Using Template Models to Identify Exoskeleton User Intent

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Summary

- **Context:** Exoskeletons present the opportunity to restore mobility and independence following musculoskeletal injury
- **Challenge:** Increase the fluency of the human-machine interface for lower-body exoskeletons
- **Approach:** Leverage the physics of walking via template models [1-3] to detect user intent
- **Status:** Human subjects study completed to gather intent data. Analysis shows signals of intent change from exoskeleton sensors

Figure 1. Template models of walking as advocated by (a) six determinants of gait, (b) inverted pendulum theory, and (c) compliant limb operation.

Human Subjects Study

- Experiments with able-bodied and non-able-bodied users in the Ekso GT (n = 15)
- Varying levels of experience
- Subjects instructed to walk naturally in a motion capture arena while using crutches or a walker
- **Verbally commanded to either speed up, slow down, stop, or make no change to gait**

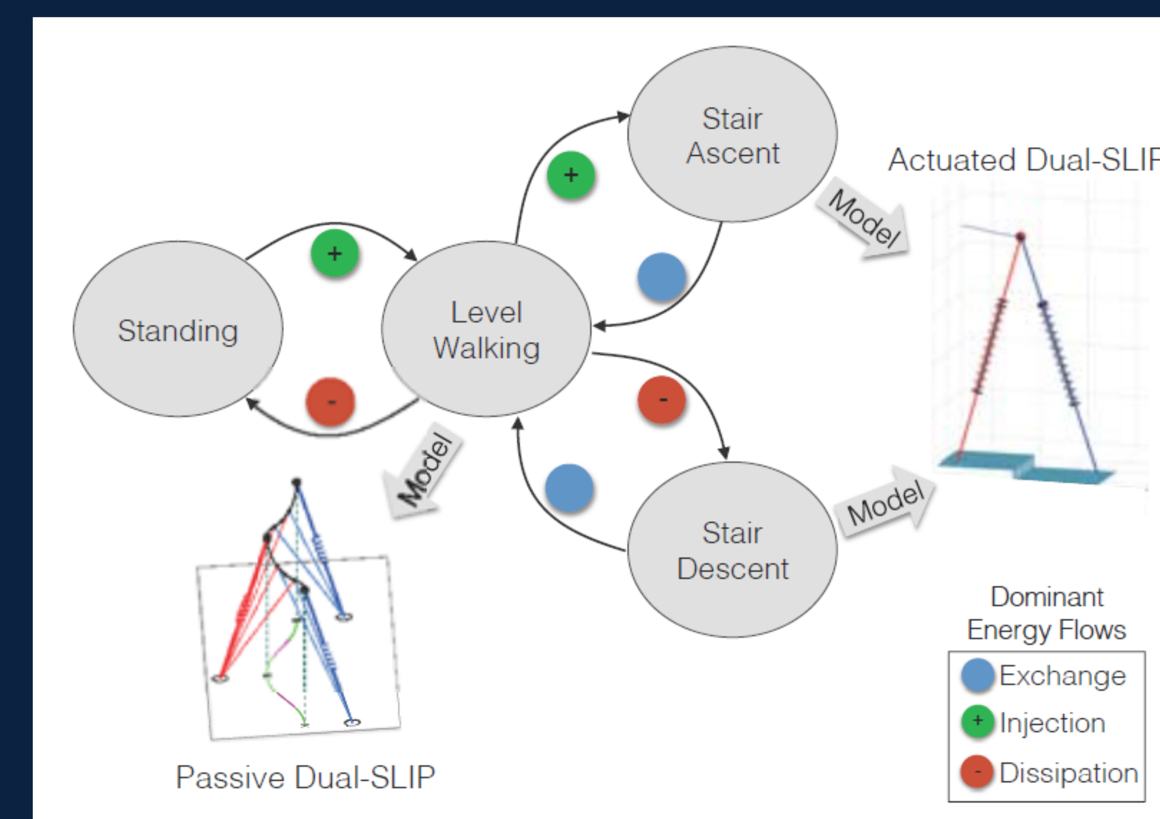

Figure 2. Template model indications of intended transitions in gait modes

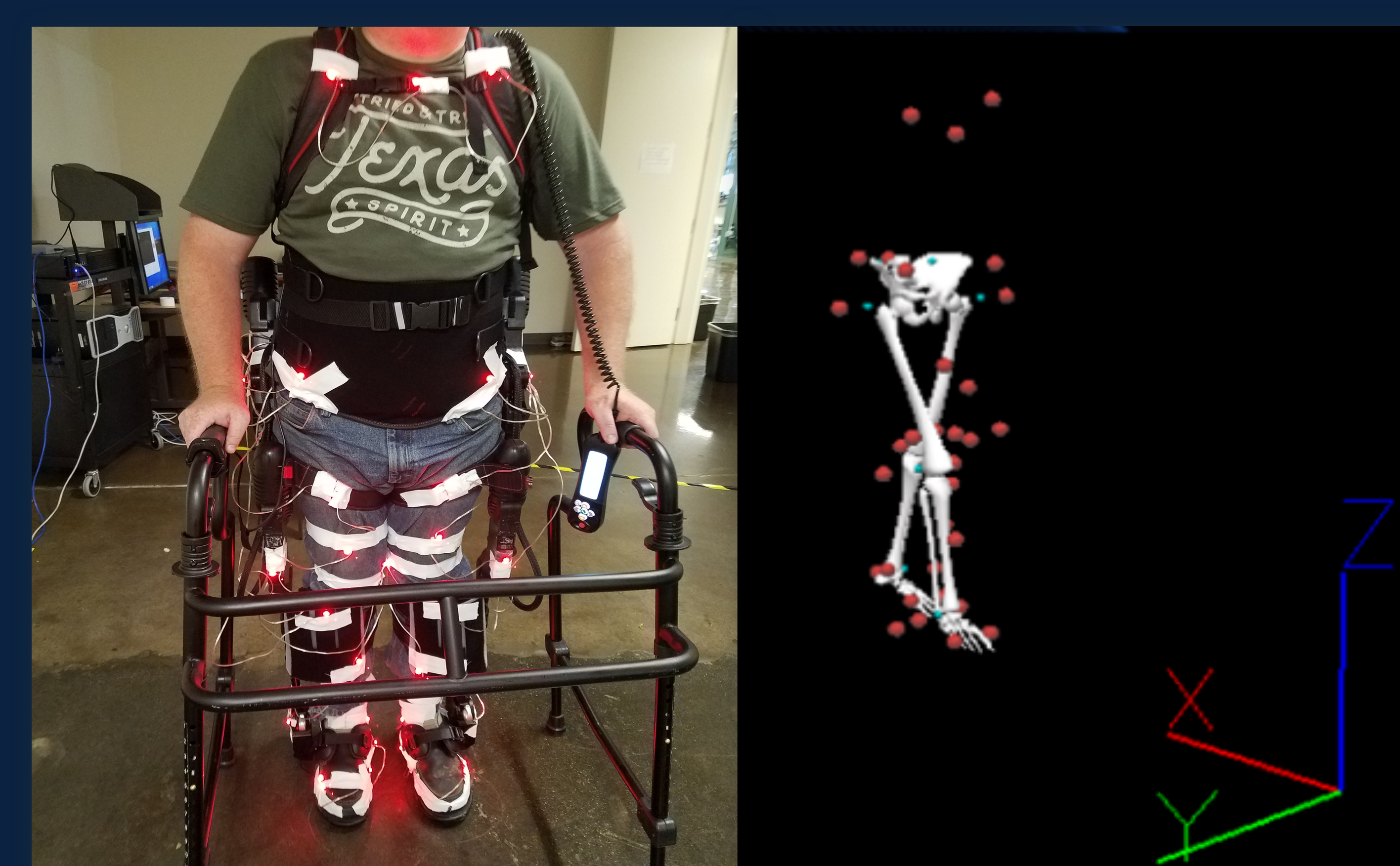

Figure 3. [Left] Subject in EksoGT wearing motion capture equipment. *[Right]* Reconstruction of the gait in Visual3D.

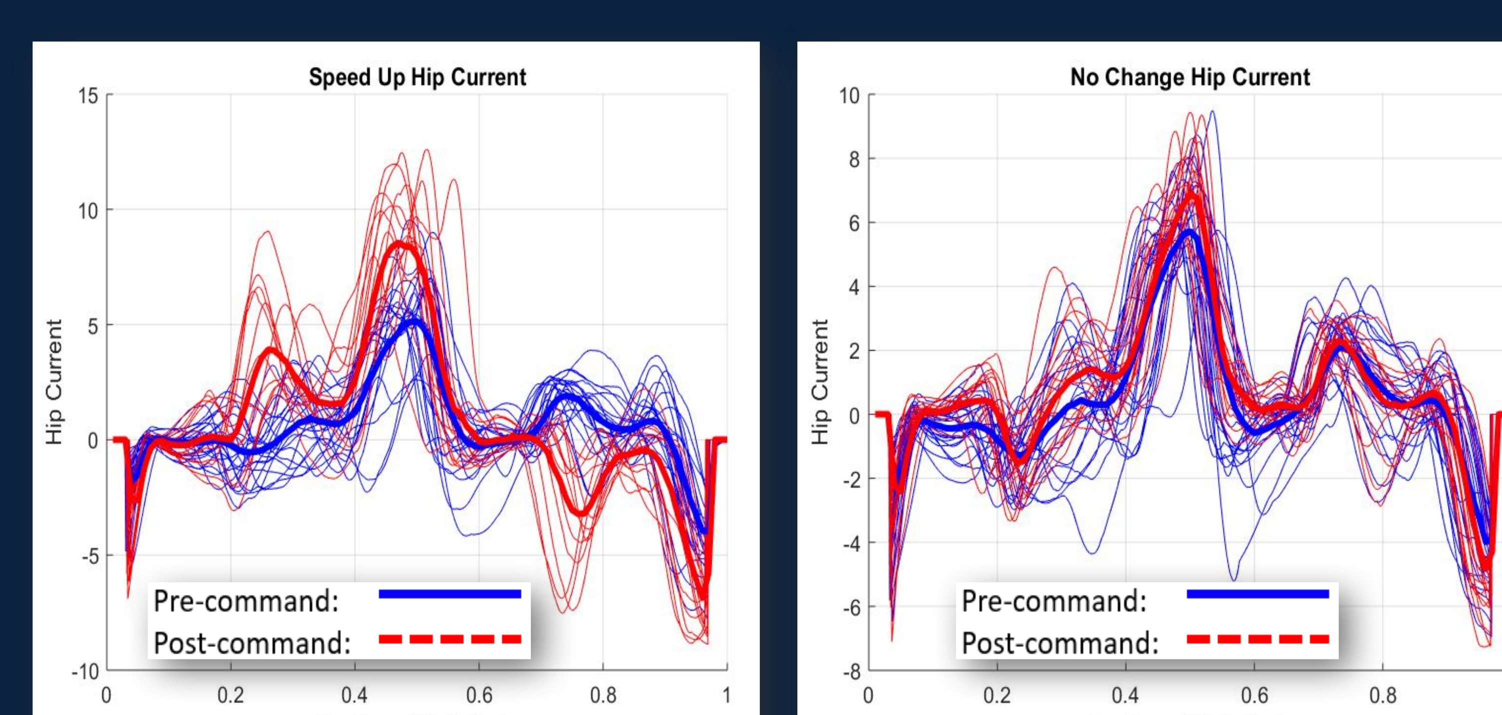

Figure 4. [Left] Hip joint motor current over the gait cycle for **Speed Up** trials. *[Right]* Hip joint motor current over the gait cycle for **No Change** trials.

Preliminary Analysis

- **Observed kinematic and kinetic indications of intent change**
- Joint motor currents measured by the exoskeleton affected by changes in intent
- Specific changes dependent on gait phase and assistance mode

Figure 5. EksoGT

Ongoing Work and Next Steps

- **Study of how the metrics measured by the exoskeleton map to the Dual SLIP model**
- Comparison of template gait before and after the intent-change command
- Assessment of detection delay for template-based intent recognition
- Integration of intent detection with the Ekso GT controller

References

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[2] R. J. Full and D. E. Koditschek, "Templates and Anchors: Neuromechanical Hypotheses of Legged Locomotion on Land," *Journal of Exp. Biology*, 1999.
[3] H. Geyer, A. Seyfarth, and R. Blickhan, "Compliant leg behaviour explains basic dynamics of walking and running," *Proceedings of the Royal Society B*, 2006.