Chapter 6
Multi-Feature Fusion and Machine Learning:
A Model for Early Detection of Freezing of Gait Events in Patients With Parkinson's Disease

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ABSTRACT

Freezing of gait (FoG) is a common symptom of Parkinson's disease (PD) that causes intermittent absence of forward progression of patient's feet while walking. Accordingly, FoG momentary episodes are always accompanied with falls. This chapter presents a novel multi-feature fusion model for early detection of FoG episodes in patients with PD. In this chapter, two feature engineering schemes are investigated, namely time-domain hand-crafted feature engineering and convolutional neural network (CNN)-based spectrogram feature learning. Data of tri-axial accelerometer sensors for patients with PD is utilized to characterize the performance of the proposed model through several experiments with various machine learning (ML) algorithms. Obtained experimental results showed that the multi-feature fusion approach has outperformed typical single feature sets. Conclusively, the significance of this chapter is to highlight the impact of using feature fusion of multi-feature sets through investigating the performance of a FoG episodes early detection model.

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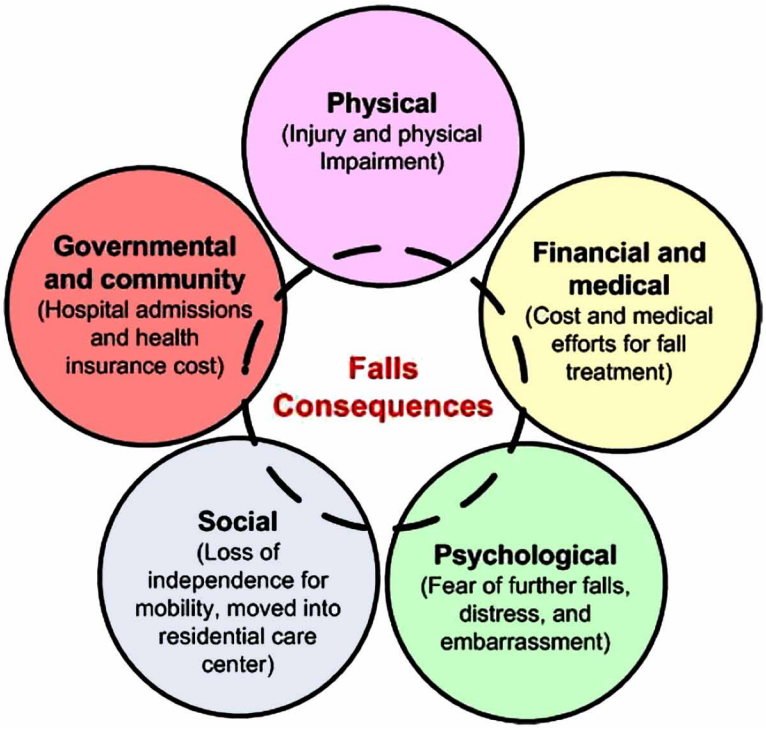
Figure 1. The main consequences related to elderly falling



BACKGROUND

Parkinson's Disease (PD) is a degenerative disorder, which affects patient's movements. It is marked by decreased dopamine levels in the brain and considered as the second most common symptom after Alzheimer's Disease (AD). A lack of dopamine, which results in abnormal nerve functioning, causes a loss in the ability to control body movements. The PD has influenced about 1% or 2% of elderly people worldwide (Nilashi, 2016). This study aimed to detect Freezing of Gait (FoG) attacks in patients with PD, using different features and classifiers, for increasing the detection performance and decreasing the social costs that face the patients with PD symptoms. The PD patients usually spend almost two more days in hospitals, 43 more days in care institutions, and fill more than 20 medical therapies than the non-PD subjects do. The total cost for PD patients is more than a double of the non-PD subjects. On the other hand, the productivity loss recorded for PD patients reaches 49.4% (Dua et al., 2006). Furthermore, as shown in Figure 1, among several consequences related to elderly falling, the loss of independence risk represents a significant social consequence. That is, the PD patient will constantly be dependent on one of the family members or a medical center caregiver (El-Bendary et al., 2013). According to the World Health Organization (WHO), the percentage of Global Disability Adjusted Life Years (DALYs) by 2030 will increase by 0.13% for patients with PD, coming after the percentage of Alzheimer's Disease that has been predicted to increase by 1.2%. Also, the deaths for PD patients will reach 23% by 2030 as the total deaths globally for neurological disorders will reach 12.22% (Dua et al., 2006).

Parkinson's Disease contains two types of symptoms that affect the quality of daily life; namely, motor and non-motor symptoms. Motor symptoms or cardinal symptoms contain resting tremor, rigidity,