Variable Impedance Control of the Robotic Ankle Joint

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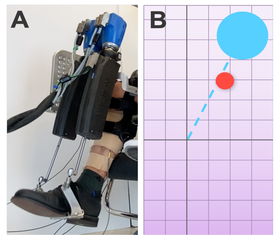
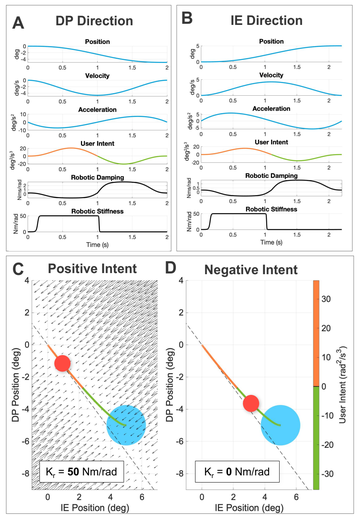
Research Question

Will assistance from a **wearable ankle robot** using a variable impedance controller allow human users to move in an agile and stable way that requires less effort than commonly-used controllers?

Methods

In this study, **10 human subjects** wore an ankle robot that provided assistance through a variable impedance controller.





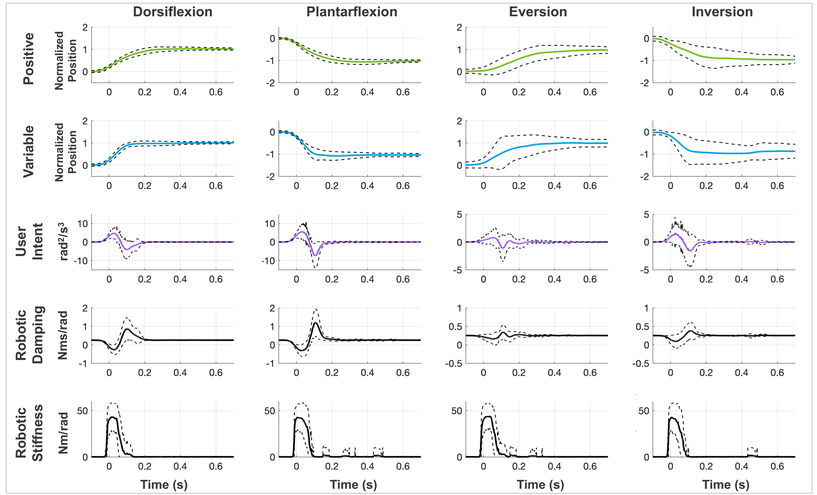
Variable damping was calculated using velocity ($\dot{\theta}$) and acceleration ($\ddot{\theta}$). User intent recognition was based on changes in kinetic energy, $\dot{\theta}\ddot{\theta}$.

Variable stiffness was used to ensure subjects moved in a straight path based on the subjects' intent of direction.

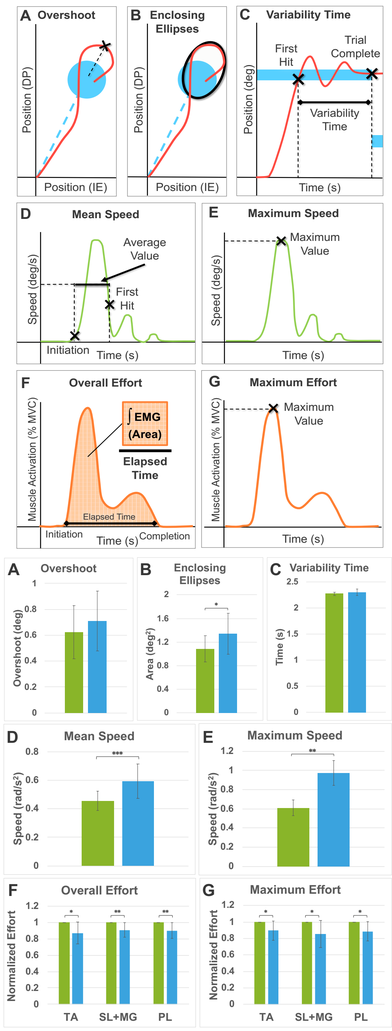
Results

- The variable impedance controller was compared with a positively damped, zero stiffness controller.
- Statistical analysis demonstrated similar results for stability, an increase in agility, and a reduction in overall human effort for the variable impedance controller.

Representative Subject Results



Group Results



Conclusions

- The variable impedance controller was shown to:
  - Maintain Stability
  - Improve Agility
  - Reduce Effort
- By using information about the inherent human ankle impedance, a variable impedance controller was designed that is less conservative than commonly-use positive damping controllers.

Future Work

- Use machine learning (Bayesian Optimization) to tune the parameters in the variable impedance controller.
- Test the controller in different environments (e.g., a walking study) and for different joints (e.g., the shoulder).

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