systole.

Impure blood flows into the right atrium through the veins with lack of oxygen, these veins known as superior and inferior vena cava. The right atrium collects impure blood from head, neck, chest and arms through the superior vena cava. It collects impure blood from the remainder of the trunk and the legs through the inferior vena cava. During the pumping phase of atrial, blood flows through the tricuspid valve from right atrium to the right ventricle. During ventricle contraction, the right ventricle is pumped out the impure blood to the lungs through the pulmonary valve for purification (oxygenation). Purified blood from the lungs is received by left atrium, which is passed to the left ventricle during atrial systole through the mitral valve. The most important and the largest part of cardiac chamber are known as the