Estimation of Human Characteristics for Controlling a Robotic Walking Aid

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論文内容要約

The current increase of longevity in Europe and other developed countries results in the fast growing population of the senior citizens. Older adults, people aged 65 or older represented 11% of the world population in 2009, and the percentage is expected to double by 2050. Fine motor skills, balance, and strength are among the abilities that decline with age. These age-related declines in physical abilities may negatively impact the elderly person's ability to maintain their independence in their home environment. Therefore, they need nursing support to perform their daily activities.

With the rise of the senior citizens' ratio in the populations, assistance robots can play an important role to reduce the workload of nurseries and increase the independence of elderly or people with disordered mobility to perform their daily activities with little help from people around them.

On the other hand, there are several public services that work to increase the accessibility of healthy users in the environment. Providing similar systems for physically impaired people can increase their mobility. But as of today, no such system exists. One of the main reasons for this absence is the fact that assistance devices are personalized and adapted and adjusted to each user's physical characteristics and ability. To propose a public assistance system for people with physical impairments, we need to be able to adjust and adapt them easily to each user. Since most of the users of this system are people with lack of strength and mobility, the process of the adjustment of the assistive devices needs to involve the users the least possible. For that, we firstly need to be able to detect and estimate the information needed for the most accurate possible adjustment and in an automatic way.

In this thesis, we contribute to resolving the problem of accessibility of public spaces for persons with reduced mobility. We specify an assistance system based on the cooperation of distributed robotic modules in the environment. The assistance is based on a set of collaborative assistance modules. This approach is called Ambient Assistance. It is part of the research project AccesSim, which focuses on the diagnosis of

indoor and outdoor accessibility. It is characterized by adaptation to users' needs according to their physical abilities, their profile and their situation. This analysis must be done in real time, to detect the current situation and the intention of the person. It also relies on collaboration between the modules assistance and the environment.

In Chapter 2, we present a generic architecture of an ambient assistance multi-agent system to address the mobility needs of people with impairments in a public indoor space. Our proposed system is modular and expandable. This concept will be applied to public and private buildings like health centers, hospitals, theaters, train stations, etc.

To make assistive devices usable by several users, we first need to adjust each of the assistive equipment to the proper and comfortable position of each of the human users.

In Chapter 3, we provide a method for estimating the parameters of disabled people before they use the assistive devices. We focus on the observation and estimation of the approximate human morphology remotely and without any physical contact between the users and the assistance modules. This measurement will be used to adjust the assistive devices appropriately for each user.

Among different human characteristics, height and weight are identified as the two important factors to provide adapted assistance and ensure comfort and security of the user. Body segment lengths can be calculated according to the height and can be used as the reference to adjust different parts of the assistance devices. Weight, on the other hand, is an indicator of the amount of force the assistive device needs to be able to support. It can also be combined with the height and human linkage data for creating the human model and the dynamic control of the equipment.

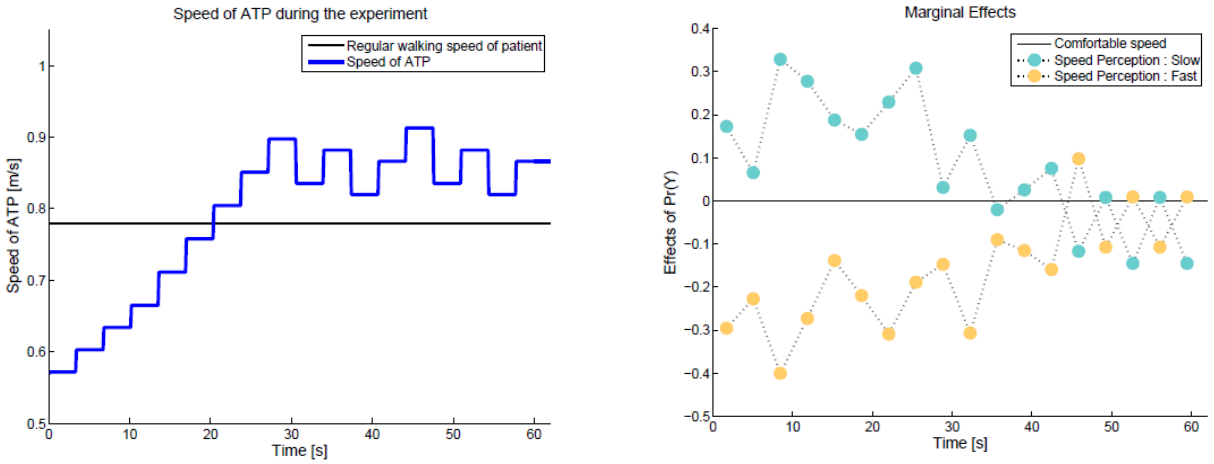
We use the Kinect for the measurements. Although there are several advantages in using Kinect, including its low price, its drawback is the low level of accuracy. Therefore, one of the objectives of this chapter is to increase the accuracy of remotely measured human data by Kinect. We improve the accuracy of the measurement by applying an adapted filtering process and a linear regression method. The result of the height measurement is accurate enough for the adjustment of different parts of the assistance equipments, including the height of the handles' of walkers and the height of seats in wheelchairs. The result of the work contributes in improving the accuracy of the human measurements done by Kinect.

In Chapter 4, we focus on adaptation and adjustment of speed of an ambulation assistance device with a non-invasive generic and low cost sensory system. We propose an ambulation test platform (ATP) as an assistance device demonstrator of the ambient assistance system that was proposed in Chapter 2. Selection of the ambulation assistance is based on the fact that walking is reported as the most important form of

physical activity to improve public health.

To derive the variable indicators for speed adjustment, we have conducted several experiments with physically impaired and healthy subjects. We apply Multinomial Logit Model (MNL) to the collected data to study the relevant indicators to identify the comfort speed of users. Based on the experiments results with the physically impaired patients, we observe that using our test platform can increase the average walking speed up to 30%.

In Chapter 5, we demonstrate the performance of our proposed method in real time. We are able to adjust the speed of an ambulation test platform to the comfortable speed of a hemiplegic patient. As shown in Figure 1, it took about 30 seconds to detect the patient's comfortable walking seed with ATP which was 10% faster than his natural walking speed. To ensure the safety and use the maximum physical capacity of users, we selected a set of indicators to estimate the perception of users regarding their walking speed in real time. These indicators could be used to adjust the speed of any type of intelligent, active, and passive walkers - to the comfort walking speed of the users.



(a) Speed of ATP during the experiment

(b) Estimation of speed perception

Figure 1. Speed adjustment of ATP – Experiment with a hemiplegic patient

Finally, chapter 6 concludes this dissertation.

All the contributions of this thesis are validated through experimental results with persons with reduced mobility.