Enhancing human navigation ability using an active wearable exoskeleton

[1,2]Carlos Carrasquillo, [1,2]Aakash Bajpai, [1]Divya Iyengar, [1]Killian Collins, [1,2]Anirban Mazumdar, [1,2]Aaron Young

[1]*George W. Woodruff School of Mechanical Engineering,* [2]*Institute for Robotics and Intelligent Machines*

Scan for a video demo

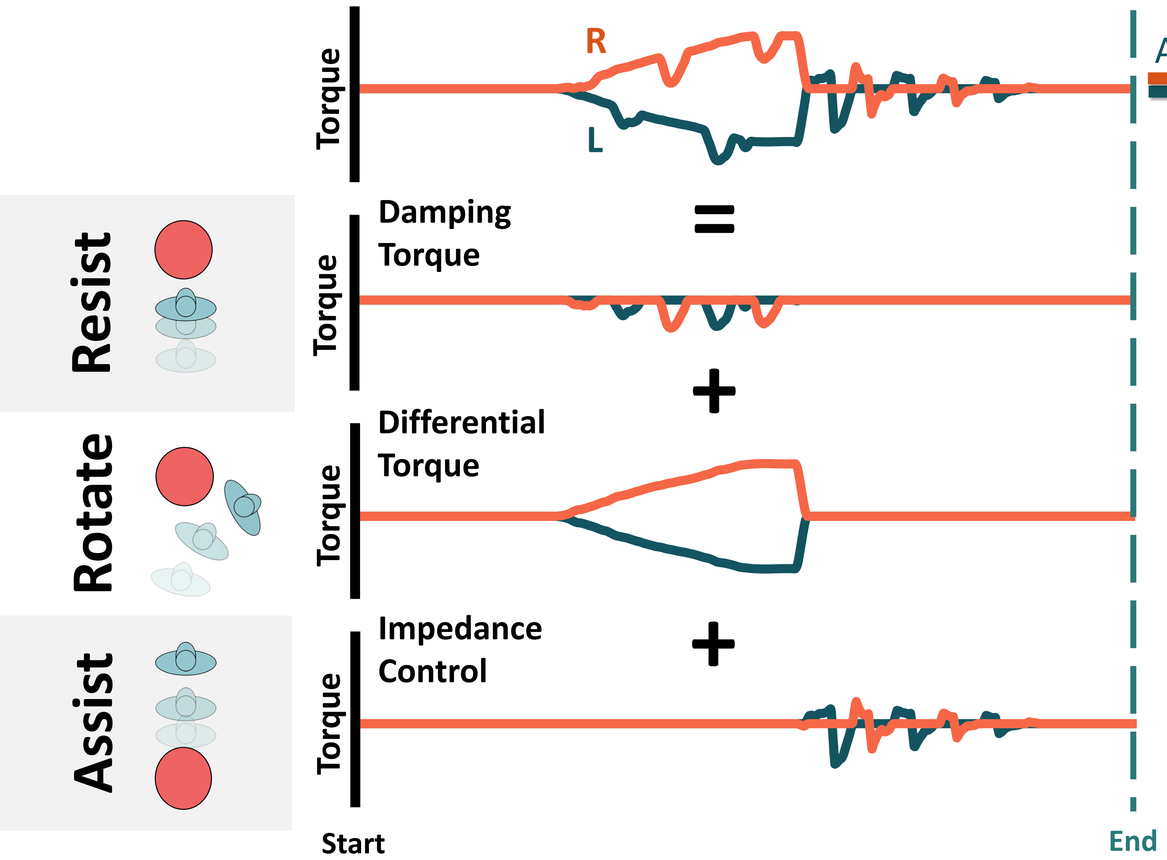
Goal of This Project

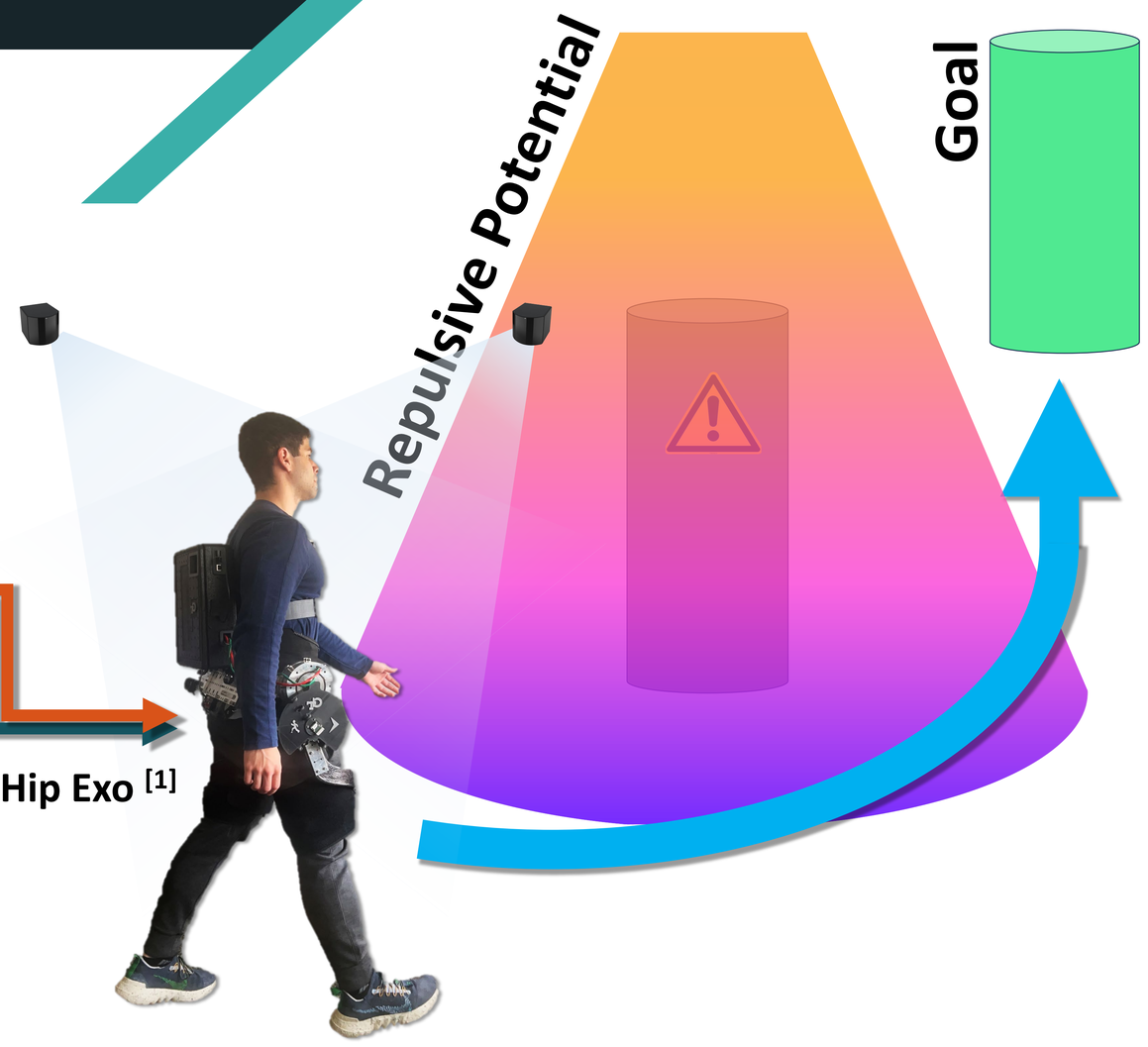
How can we promote **safe navigation** when visibility is low?

- Visibility may be impaired by dust, smoke, dense fog, or poor eyesight.
- Existing tactile and auditory devices require single-purpose hardware.

Hypothesis: Tactile feedback from an active exoskeleton can improve navigation ability compared to vision alone.

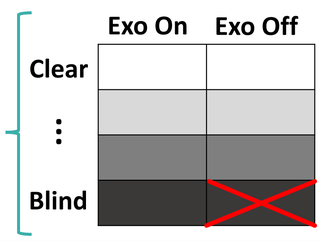
How the Controller Works

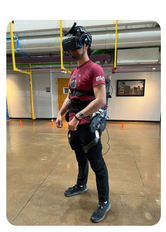




Experiment

- N=10
- Performed in **virtual reality**
- 7 conditions, 16 levels/condition
- 3 obstacle danger levels, d





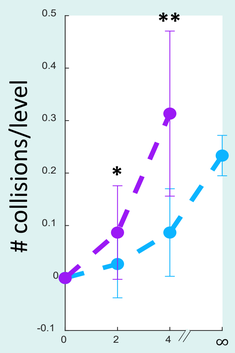
Results

Collisions

Collisions were significantly reduced with exo in all visibilities except clear.

exo on

exo off



Health Metric

Performance with exo on was significantly better in all visibilities except clear.

$$h_0 = 100$$

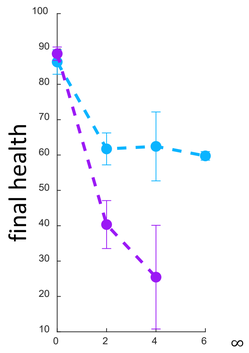
$$h_{i+1} = h_i - G \sum_{k=1}^{\#\text{obstacles}} d_k \frac{1}{r_k^2}$$

damage taken at t_i

damage gain

radius/danger level of obstacle k

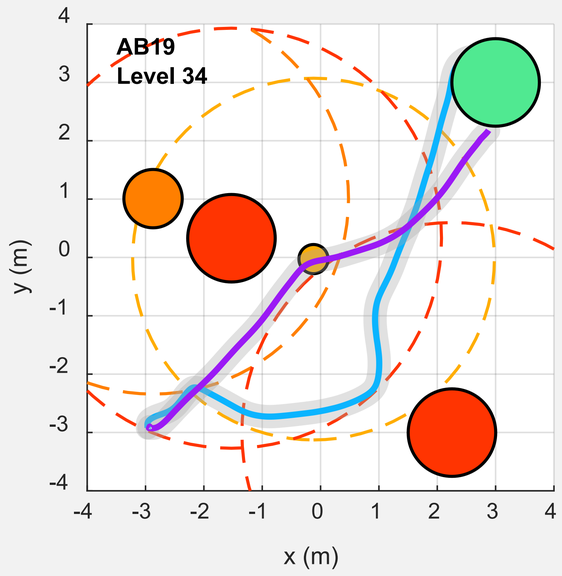
distance to obstacle k

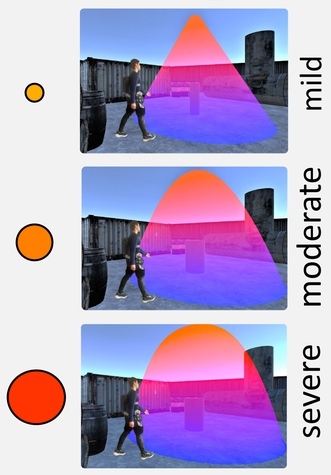


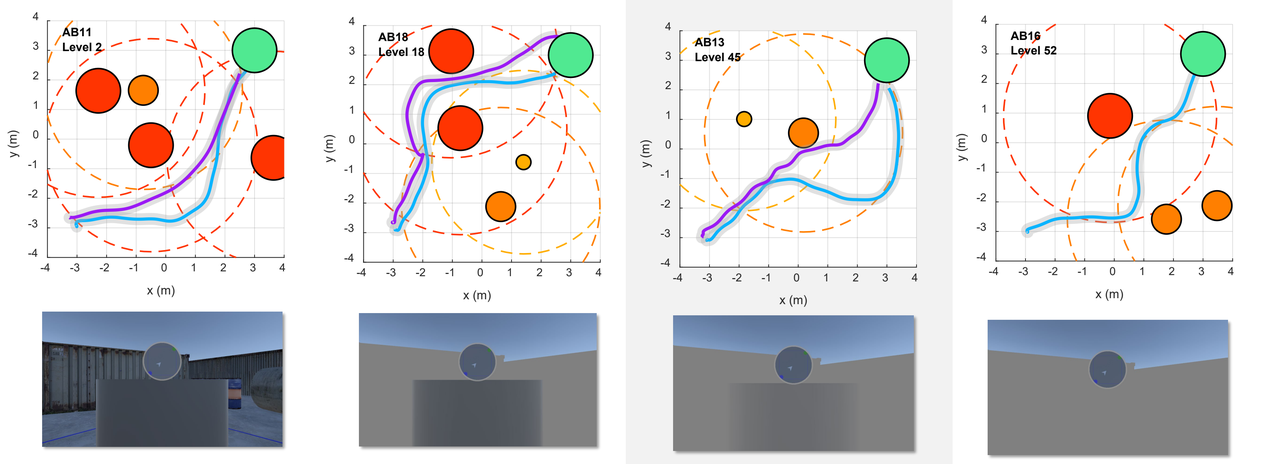
Sample Trials

exo on

exo off







Clear → **Decreased Visibility** → **Blind**

References & Acknowledgements

This work is supported in part by an NSSEG fellowship sponsored by the Army Research Office. The authors would like to thank Joshua Fernandez, Connor Bossard, and Marilyn Braojos for their contributions to the ideation, development, and guidance of this project.

[1] A. Bajpai *et al.*, "Design and Validation of a Versatile High Torque Quasi-Direct Drive Hip Exoskeleton," 2023.