# Determination of the characteristic features of elderly gait for optimal posture recovery using robotic assistive devices

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### **1** Introduction

It is predicted that in the near future the age of the population will increase, leading to a larger number of people with mobility disabilities [1] [2] [3]. Different types of mobility aids, such as canes or walkers, are widely used, but their functionalities are limited and cannot fully replace the support given by a human carer. On the other hand, there aren't enough professionals to take care of all elderly people, providing physical support may cause injuries to the carer, and having to depend on another person reduces the independence of the patients. For these reasons, the development of robotic mobility aids capable of providing cognitive and adaptive physical support is now a very active research field [4] [5] [6].

The MOBOT project aims at developing a robotic rollator with an actuated mobile base and handles, used to provide support during sit-to-stand transfers and aid in posture control while standing and walking (Figure 1). Various sensors, including two Kinect cameras, laser depth sensors, and force / torque sensors in the handles, are used to detect the state of the user and adapt the behavior of the device online.



Figure 1: A picture of motion capture recordings recordings featuring a MOBOT rollator prototype.

### 2 Methods

To provide online support two approaches are proposed. The first one consists in computing many control strategies offline and switching between them based on the feedback from the rollator sensors. The second approach is to use online control techniques, such as nonlinear model predictive control, that can predict the future dynamics of the system based on the current measurement of its state and immediately compute an optimal control strategy.

In any case, it is first necessary to have a good understanding of the characteristic features of elderly gait, either to formulate an objective function that can generate it with good approximation, or to develop a classifier that can determine the level of disability of the user and select the most appropriate strategy to support him.

Fifteen elderly people with mobility issues were recorded with motion capture and standard cameras. A group of twenty non-specialist was asked to rate the performance of each subject after watching short parts of the standard videos. The presence of a correlation between several gait features and the rating was investigated by computing the spearman correlation coefficient (see Figure 2). The features include frontal and lateral trunk leaning angle, lateral displacement of the pelvis, maximum heel height, gait velocity, single support to double support time ratio, and step length, width and frequency. The features with a good correlation can be potentially used in the future for the classification of elderly gait.

Additionally, full-body geriatric walking motions were generated by using optimal control techniques. The employed objective function includes the features that are hypothesized to be characterizing elderly gait (see for example the sequence in Figure 3). These features include the aforementioned ones, as well as other ones such as the minimization of joint velocities, of absolute work, and of the distance between the ground reaction force insertion point and the projection of the ankles on the ground. The qualitative observation of the results obtained until now has provided an indication about which of these objective function terms are adequate to generate geriatric-like walking motions.

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**Figure 2:** Values of the Spearman correlation coefficient for the studied gait features. For most features both the mean value and the standard deviation (std) were considered.



Figure 3: Walking sequence generated by minimizing single and double support time ratio.

## 3 Future work and open questions

Future work directions that can benefit from the current results include:

- Training classifiers to determine the fitness of the subject online and adjust the behavior of the mobility aid accordingly.
- Fitting the rigid body model of the human to the motion capture experiments, in order to investigate the values of the the potential objective function terms and to have an idea on how to formulate a mixed objective function capable of generating realistic geriatric walking motions.
- Using such objective function to generate optimal motions to be implemented in the rollator and to develop predictive online optimal controllers with the aim of providing optimal balance support.

There are also several open questions to be discussed:

- Are there other possible objective function terms to generate geriatric like motions?
- Can some of these terms be related to specific pathologies?
- To what extent is it really possible to generalize the characterization of geriatric walking, given that usually it is determined by several different pathologies with different impact on the walking performance?
- With what reliability is it possible to use optimal control to predict the future motion of the user and react in real-time to dangerous situations, such as a fall?

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