Using Template Models to Identify Exoskeleton User Intent

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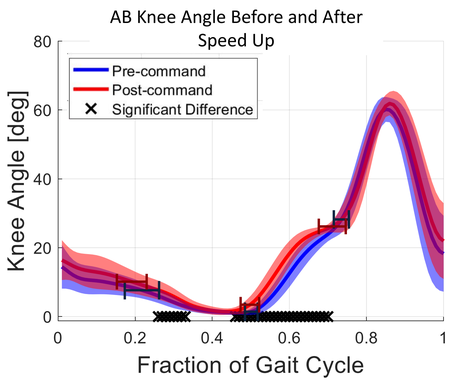
Motivation: Increase human-machine interface fluency of lower-body exoskeletons used to restore mobility after neuro-muscular injury

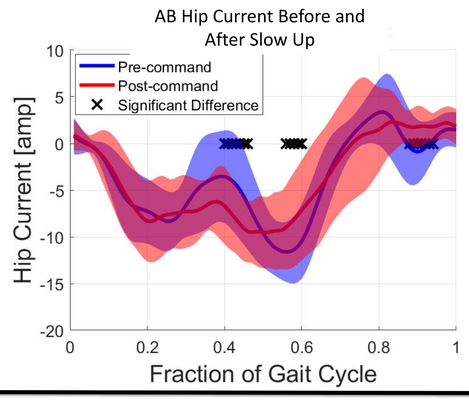
Introduction

- Identify when user wishes to **speed up** or **slow down** using only sensors already **onboard** exoskeleton (motor encoders & current commands)
- Develop intent recognition strategy for able-bodied **(AB)** & non-able-bodied **(NAB)** individuals with chronic spinal cord injury (SCI)

Human Subject Study

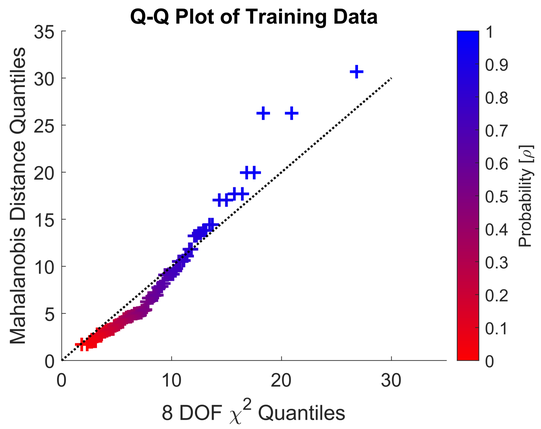


- Onboard sensor responses to intended gait speed changes for 3 AB subjects
- Speed up/slow down increased/decreased joint range of motion

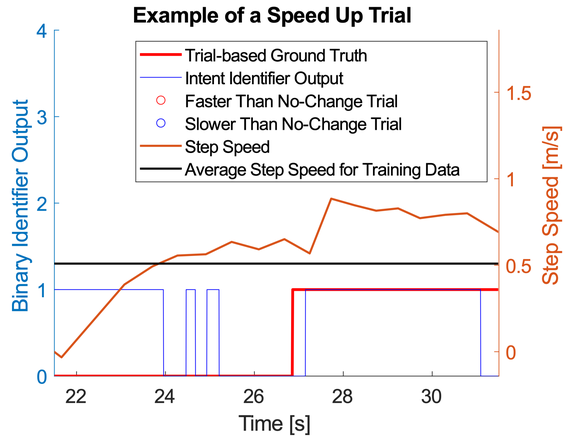


- Statistically significant differences localized around gait events
- Both time-scaling & trajectory shape of sensor measures affected by intent change

Data-driven Intent Identification

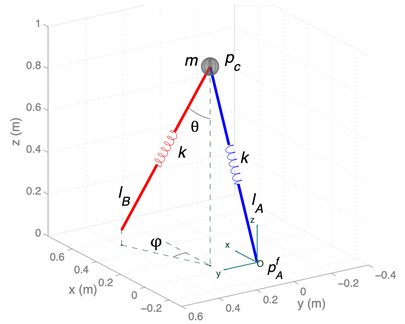


- Multivariate **Gaussian model** of 'constant intent' walking built from onboard sensor data (2 sensors x 2 joints x 2 legs)
- **Mahalanobis distance** quantifies likelihood that new data belongs to constant intent model

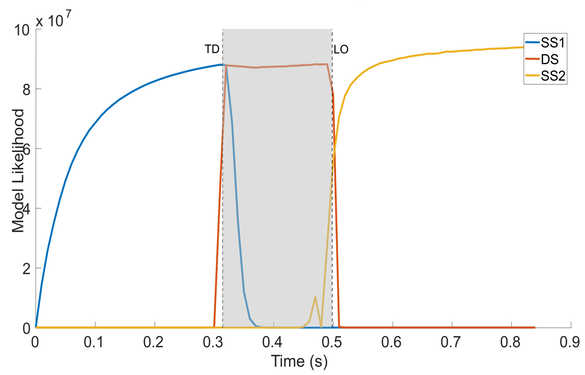


Model-based Intent Identification

- **Interactive Multi-Model (IMM) Filtering** matches user gait to pre-existing 3D-SLIP model gait in library spanning **0.4-1 m/s**
- Bank of **parallel Kalman filters** generate estimates fused using likelihood-based weighted average



- IMM varies likelihoods as gait progresses
- Likelihoods transition between single & double support (shaded)



Next Steps

- Test data-driven & model-based algorithms in **real time**
- Determine **device reaction** once intent determined
- Assess **user comfort** & algorithm sensitivity/accuracy

Broader Impacts: Intent identification methods viable for individuals with incomplete SCI & amputees with active prostheses
Greater control & maneuverability facilitate exoskeleton adoption outside of clinical setting

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