Using Template Models to Identify Exoskeleton User Intent

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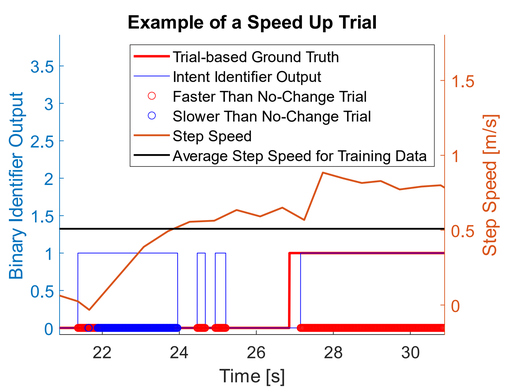
Introduction

- **Motivation:** Increase human-machine interface fluency of lower-body exoskeletons used to restore mobility after neuro-muscular injury
- 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)** individuals & non-able-bodied **(NAB)** individuals with chronic spinal cord injury (SCI)

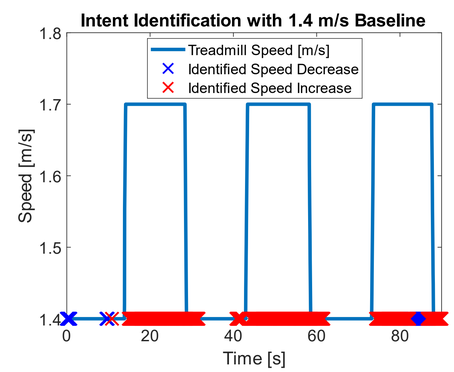
Data-driven Intent Identification

- Multivariate **Gaussian model** of 'constant intent' walking built from onboard sensor data
- **Mahalanobis distance** captures likelihood of new data belonging to constant intent model
- Success shown for simulated real-time **exoskeleton data**



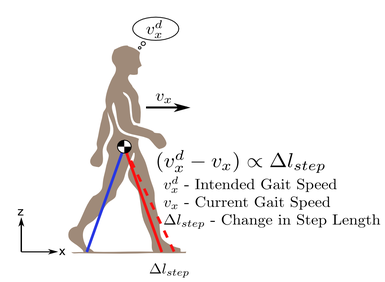
Real-time Human Experiments

- **Xsens** inertial motion capture suit acting as stand-in for exoskeleton
- **Intent identifier** monitors joint angles, indicates user intention to change speeds when walking on a treadmill



Footstep-based Intent Identification

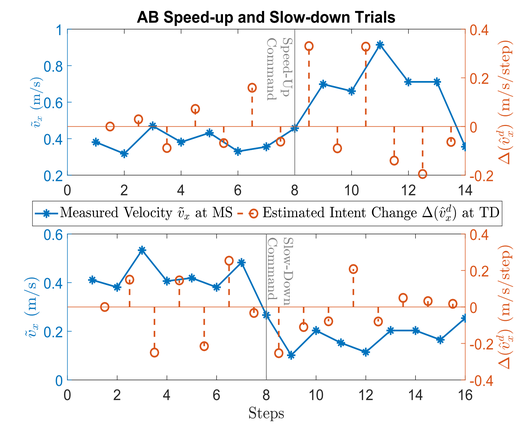
- **Two-stage estimator** leverages changes in foot placement to infer intended gait speed
- **First stage:** Bayesian update uses a data-driven footstep placement model to update estimate at touchdown (TD)

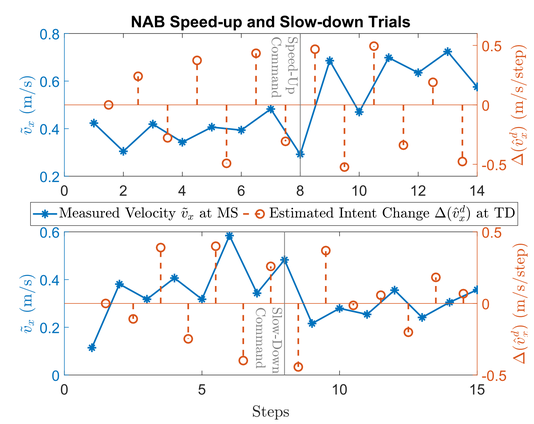


- **Second stage:** Kalman filter updates at midstance (MS)
- Estimator termed a **Buttressed Kalman Filter (BKF)** as the Bayesian update reinforces the Kalman update

BKF Evaluation on Human Data

- **Evaluated on AB and NAB data** for speed-up/slow-down trials
- Intended gait speed change is predicted before it physically happens





- Intent estimation for NAB trials improved with **hip motor current data**
- Estimated intent change **provides a "speed-up/slow-down" signal** to the exoskeleton

Next Steps

- Test data-driven & footstep-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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