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Evidence-based biomechanical optimization of assistive devices (exoskeletons, prostheses etc.)

Victoris, a consortium of research laboratories of Ghent University with expertise in biomechanics, physiology and engineering is seeking partnerships with developers of assistive devices for walking or running interested in:

1. **Identification of optimal actuation pattern for their device based on the Ghent University exoskeleton parameter sweep database.**
2. **Fine-tuning of assistive device actuation settings via the Ghent University optimization protocol.**

Introduction

The market of robotic assistive devices for walking is forming steadily as in 2009 and 2012 respectively the first robotic exoskeleton and powered prosthesis were commercialized.
Up till now, labs that design robotic assistive devices based their controls on literature data of normal walking biomechanics. However, we know by now that the biomechanics of robot-assisted walking are very different from normal walking. In addition, by choosing to simply imitate biological walking they inevitably also impose the imperfections of the human locomotor system. Therefore, this traditional approach is less likely to result in human augmentation beyond biological limitations.

Technology

Researchers at Ghent University have developed a new optimization method which consists of parameter sweeps of multiple device parameters while measuring metabolic energy cost and walking biomechanics. For this research, a pneumatically powered exoskeleton was used that is tethered to a control unit such that actuation parameters instantaneously monitored and tuned.
This approach was highly successful as in 2013 our experimentally optimized exoskeleton was the first ever worldwide to be able to reduce the metabolic cost 6% below the cost of walking with normal shoes. In other words, this means that walking with the Ghent University exoskeleton required less effort than walking with normal shoes.

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Applications

The expertise from Ghent University can be used for two applications:

1. **Identification of optimal actuation pattern based on Ghent University exoskeleton parameter sweep database**

We can suggest the best actuation pattern for any desired optimization criterion (e.g. metabolic cost, reduction of stress in a specific joint, …) based on our existing database. For those who already developed some actuated exoskeleton, we can see where its actuation pattern is situated and recommend technical adjustments.

2. **Fine-tuning of assistive device actuation settings via Ghent University optimization protocol**

When an existing walking assistive device has been developed, we are able to conduct a parameter sweep with the desired test population at our gait lab. This can be done for robotic exoskeletons for walking, running prosthesis, etc. Based on our expertise of assisted-gait biomechanics we can preselect a fine range in which parameters need to be varied. Our gait lab is state-of-the-art with metabolic measurement equipment, motion capture cameras, split-belt force treadmill and a 30m runway with embedded force plates.

Advantages

With our methodology we have obtained the following advantages so far:

- Reduced metabolic cost by -6 % compared to walking with normal shoes.
- Expected increase in walking velocity by 4% at same level of effort.
- Less electric energy (e.g. from battery) required for same walking distance.
- Enhanced maximum performance by + 8% compared to biological limit.

Status of development

We have recently conducted a more advanced parameter sweep where we obtained a 9% reduction. We estimate that in the next two years reductions around 20% will be realistic with planned hardware improvements.

Partnership

For application (1) we ask the partner to provide information about which actuation parameters will be used to control their device and the desired outcome variable. If our partner already has a working device, we will ask the parameter values in order to evaluate where it is situated compared to our database.
For application (2) we ask the partner to provide a fully-functioning assistive device with tunable actuation settings. If technological improvements need to be made, we will involve our engineering partners into the project.

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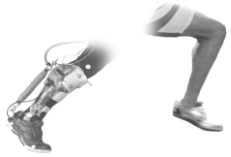

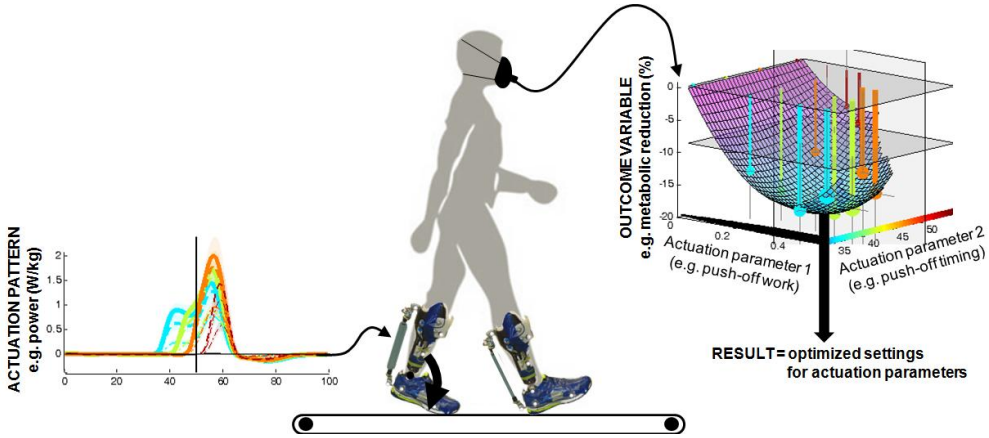

Figure

Overview of the parameter sweep methodology which allows to identify optimized actuation parameters based on human biomechanics experiments.

The Inventor

dr. Philippe Malcolm. YIA award at International Society of Biomechanics, 2007

Reference

Malcolm P, Derave W, Galle S, De Clercq D (2013) A Simple Exoskeleton That Assists Plantarflexion Can Reduce the Metabolic Cost of Human Walking. PLoS ONE 8(2): e56137.

(More than 15 citations and 5000 views in less than 2 years. Optimal timing and parameter sweep methodology has been applied since the publication by other labs including labs from MIT, Harvard, Carnegie Mellon and TuDelft.)

Keywords

Biorobotics, biomechanics, exoskeleton, mobility, neuromechanics, prosthesis, rehabilitation, walking.

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