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ORIGINAL RESEARCH

Fall detection and human activity classification using wearable sensors and compressed sensing

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Abstract
The fall of elderly patients is still a critical medical issue since it can cause irreversible bone injuries due to the elderly bones weakness. To mitigate the likelihood of the occurrence of a fall, continuously tracking the patients with balance and health issues has been envisaged, despite being unpractical. To address this problem, we propose an efficient automatic fall detection system which is also fitted for the detection of different activities of daily living (ADL). The system relies on a wearable Shimmer device, to transmit some inertial signals via a wireless connection to a computer. Aiming at reducing the size of the transmitted data and minimizing the energy consumption, a compressive sensing (CS) method is applied. In this perspective, we started by creating our dataset from 17 subjects performing a set of movements, then three distinct systems were investigated: one which detects the presence or the absence of the fall, a second which detects static or dynamic movements including the fall, and a third which recognizes the fall and six other ADL activities. In the acquisition and classification steps, first only the data collected by the accelerometer are exploited, then a mixture of the accelerometer and gyroscope measurements are taken into consideration. The two configurations are compared and the resulting system incorporating CS capabilities is shown to achieve up to 99.8% of accuracy.

Keywords Fall detection · Human activity · Wearable sensors · Compressed sensing · Classification

1 Introduction

One of the major problems the current societies have to face, is the aging and the lack of physical activity of their population. These two factors (age and non activity) are behind disastrous fall accidents, which take place indoors or outdoors. Various statistical studies stated that falls are the principal cause of hospitalizations for injuries (Sherrington Catherine 2017), and recent reports show that 30% of people, at the age of 65 or over, have the highest risk of falling (Lusardi 2017). This has led to an increased number of interventions for securing or aiding this category of population. To consolidate these efforts, research interest has also been oriented towards the investigation of technical solutions to rescue/save people's life. Under this umbrella, the development of technology and the miniaturization of electronic devices which can collect health data, have enabled the design/deployment of applications, such as fall detection or health monitoring (Sheltami et al 2016; Vallabh and Malekian 2018). A fall detection system, for instance, allows to prevent the elderly subjects fractures, and sends an alarm to the nearby hospital, thereby allowing timely intervention, to provide a first aid to the patient. Moreover, the system may collect the per day activity of the patients in order to monitor their health's state and progress.

Several approaches have been proposed to identify fall and ADL activities using a multitude of sensors and approaches (Casilari et al 2017; Micucci et al 2017). Li et al (2009) utilized a sample thresholding method between an accelerometer and a gyroscope to detect the fall. Similarly, Lee and Carlisle (2011) applied a two thresholding method to analyze the data acquired from a smartphone and an accelerometers, in order to identify the movements and the different simulated falls. The technique of thresholding has some

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