Automatic fall risk assessment for challenged users obtained from a rollator equipped with force sensors and a RGB-D camera (IEEE Int. Conf. On Intelligent Robots and Systems (IROS) 2018)

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**Extended abstract**:

Population is steadily aging, leading to an increasing number of elderly people with disabilities. Many of these persons use assistive devices in their every day life. Rollators and walkers are among the most usual devices for mobility assistance. However, falls are one of the most important problems in rollator users. Only in community-dwelling elderly, people fall at least once per year. Furthermore, more than 50% of all unintentional injury deaths in elderly people were produced by falls. Even non-fatal fall related injuries lead to hospitalizations, emergency department visits and the treatment in outpatient settings  involving important personal and economical cost.

A fall can be produced by a variety of factors. A high percentage of these factors are related to intrinsic body capabilities and/or to changes in the environments. Specifically, gait and balance disorder or weakness provoke a 17% of falls in the elderly. On the other hand, changes in the environment account for 31% of falls in the elderly due to trips or slips. Fall risk detection in elderly population may reduce mortality and also, injury related personal and economical costs.

There are two different approaches to fall risk detection: manual and automatic assessment. Manual assessment is performed via supervised medical tests. In these tests, a nurse or therapist evaluates different tasks solved by the evaluated person. For example, the well know Tinetti Mobility Test evaluates a person's gait and balance in 17 different tasks (e.g. step symmetry, step continuity, rises from chair, etc). Manual assessments have some drawbacks. First, they require supervision by clinicians; hence, they are only obtained punctually and in controlled situations rather than in everyday life. Besides, they only provide general, conditionrelated information regarding fall risk, so fall risks provoked by changes in the environments can not be detected.

Automatic assessment approaches rely on information gathered from user-centred sensors to automatically evaluate fall risk. These methods may provide continuous feedback and, hence, they may provide information about imminent falls related to changes in the environments. Automatic fall risk detection methods may be loosely split into three categories depending on the sensors type, namely wearable sensors, ambient sensors and onboard sensors. Wearable sensors based approaches rely on placing embedded sensors in specific limbs, joints or body parts,. Ambient sensors based approaches rely on distributing sensors' in the environment to capture the person's activity or posture and, hence, their use is constrained to specific locations. Alternatively, if a person relies on an assistive device, sensors can be placed onboard,. Each approach has advantages and drawbacks.

The most common approach to measure fall risk is to analyze the value and/or variation of one or several spatiotemporal gait parameters, e.g. walking speed or the stride-to-stride 1 variability. Also, a person's posture can be used as fall risk estimator too. For example, in posture is used to calculate the person's gravity center and his/her base of support. This method detects fall risk when a person's gravity center is outside of his/her base of support. Other approaches rely on generating user models to detect anomalies, assuming that unusual postures/positions could be provoked by

environmental hazards situations or by balance disorders. Both these causes are strongly related with fall risk. In these approaches, fall risk is not binary, but measured as the difference between the person’s model and the actual person’s position.

The spatiotemporal gait parameters approach can be implemented on a rollator using wheel encoders and force sensors in its handlebars. However, it has been reported that these parameters are not fully reliable to assess fall risk if they are used alone because the fear to fall can alter the values of gait parameters. For example, in order to increase their stability, some users reduce their speed,. Alternatively, user’s posture can be estimated using range sensors in the rollator. However, their readings depend on the users’ clothing rather than on their body alone, plus they do not take into account weight bearing on the device for balance estimation. Other approaches extract a user model from feet position with respect to the rollator. In these methods, it is necessary to model each user first to obtain his/her personal model. Also, they do not take into account weight bearing on the rollator either, e.g, similar feet positions would return similar fall risk, despite how much weight the rollator is supporting. In this work, we propose to combine this model based approach with force sensors on the rollator handlebars to overcome the commented drawback.

The purpose of this work is, consequently, a novel approach to automatically estimate the imminent fall risk in rollator users using on board sensors. For validation, we suppose that users with a high global fall risk will have a higher imminent fall in average than users with a low global fall risk. Hence, we will correlate the obtained imminent fall risk values with the well know Tinetti Mobility Test and also with walking velocities, which are traditional global fall risk estimators. The main contributions of this work are: i) a normalized model of a well balanced rollator user using both feet position and weight support; and ii) an automatic estimator of imminent fall risk in rollator users. The methodology will be validated with 10 challenged volunteers presenting a variety o physical and/or neurological disabilities. Even though this is a preliminary work with a reduced number of volunteers, results show that fall estimation works correctly when compared with traditional estimators.