Chapter 4.8
Ubiquitous Risk Analysis of Physiological Data

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ABSTRACT

Current advances in sensing devices and wireless technologies are providing a high opportunity for improving care quality and reducing the medical costs. This chapter presents the architecture of a mobile healthcare system and provides an overview of mobile health applications. Furthermore, it proposes a framework for patient monitoring that performs real-time stream analysis of data collected by means of non-invasive body sensors. It evaluates a patient's health conditions by analyzing different physiological signals to identify anomalies and activate alarms in risk situations. A risk function for identifying the instantaneous risk of each physiological parameter has been defined. The performance of the proposed system has been evaluated on public physiological data and promising experimental results are presented. By understanding the challenges and the current solutions of informatics appliances described in this chapter, new research areas can be further investigated to improve mobile healthcare services and design innovative medical applications.

INTRODUCTION

Technological advances in sensing devices, miniaturization of low-power microelectron-

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ics, and wireless networks enable the design and exploitation of wireless devices capable of autonomously monitoring human health conditions to improve mobile healthcare services for patients and health professionals. Mobile health applications may play a key role in saving lives by allowing timely assistance, in collecting data for medical research, and in significantly cutting the cost of medical services. Hence, advances in health information systems and healthcare technologies offer a tremendous opportunity for improving care quality while reducing cost [Lee, 2006]. Non-invasive medical sensors measuring vital signs (e.g., temperature, heart rate, blood pressure, oxygen saturation, serum glucose), integrated into tiny intelligent wearable accessories (e.g., watches [http://www.skyaid.org/LifeWatch/life_watch.htm]), are currently under development [Jovanov, 2005]. Wearable devices allow an individual to closely monitor changes in her or his vital signs for extended periods of time and provide a comprehensive view of a patient's condition. These devices can be integrated into a general health system architecture to continuously monitor patient health status and timely recognize life-threatening changes. Hence, an important issue in this context is the real-time analysis of physiological signals to characterize the patient condition and immediately identify dangerous situations.

This chapter describes the architecture of a mobile healthcare system and provides an overview of health applications. Furthermore, it proposes a flexible framework called IGUANA (Individuation of Global Unsafe Anomalies and Alarm activation) to perform stream analysis of physiological data to monitor a patient's health condition, by analyzing physiological measures collected by means of a set of wearable sensors. The real-time analysis exploits data mining techniques for assessing the instantaneous risk of monitored people. To allow ubiquitous analysis, real-time processing is performed on mobile devices (e.g., Pocket PCs and smart phones). When a dangerous situation is detected, an immediate intervention may be requested by raising an alarm (e.g., phone call, SMS) to the closest medical centre.

MOBILE HEALTH SYSTEM ARCHITECTURE

The overall architecture of a mobile health system (see, e.g., [Jones, 2006], [Apiletti, 2006]) is shown in Figure 1. It may be composed by some or all of the following subsystems:

- A body sensor network
- A wireless local area network
- A GSM network

Each individual (patient) wears a set of sensors that monitor physiological signals. These sensors, which are integrated into non-invasive objects, are connected to the user's device (also called personal server, e.g., a smart phone or a PDA) through a short range communication link (e.g., Bluetooth), in charge of transmitting recorded signals. The device may locally elaborate the incoming signals to immediately detect life-threatening situations. The set of wearable sensors and the mobile device form the body sensor network.

The second subsystem allows the communication between the user's mobile device and the elaboration centre, possibly by means of an infrastructure node (e.g., an access point). Communication with the elaboration centre may occur when recorded data is transferred to the system for off-line analysis or to backup/gather historical data. Finally, through the GSM network an alert message may be sent to the closest medical centre to request prompt medical intervention when a risk situation is detected.

A more detailed description of each subsystem is presented in the following.

Body Sensor Network. A body sensor network consists of multiple sensing devices capable

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