On and Off the Person ECG Data Sensing and Processing Technology

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Abstract

In the era of the IoT, associated with the growth of technological innovation in the field of ubiquitous computing, sensors are nowadays at the core of wearables and applications aiming at wellbeing and fitness. Continuous monitoring of physiological signals has become a reality, with the generalization of self-tracking and wearable devices, such as wrist bands, smart watches, and smartphones, mostly focused on quantifying physical activity.

Concerning heart-related activity, the most common technology is based on pulse photoplethysmography (PPG), a simple and low-cost optical technique that can be used to detect blood volume changes, from which the instantaneous heart rate can be determined. While many commercial systems exist exploring this modality, the reliability of the provided measurements, most often in terms of average heart rates in (unspecified) temporal windows, is dubious, which poses the question of how precise and useful they actually are. Independent evaluation of some of these devices, namely the popular brands Fitbit and Samsung Gear smart watches, lead to disappointing results. Hence, adoption of a particular device for clinical purposes requires critical validation.

In a different perspective, a new paradigm entitled off-the-person acquisition that consists of embedding health and self-tracking technology on everyday-life objects, complements the on-the-person wearable paradigm with more advanced sensors, such as Electrocardiography (ECG), and Galvanic Skin Resistance (GSR). Built upon authors' work on low cost systems for physiological measurements [1], such devices provide clinical grade recording of ECG signals [2][3]. Furthermore, ECG signals, measuring heart's electrical activity and assessing both rhythmic and morphological patterns of activity, provide a much richer plethora of information. In our work, exploration of this signal is three-fold:

person identification/authentication [4], emotion assessment [5], and health monitoring [6]. This paves the way to personalized health frameworks.

The richness of information acquired by these sensors can additionally be complemented by other sources of context and temporal information, in a continuous monitoring framework. Besides cardiac conditions, it has been shown that patterns of ECG temporal evolution correlate with other health conditions. In particular, epileptic seizures can be predicted with about 30 minutes anticipation by monitoring ECG patterns in the temporal domain. By applying supervised and unsupervised learning techniques to these physiological data, tracking trends and individual time evolution patterns of cardiac activity, it is expected that preventive health scenarios, in addition to personalized diagnosis and treatment, may provide significant impact on health and wellbeing. Current work thus provides a step forward towards personalized continuous health monitoring, prevention and treatment.

Keywords: Personalized health monitoring, preventive healthcare, pervasive ECG monitoring

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