Chapter 4
Data Reduction Techniques for Near Real-Time Decision Making in Fall Prediction Systems

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ABSTRACT

Unintentional falls are a frequent cause of hospitalization that mostly increases health service costs due to injuries. Fall prediction systems strive to reduce injuries and provide fast help to the users. Typically, such systems collect data continuously at a high speed through a device directly attached to the user. Whereas such systems are implemented in devices with limited resources, data volume is significantly important. In this chapter, a real-time data analyzer and reducer is proposed in order to manage the data volume of fall prediction systems.

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1. INTRODUCTION

Hospitalized patients, people with movement-related disorders, and elderly people are high risk categories of encountering falls (Schwendimann, 2006) (Ambrose, 2013) (Canning, 2014). Currently, modern hospitals are well-equipped with monitoring and data collection devices to store and analyze patient data (Baig, 2013). Moreover, since fall is one of the negative consequences of some diseases such as Parkinson and rheumatism, which provoke disturbance in gait pattern, several gait assessment systems have been developed to measure or monitor gait parameters of patients. In addition, the risk of falling increases progressively with age, so several fall avoidance systems have been developed for elderly people in order to reduce fall injuries, in particular hip fracture.

Generally speaking, applicable fall avoidance systems can be categorized into three different types: detection, prediction, and prevention systems. Fall detection systems notify an acquaintance of the user in case of fall occurrence (Mubashir, 2013). These systems can be used to provide fast help after a fall, but they do not avoid it so, they are less effective than the other systems. Fall prediction systems strive to predict a fall before its occurrence (Staranowicz, 2013). Fall prevention systems provide solutions for preventing the fall (Majumder, 2013). Since predicting a fall is the most promising approach, the fall prediction algorithms are considered to be studied in this chapter. One category of fall prediction systems investigates balance and muscle strength through some offline tests such as Timed Up and Go (TUG), Berg Balance Scale (BBS), Sit To Stand (STS), and One Leg Stand (OLS) (Grant, 2014) (Vellas, 1997) (Muir, 2008) (Shumway-Cook, 2000). If the fall risk is high, a probable future fall can be prevented through some exercises. Typically, mentioned fall risk tests are applied by experts in clinical environments to evaluate balance and lower limb strength. The drawbacks of the mentioned tests are the demand of time and effort and they need to be conducted in a supervised environment. Therefore, they may suffer from influences such as the Hawthorne effect (McCarney, 2007), i.e., an individual modifies his/her behavior due to awareness of being observed. The other dominant category of fall prediction systems investigates real-time recognition of abnormal gait patterns to predict, or at least reduce, the injuries of a fall in real-time. Real-time fall solutions avoid a fall by alerting the user or using an external aid such as a walker or a robot (Di, 2011) (Hirata, 2006). Choosing between real-time or offline systems depends on the user circumstances. Generally speaking, if a user categorized in high risk of fall out of offline test, a real-time system can help to avoid a serious injury.

Most of the real-time fall prediction systems are based on kinematics and consider user's posture or gait variables. Kinematic-based solutions usually exploit movement sensors to investigate the parameters of a fall, i.e., the characteristics of the movement of the body. This chapter investigates real-time fall prediction systems exploiting accelerometer sensor. Real-time fall prediction systems usually have some steps in common: firstly, data are collected from sensors, and then they are analyzed to compute the appropriate feature set. Finally, the risk of a possible fall is evaluated through gait analysis techniques.

The quality of data must be guaranteed while acquiring and storing it rapidly. High-quality is a precondition attribute for analyzing and using data in order to guarantee a reliable result. The increase in data volume causes great difficulties for storage and analysis. Collected data during a walk has a quasi-periodic temporal dependence, so the time series is difficult to be modeled. Gait variables generally interact in a complex non-linear fashion, which requires high volume of data to be analyzed. Several gait models have been developed for the fall prediction systems in the literature. Most of the fall prediction systems achieve high accuracy by means of complex mathematics, which leads to high computational time. Since the data volume directly affects the performance, finding a technique with high accuracy