Chapter 3
Next Generation Body Area Networks and Smart Environments for Healthcare

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ABSTRACT

The evolution of wireless network protocols such as Bluetooth and ZigBee, and the reducing size, cost (and power consumption) of small scale sensor devices means that new approaches to healthcare monitoring and provision are now possible. From the technological side, new wireless devices can be envisaged that can monitor patients both externally (in terms of movement, flexibility and mobility) and even internally (in terms of embedded devices). From the health and social care side, such wireless devices can allow home monitoring of patients. This can allow more efficient and effective use of health and social care professionals, and also allow patients in remote areas to potentially receive as much healthcare monitoring as patients in urban environments. However, it is important that any use of such new technologies is carefully piloted and integrated with traditional health and social care approaches, especially in terms of the reliability and security of patient data. In this chapter, the authors provide a discussion on the state-of-the-art research initiatives that are trying to address these challenges. A discussion is presented on some of the more recent background work and a view of what future body area networks and smart environments might look like. Throughout the discussion the authors present the challenges faced by many research communities and the likely trends that will emerge given such challenges.

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INTRODUCTION

In recent years there has been a noticeable increase in ubiquitous and pervasive communication networks. This has led to a surge in the production of new types of devices that exploit such networks. These devices now drive an insatiable consumer appetite for richer applications and services that can be used anytime and anywhere. Such advances have made it possible to support new ways of using mobile technologies, e.g., machine-to-machine communications, which has been particularly useful for automatically gauging and billing consumer energy usage. Furthermore, it has provided a platform that enables all physical objects, such as doors, roads, trees, environments and people, to form part of these networks via wireless sensor technology.

The enhancement of everyday objects with networking, sensing, and data processing capabilities has allowed concealed information (ranging from atmospheric temperature to human physiological states and kinetics) to be given a digital value. This allows information about physical properties to be observed and used within the network by many different applications and services. For example, sensors attached to a person's body act as information providers that extract data from the nervous, muscular, vascular, kinematic and kinetic systems. From the voluminous data streams, algorithms will be required to reason over this data to form patterns and classifications that help provide meaningful information about a person's health and well-being. This could for example allow early signs of a health event to be detected before it has had a chance to fully develop. Whilst there may not be any obvious visible triggers to use as guidance, there will be significant change in physiological state and/or physical activities.

Classifications can be developed from patient behaviours observed (and reasoned over) from streamed events. The major concern is how potentially discontinuous and discrete behaviours may relate to each other. Firstly, context and time may affect segments and alter their behaviour accordingly. Secondly, there will be variability within segments and this type of data will differ from those that are static - it is variability that makes the classification process complex. For example, increases in heart rate could produce the same data under many different contexts, i.e. running, fear, or dehydration. Hence context will directly influence the classification process.

This is further complicated by the fact that people are highly mobile and even in a static position the behaviour of people will produce hundreds of data streams. Taking into account a person's mobility, their social interactions and psychological changes, it will make it difficult to isolate and understand a single segment or piece of behaviour. Yet the benefits are potentially huge. In healthcare it will provide new ways of exploring and quantifying latent behaviour, such as mood variation, feelings of distress and fear relating to illness or physical threat, depression, and pain.

This chapter presents one of the most timely research topics in healthcare. Remote and wireless patient monitoring and stream reasoning over data produced by body area networks will be paramount in next generation healthcare. This chapter explores some of key challenges faced by researchers working in this new up and coming research area.

BACKGROUND

Wireless Communications in Healthcare

The increasing number of intelligent and self-operating communication and computational devices has changed the concept and landscape of wireless networks. Home appliances, vehicles, small fixtures on buildings, and sensors connected to the network are making global connectivity a reality. This will provide flexibility, intelligence,

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