

Deep Learning enabled Fall Detection exploiting Gait Analysis

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Abstract—Falls associated injuries often result not only increasing the medical-, social- and care-cost but also loss of mobility, impair chronic health and even potential risk of fatality. Because of elderly population growth, it is one of the major global public health problems. To address such issue, we present a Deep Learning enabled Fall Detection (DLFD) method exploiting Gait Analysis. More in details, firstly, we propose a framework for fall detection system. Secondly, we discussed the proposed DLFD method which exploits fall and non-fall RGB video to extract gait features using MediaPipe framework, applies normalization algorithm and classifies using bi-directional Long Short-Term Memory (bi-LSTM) model. Finally, the model is tested on collected three public datasets of 434x2 videos (more than 1 million frames) which consists of different activities and varieties of falls. The experimental results show that the model can achieve the accuracy of 96.35% and reveals the effectiveness of the proposal. This could play a significant role to alleviate falls problem by immediate alerting to emergency and relevant teams for taking necessary actions. This will speed up the assistance proceedings, reduce the risk of prolonged injury and save lives.

Keywords— Deep Learning, Gait Analysis, Elderly Fall, LSTM, Pose Estimation.

I. INTRODUCTION

Elderly falls is a major global concern all over the world. Recent WHO report [1] shows that each year an estimated of 684000 individuals die from falls globally and 37.3 million falls that are severe enough to require medical attention. About \$50 billion is spent on medical costs related to non-fatal fall injuries and \$754 million is spent related to fatal falls each year in United States [2] and projected of falls associated cost of \$100 billion by 2030 [3]. These falls are multi-factorial problem associated with intrinsic mental or physical health, environment, and aging problem which result in different severe injuries, functional disorder, short/long-term care, disability and even can lead to death. Earlier responses of the elderly's falls help to lower injury and death rate as well as reduce associated care and treatment costs which result decrease the serious consequences. Fall detection is an effective protection strategy to automatically detect the occurrence of falls and takes timely interventions (e.g. send notification to caregivers, generate alarm to rescue team and inform

relatives). An automatic fall detection system is important that will create comfort living and ensure better healthcare for elderly people.

In recent years, numerous solutions for fall detection have been presented in literature review [4] which can be broadly categorised into three groups: wearable sensors [5], ambient sensors [6] and vision based sensors [4]. Wearable sensor-based fall detection technologies are growing fast where they use inertial sensors such as accelerometer, gyroscope, magnetometer, inertial measurement units (IMU), barometric altimeter, and pressure sensors [7]. Although, wearable sensors-based approaches have achieved high performances for detecting falls, they must be worn all day which is uncomfortable for elderly people, and they sometime forget to wear it, not practical for older adults. In ambient fall detection systems, electronic devices are installed in the living environment, digitally enriched with sensors, processing and communication technologies in order to analyse fall associated movement of the person [8]. However, the installation cost of these environmental based sensors is relatively high which is limited by the detective range. From intensive investigations of contemporary methods, most of the recent research on fall detection is focused on the use of vision-based methods for developing robust fall detection system. Cameras are almost everywhere nowadays either in terms of smartphones, installed surveillance cameras, security IP cameras or others. Vision based classic machine learning techniques such as support vector machine (SVM), decision threshold tree, Naive Bayes, least squares method (LSM), k-Nearest Neighbor (k-NN), and artificial neural networks (ANNs) and other machine learning algorithms are used for fall detection [9] with higher detection accuracy. These algorithms use lengthy process of handcraft features extraction which is cumbersome. It also requires a lot of prior knowledge and meanwhile the computation is large. Therefore, researchers started to develop deep-learning-based models few years ago that quickly turned into the dominant approach in the field of vision-based fall detection.

In this paper, we present a Deep Learning enabled Fall Detection (DLFD) method exploiting Gait Analysis framework that shows comprehensive solution for addressing the fall issue mentioned above. More in details, we select 12 body key-points that represent human upper and lower limbs gait information. The gait key-points are detecting using MediaPipe [10] from videos. A bi-LSTM model is developed for classifying fall and no-fall. Three publicly available