

Research Proposal

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1 Introduction

- General Area to be studied
 - Personalization of Prosthesis / Orthoses / Exoskeleton design [1]
- Why this area is important
 - many people suffer from locomotor defects, thus significantly modify the biomechanics and muscle activity of joints (e.g. asymmetrical gait patterns) [2]
 - correct locomotion (e.g. gaits) defect for disabilities [3]
 - reduce energy cost for long-distance locomotion [4]

2 Research Questions

- what is already known in the field (with several critical studies)?
 - common design goals for prostheses exoskeletons
 - * light-weight [5]
 - * high energy density and efficiency [6]
 - Therefore: 2 approaches to design prostheses / exoskeletons
 - * tethered [7]
 - * autonomous [8]
- Why these studies are not sufficient, thus requiring my further research?
 - both design are trade-offs: tethered exo has a smaller added mass penalty [9], while autonomous exo is easier to generate light-weight features [6].
 - The ultimate goal of prostheses / exoskeleton design is to be generalized in design and personalized in user experience.
- **Key Research Questions, and Relevant Rationale**
 - how to weigh the benefits of drawbacks of different prostheses / exoskeleton design for personalization?

3 Plans and Methods

- Biomechanics: multiple ways to evaluate metabolic cost, by **Sensor Fusion** (respirometry, electromyography (EMG))
 - Lead to: mixed control strategy (data driven + classical control)
 - benefit: better understanding of mechanics (mid-level control side), contributes to the high level control (e.g. locomotion modes, various walking speed), make it more adaptable to dynamic movement.
- Mechatronics (wearable robotics) design: variable stiffness and impedance (interchangeable components [5], compact energy storage devices [6], impedance control [10]).
 - Goal: provide net energy gain for the user, thus reducing the metabolic cost of locomotion
 - Components should be adjustable (e.g. series spring), while maintaining control bandwidth [11]

4 Significance

- personalized in **assistance**
- personalized in **rehabilitation**

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