Exoskeletons supporting postural balance – the BALANCE project*

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INTRODUCTION

Lower extremity exoskeletons have become an established technology. Nowadays they can be bought from different companies around the world, such as the autonomous exoskeletons eLegs from Eksobionics (eksobionics.com), HAL from Cyberdyne Inc. (www.cyberdyne.jp) and Indego from Parker (indigo.parker.com), or treadmill based exoskeleton systems such as the Lokomat from Hocoma (www.hocoma.com). The features and pricing of these devices are such that they are mostly only suitable for providing gait training in clinical rehabilitation.

In the future, applications of leg exoskeletons are foreseen as assistive device in the all-day living environment or as support for workers or soldiers that perform strenuous tasks. For such applications a number of issues have to be resolved for exoskeletons to become feasible. Important issues being: cost, range of use (battery life, energy use), size/bulkiness, human-cooperative control, meaning the ability to function efficiently together with a (partially) functional person, and finally safety, mainly in the sense of avoiding falls [1, 2].

In all current exoskeletons the devices provide or support the essential movements of the stance and swing leg that contribute to progression of the body during walking, but they do not provide or support the adequate behavior of the legs as is needed to maintain postural stability. This means that such exoskeletons can only be used safely by healthy users that can take care of maintaining their postural balance themselves, or they have to be used in combination with crutches, walkers, or overhead supports in cases where the user is not able to maintain his/her postural balance.

The EU FP7 project BALANCE (www.balance-fp7.eu) aims at supporting the function of maintaining postural balance directly through the leg exoskeleton, in such a way that the exoskeleton cooperates with its user in a natural way. In the project the acronym BALANCE stands for **B**alance **A**ugmentation in **L**ocomotion, through **A**nticipative, **N**atural and **C**ooperative control of **E**xoskeletons.

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CHALLENGES IN BALANCE

On the road to realizing active support of postural balance as integrated exoskeleton function lie many challenges. The main challenges addressed in the BALANCE project are:

- Obtain a proper understanding of how humans realize a robust postural balance control during functional standing and functional walking, both to improve understanding of the principles of human postural balance control and in order to be able to have an exoskeleton cooperate with a human on the task
- Develop controller algorithms that robustly implement postural stability supporting strategies.
- Realize a sense of balance that allows to assess the postural balance during functional standing and walking, and allows to trigger proper (re-)actions
- Develop strategies for human-cooperative robot control, as in the typical situation the user will have remaining or full functionality and needs to cooperate with the robot
- Create an exoskeleton that has adequate features in order to be able to demonstrate the postural stability support.
- Develop strategies to evaluate the performance of the exoskeleton on these tasks, including evaluation scenarios and adequate safety measures.
- The term ‘functional walking’ is used to distinguish walking as it takes place in real life, from ‘walking’, taken as ‘constant-speed straight walking on flat ground’. Functional walking includes many additional gait tasks, such as gait initiation and termination, turning, avoiding obstacles, stepping up or down height differences, and dual tasks, - for example walking while lifting an object and so on.

As BALANCE does not especially consider the functions that relate to human anticipative control (understanding the environment, prior knowledge about human intentions) and the hardware will miss some subtle human degrees of freedom, for example secondary pelvic rotations, the project will also yield information on what can be achieved within such limitations and what not. In the first year of the project, these challenges have all been initially addressed in parallel.

REFERENCES

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