Chapter 48
The MobiFall Dataset:
Fall Detection and Classification with a Smartphone

George Vavoulas
Technological Educational Institute of Crete (TEIC), Biomedical Informatics and eHealth Laboratory (BMI Lab), Greece

Charikleia Chatzaki
TEIC- BMI Lab and Foundation for Research and Technology – Hellas, Computational Medicine Laboratory, Institute of Computer Science, Greece

Matthew Pediaditis
TEIC - BMI Lab and Foundation for Research and Technology – Hellas, Computational Medicine Laboratory, Institute of Computer Science, Greece

Emmanouil G. Spanakis
TEIC- BMI Lab and Foundation for Research and Technology – Hellas, Computational Medicine Laboratory, Institute of Computer Science, Greece

Manolis Tsiknakis
TEIC- BMI Lab and Foundation for Research and Technology – Hellas, Computational Medicine Laboratory, Institute of Computer Science, Greece

ABSTRACT

Fall detection is receiving significant attention in the field of preventive medicine, wellness management and assisted living, especially for the elderly. As a result, several fall detection systems are reported in the research literature or exist as commercial systems. Most of them use accelerometers and/ or gyroscopes attached on a person's body as the primary signal sources. These systems use either discrete sensors as part of a product designed specifically for this task or sensors that are embedded in mobile devices such as smartphones. The latter approach has the advantage of offering well tested and widely available communication services, e.g. for calling emergency when necessary. Nevertheless, automatic fall detection continues to present significant challenges, with the recognition of the type of fall being the most critical. The aim of this work is to introduce a human fall and activity dataset to be used in testing new detection methods, as well as performing objective comparisons between different reported algorithms for fall detection and activity recognition, based on inertial-sensor data from smartphones. The dataset contains signals recorded from the accelerometer and gyroscope sensors of a latest technology smartphone for four different types of falls and nine different activities of daily living. Utilizing this dataset, the results of an elaborate evaluation of machine learning-based fall detection and fall classification are presented and discussed in detail.

1. INTRODUCTION

A fall is defined as a sudden, uncontrolled and unintentional downward displacement of the body to the ground. It is evident that falls affect millions of people (especially the elderly) and may result in significant injuries (Kannus, Sievänen, Palvanen, Järvinen, & Parkkari, 2005). Moreover, injury is a leading cause of death among elderly people (Stevens, Corso, Finkelstein, & Miller, 2006). Automatic fall detection systems rely on a set of threshold values for predetermined parameters, as well as classification rules, in order to continuously process motion data, obtained from an accelerometer and/or a gyroscope, or other sensors, and to determine in near real-time if a fall event has occurred.

Automatic fall detection is one of the hottest topics in the field of preventive health care since the last decade. Numerous papers report approaches to automatic fall detection based on the analysis of images, video, audio, as well as inertial sensor data from sensors that are either discrete (stand-alone) or integrated inside a mobile phone (Abbate, Avvenuti, Bonatesta, Cola, Corsini, & Vecchio, 2012 ; Bagalà et al., 2012; Bourke, O'Brien, & Lyons, 2007; Fudickar, Karth, Mahr, & Schnor, 2012; Rougier, Meunier, St-Arnaud & Rousseau, 2011; Sposaro & Tyson, 2009; Vaidehi, Ganapathy, Mohan, Aldrin, & Nirmal, 2011; Zhang, Wang, Liu, & Hou, 2006).

The utilization of mobile phones or smartphones for the provision of pervasive health care services (Hristoskova, Sakkalis, Zacharioudakis, Tsiknakis, & De Turck, 2014) provides a cost-effective and powerful solution to the well-known issue of increasing health-care needs and costs due to the growing population of elderly (Spanakis, Lelis, Chiarugi, & Chronaki, 2005 ; Spanakis et al. 2012). Various such fall detection systems already exist (Table 1) and each one of these uses a specific phone with different embedded sensors. Moreover each method is evaluated within its own testing environment and with its own data. Thus it is very difficult, if not impossible, to compare different existing approaches on their validity and effectiveness.

The aim of this article is to introduce a dataset developed and used for testing new methods, as well as performing objective comparisons between different existing algorithms for fall detection, classification and even activity recognition, based on inertial-sensor data from smartphones. The dataset incorporates signals recorded from the accelerometer and gyroscope sensors for four different falls and nine different activities of daily living (ADLs). The dataset, called "MobiFall" can be downloaded from the website of the Biomedical Informatics and eHealth Laboratory at the Technological Educational Institute of Crete[1]. Following a recent evaluation of threshold-based fall detection algorithms (Vavoulas, Pediaditis, Spanakis & Tsiknakis, 2013), this dataset is being used here for an initial evaluation of a machine learning-based fall detection and classification method. Having a possible real-life application in mind, the main target is to try to achieve the best possible performance for fall detection and classification, with the least necessary amount of features.

The remaining of this article is structured as follows. Section 2 presents recent work related to fall detection and classification. The dataset and the conditions under which it was produced are described in Section 3. Section 4 describes the methods for the evaluation of a machine-learning fall detection and classification algorithm, while Section 5 presents the respective results. Finally a detailed assessment of the quality of dataset and a discussion of the results obtained is given in Section 6.

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