Foundations for Physical Co-Manipulation with Mixed Teams of Humans and Soft Robots

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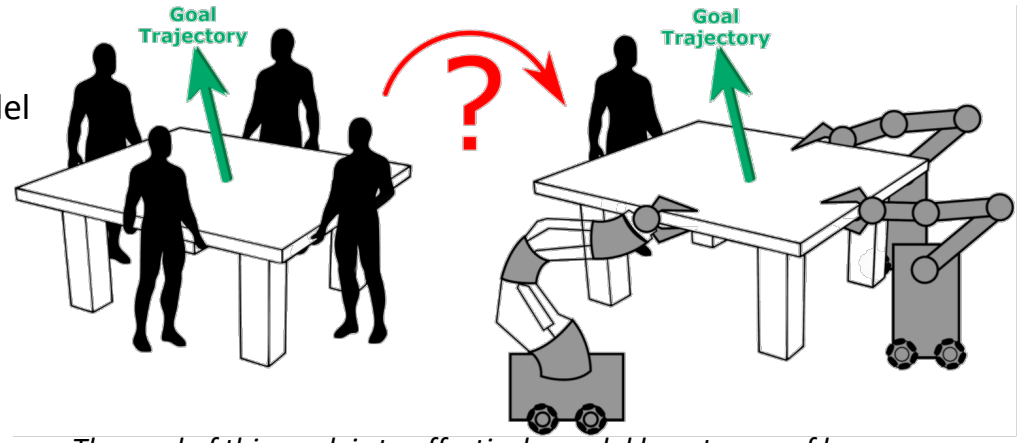
Challenge

- Optimal control strategies for uncertain systems (such as soft robots or human-robot teams) can enable improved performance but are sometimes intractable or do not explicitly model inherent uncertainty.

Solution

- Develop models of human intention and consensus during co-manipulation based on haptic data from human teams.
- Quantify uncertainty in estimation of both soft robot state and human intention.
- Develop uncertainty-aware, consensus-based optimal controllers.



The goal of this work is to effectively model how teams of humans interact during co-manipulation in order to enable teams of humans and soft robots to do the same.

Scientific Impact

- Our results will advance soft robot control and planning by explicitly modeling the inherent uncertainty of soft robots.
- We will also develop new models for human intention and consensus that can be used during haptic interactions such as co-manipulation.

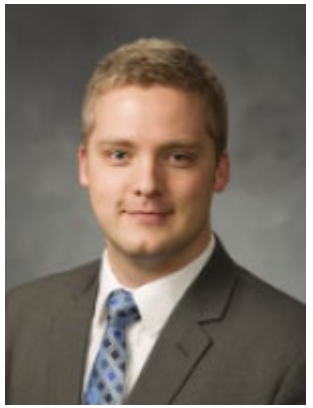
Broader Impact

- The project results will enable multiple soft robots to coordinate and reach consensus with human teammates while co-manipulating during tasks like search and rescue operations by including search and rescue team members in our studies and evaluations.
- Planned exchange with underrepresented undergraduate students to help develop and implement soft robotics education program developed at Yale.

Project Investigators:

Co-PI: John Salmon (BYU)

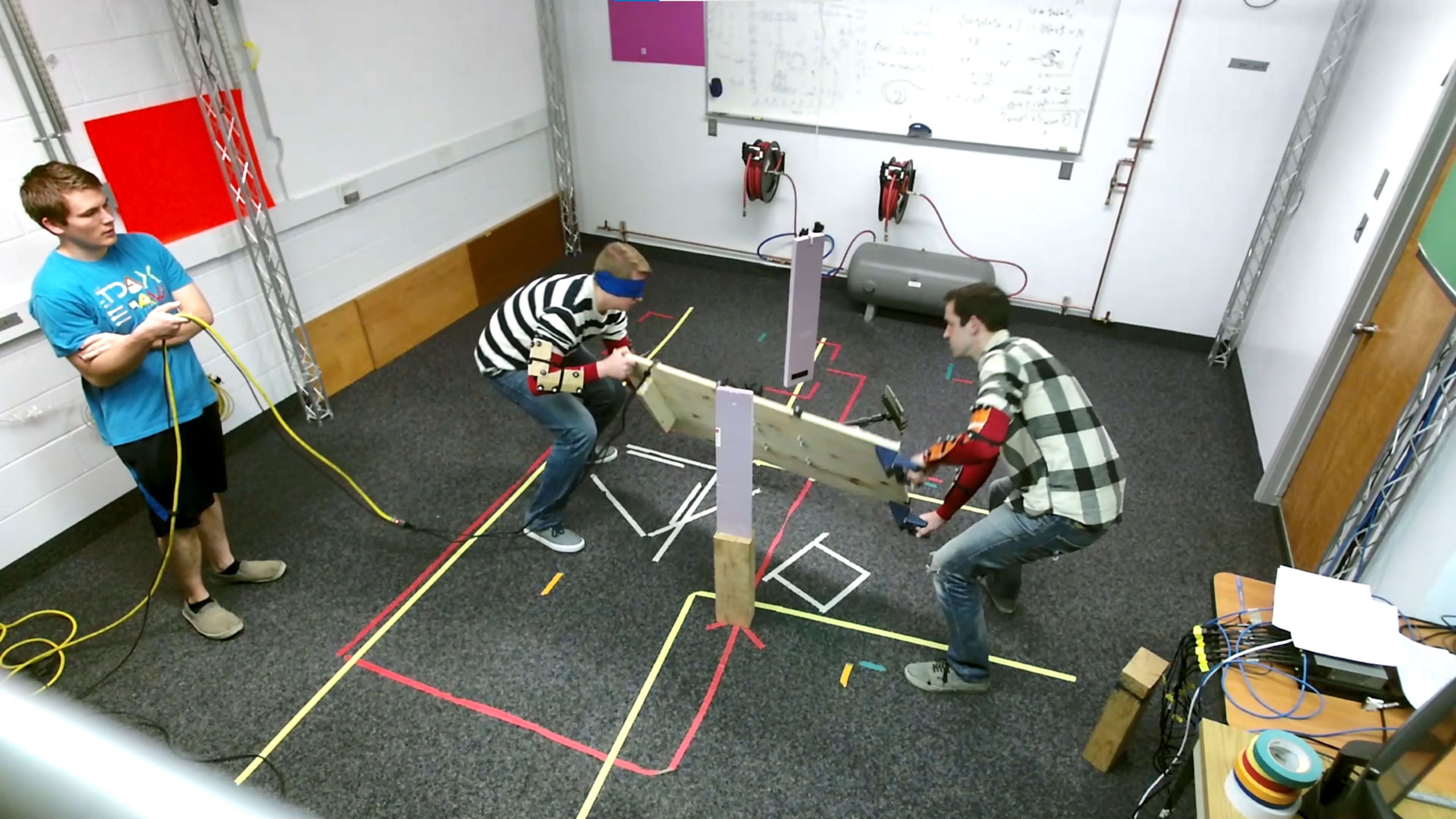
Co-PI: Rebecca Kramer-Bottiglio (Yale)



PI: – Marc Killpack (BYU)

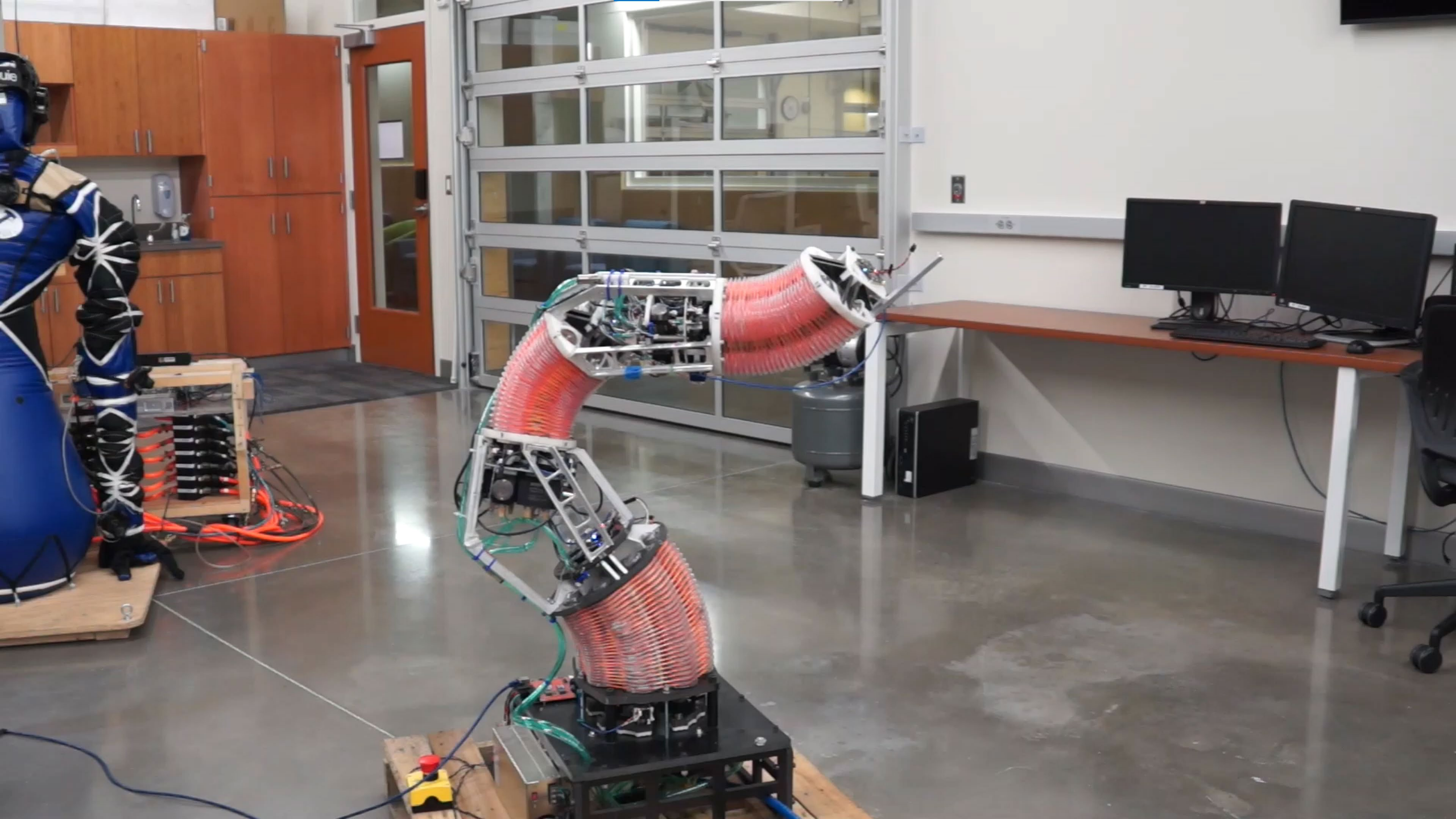
Foundation of Approach (prior work)

Dyadic Collaborative Manipulation



Foundation of Approach (prior work)

Soft Robot Model-based Control



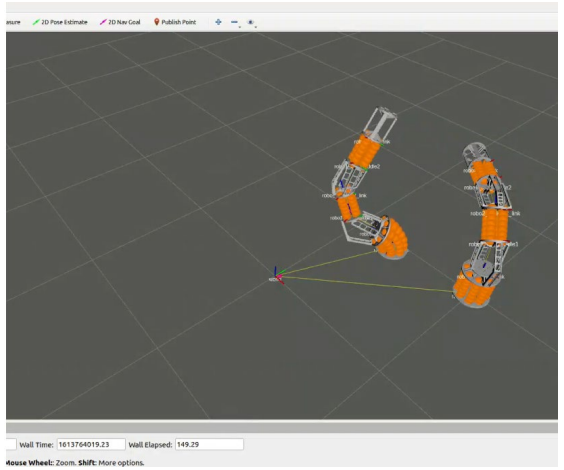
Project Objectives:

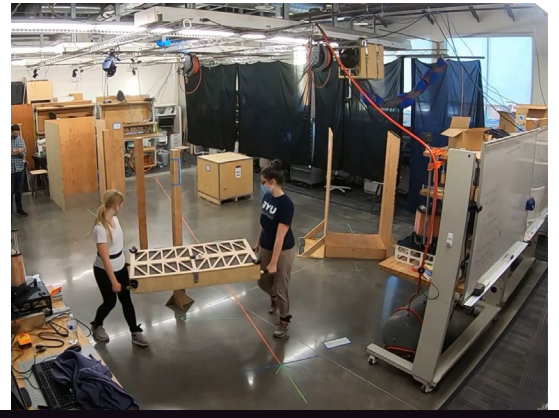
1)Model intention and consensus between multiple human agents during physical co-manipulation

2) Develop soft robot planning and control methods to compensate for uncertainty (from soft robot position uncertainty and partner intent) during co-manipulation

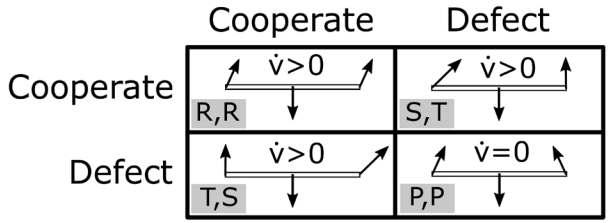
Control Models and Development

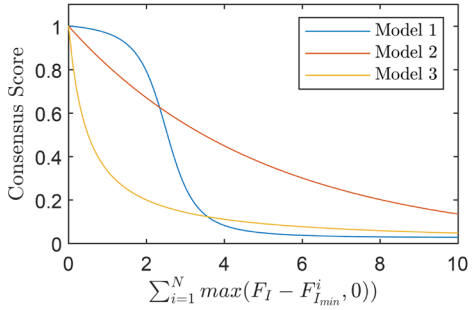
Uncertainty Quantification and Data Collection

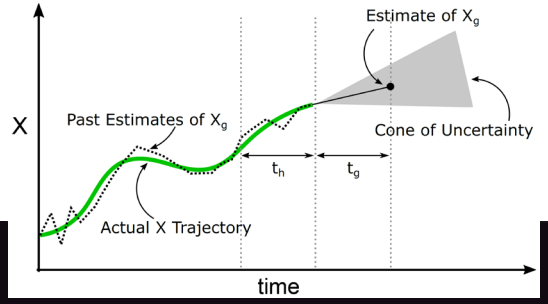




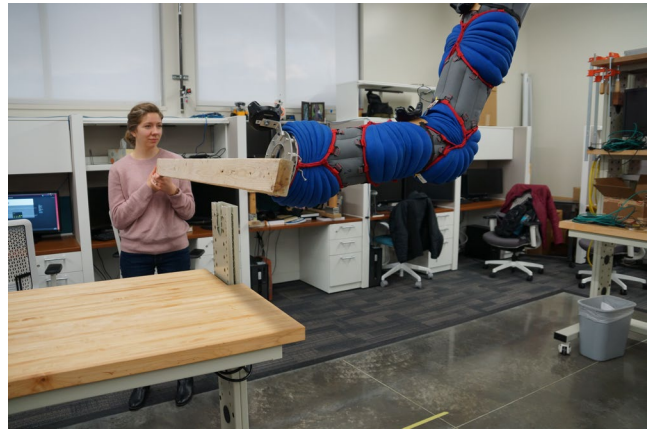
Consensus Modeling and Uncertainty-aware Control Development







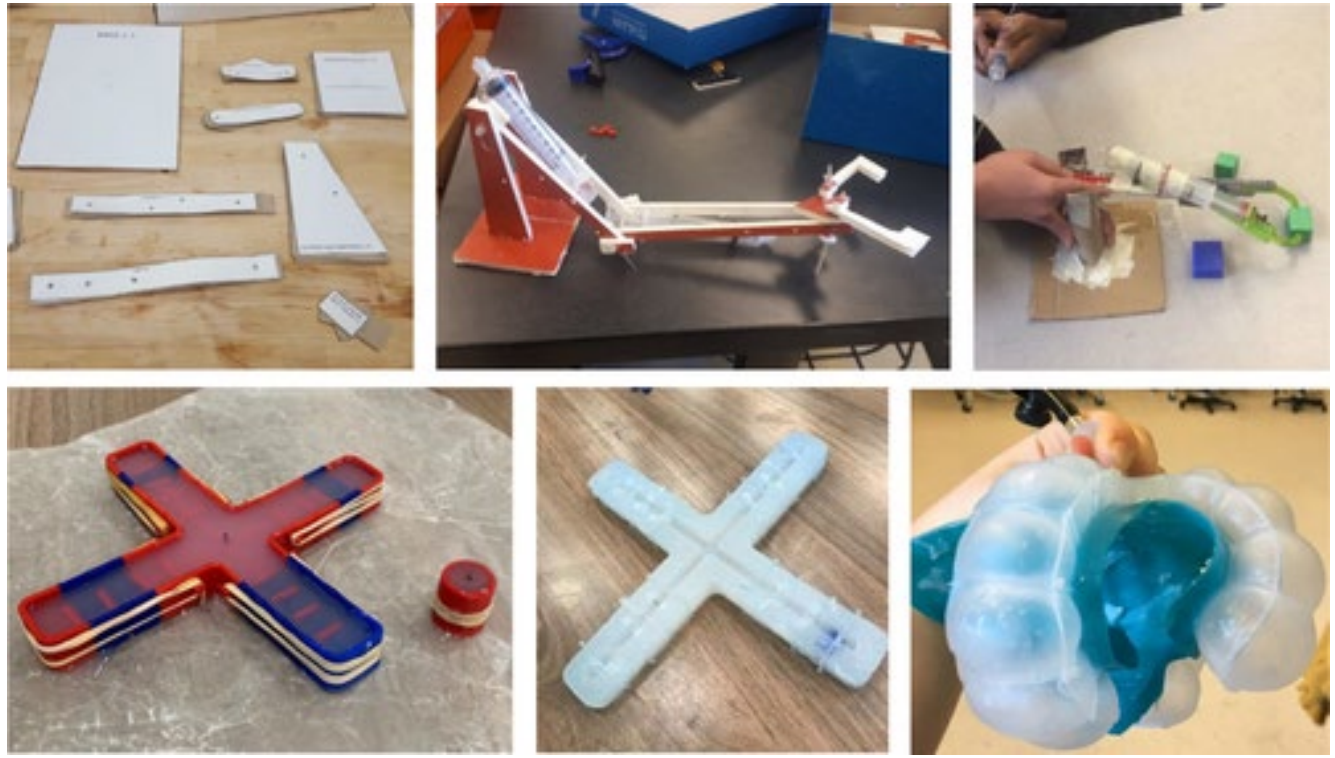
Integration for Effective Co-manipulation with Humans and Soft Robots



Broader Impact

Search and Rescue and Soft Robot Educational Outreach

https://nikkiritcher.com/sar-helo-training/



Jackson, A., Mentzer, N. and Kramer-Bottiglio, R., Increasing gender diversity in engineering using soft robotics. *Journal of Engineering Education*.