Non-Intrusive Health-Monitoring Devices

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INTRODUCTION

Technological advancements in medical and health-care areas have brought about the longevity of human beings. The World Health Organization recognizes that "the world population is rapidly ageing" and that it is necessary to "reinvent our assumptions of old age" to promote healthy living (WHO, n.d.). The subsequent increase in health-related expenses has imposed significant financial burdens on many governments and individuals. The US government has had to push for a reform in the country's medical system in order for it to stay sustainable in the future. Monitoring well-being, early disease detection and preventive health-care are becoming increasingly important in reducing the high cost of treatment and recovery from illness. This can be alleviated through the realization of e-health, by computerizing the whole process and analyzing data on a continuous basis. There are many facets of e-health. In the large scale, it involves the complete workflow of acquiring, storing and retrieving medical records, controlling accessibility and access privileges to those records, and managing the security and privacy issues that arise, for instance, the Cardiovascular Health Informatics and Multi-modal E-record (CHIME) (Zhang, Poon, & MacPherson, 2009). Monitoring and analysis on the health condition could also be performed over the cloud, riding on recent advancement of efficient and high bandwidth communication infrastructure (Li, Guo, & Guo, 2014). It has been demonstrated that the continually acquired heart-beat rate and blood pressure time series could be very useful in monitoring patient progress and predicting patient survival rate via machine learning approaches (Lehman et al., 2015). In the context of health monitoring, a major focus is on the efficient acquisition of medical information for storage and analysis. Advances in health monitoring technologies have also blurred the distinction between health and disease to make it a continuum, with a paradigm shift towards prevention, prediction, personalized treatment and participatory medicine (Andreu-Perez, Leff, Ip, & Yang, 2015). In this chapter, the preventive stage of health problem, along the venue of effective health monitoring, is studied.

Many contemporary health-monitoring technologies are more or less based on *intrusive* devices, which impose certain burdens on users and demand that they adapt to the presence of those devices. Even though this is rather accepted for a patient, this is not quite desirable for a normal person, since it will inevitably affect his/her daily life and work, especially when continual monitoring is in place. In this chapter, contemporary health-monitoring technologies are revisited, with an emphasis being paid

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on health-monitoring devices and non-intrusive approaches. The design of a novel physiological mouse that measures the heart-beat rate and respiratory rate of a user is presented, based on the processing of photoplethysmographic signals. A prototype is built with diodes and light sensors, conveying the measured light intensities for further processing upon a conventional mouse. Finally, experiments are conducted to validate the physiological mouse design, demonstrating its usability and good accuracy.

HEALTH MONITORING AND NON-INTRUSIVE TECHNOLOGY

Health monitoring has long been an important issue, and affordability and demand have always been important aspects for consideration. The former comes as a positive influence as technology advances and smaller and smarter devices become available at lower cost. The latter is induced by the changing demographics of an aging society in which more people need to rely on the technology for ensuring their health. According to (Celler & Sparks, 2015), there are currently over 40 major international manufacturers of tele-monitoring systems, and yet far more products to monitor health for vital signals. However, most contemporary health-monitoring devices are expensive, or intrusive. For instance, one cannot expect everybody to own an ECG (electrocardiogram) device at home. It is also very tedious and intrusive to attach the many needed electrodes to a human. Though such sophisticated devices are in general capable of returning a lot of sensing data, they also create heavy demand on the computation power for processing. Another example is the health chair (Anttonen & Surakka, 2005; Griffiths, Saponas, & Brush, 2014). Though not as intrusive as the ECG devices and many other similar devices, these chairs are often fairly expensive with a good number of sensors attached and they cannot often follow the users to move from places to places freely. The processing overhead or computational demand is also non-negligible.

To enhance usage and to reduce cost, this chapter focuses on *wearable health-monitoring devices* created in recent years, as they are devices that possess the potential to help ordinary users to monitor their health at home or perhaps at work. The evolution of pervasive health monitoring devices and technologies is summarized in (Andreu-Perez et al., 2015) from episodic monitoring to continuous sensing and integrated care, stepping into the era of exciting and yet demanding big data processing context. Processing and communication mechanism, security and privacy, data fusion and prediction, and other relevant issues need to be studied in this new context. Common contemporary health-monitoring devices range from simple temperature monitors, pulse monitors, to slightly more complex respiration monitors, SpO2 (oxygen saturation in blood) monitors, activity monitors, and so on. To make this health monitoring paradigm more effective, remote health monitoring over the internet is advocated. The advantages of this approach include cost-effectiveness through reducing the reliance on expensive medical personnel, and automatic recording and processing of data streams, alerting remote medical officers when there is a need based on prescribed rules representing domain knowledge. The ratio of medical doctors to patients can be increased drastically to satisfy the increasing medical demand. This has even a more far reaching effect in developing countries, where the supply for doctors is usually in severe shortage. For instance, the authors have conducted community services in the countryside of Cambodia and in Rwanda in providing health-related services mainly to kids. Some apps are developed that would be able to perform screening before enlisting a medical doctor to help. Going one step further, the communication media between devices and associated systems can become wireless. The applications for those wireless sensors, often biosensors, in the e-health domain can be classified into five major categories (Waluyo, Yeoh, Pek, Yong, & Chen, 2010), with health monitoring being the focal point in this chapter.