Foundations for Physical Co-Manipulation with Mixed Teams of Humans and Soft Robots (started Jan 2021)

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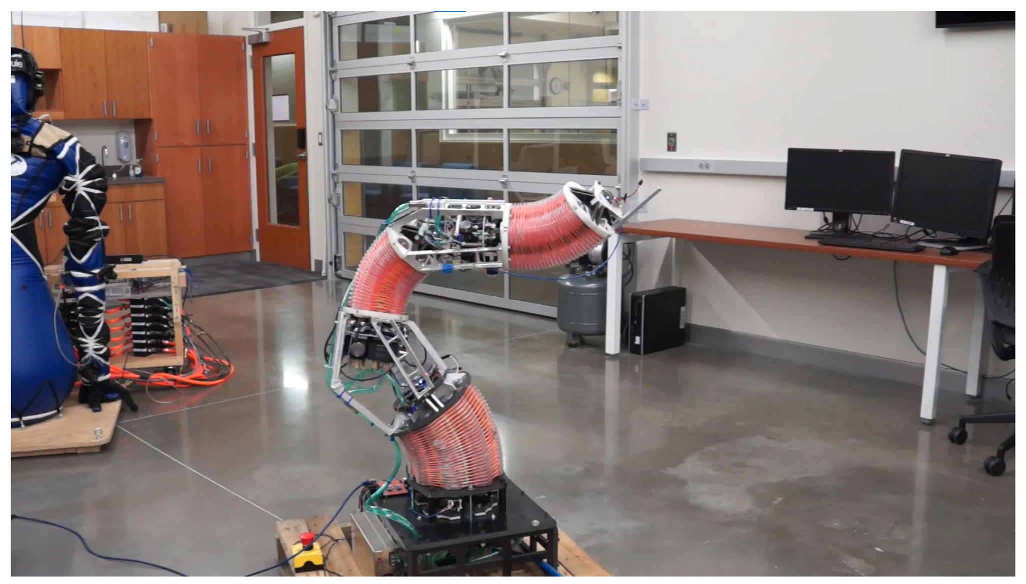
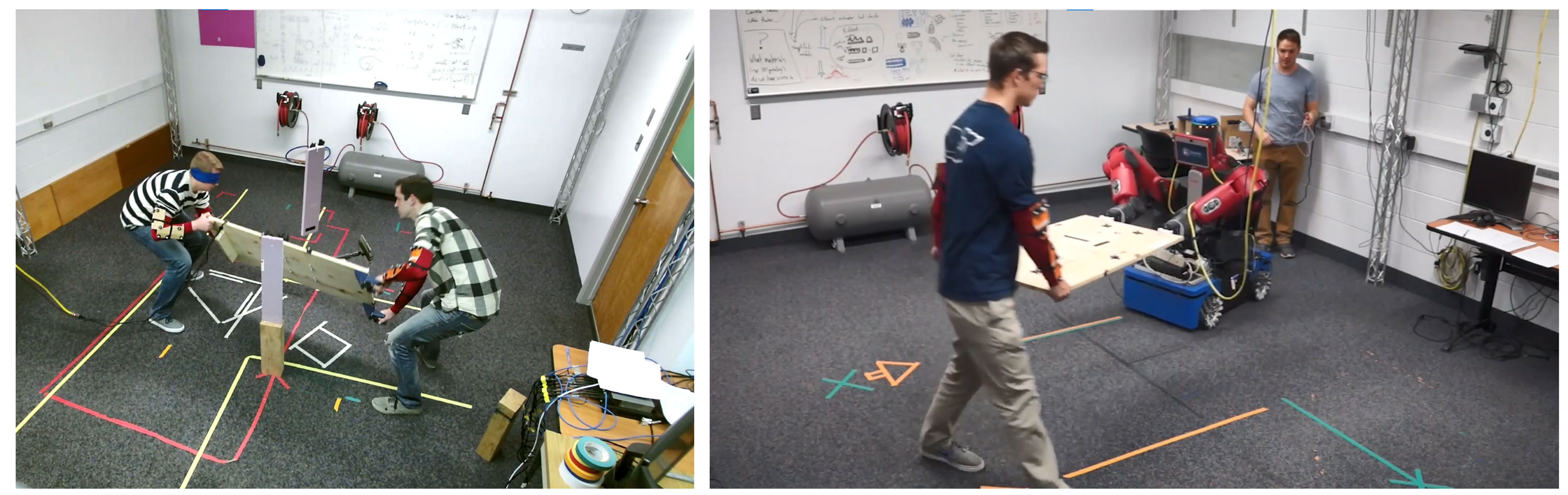
Challenge: Optimal control strategies for uncertain systems (such as soft robots or human-robot teams) can enable improved performance, but often the required models are difficult to obtain or do not explicitly model the inherent uncertainty in the problem.

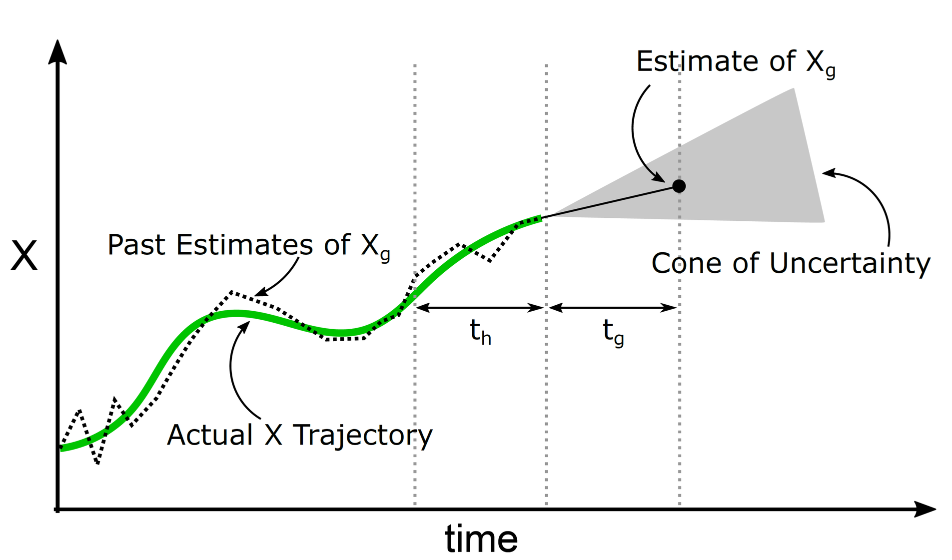


Past research in our group, on learned or adaptive soft robot control for large-scale manipulators, shows that soft robots are a viable option for human-robot co-manipulation.



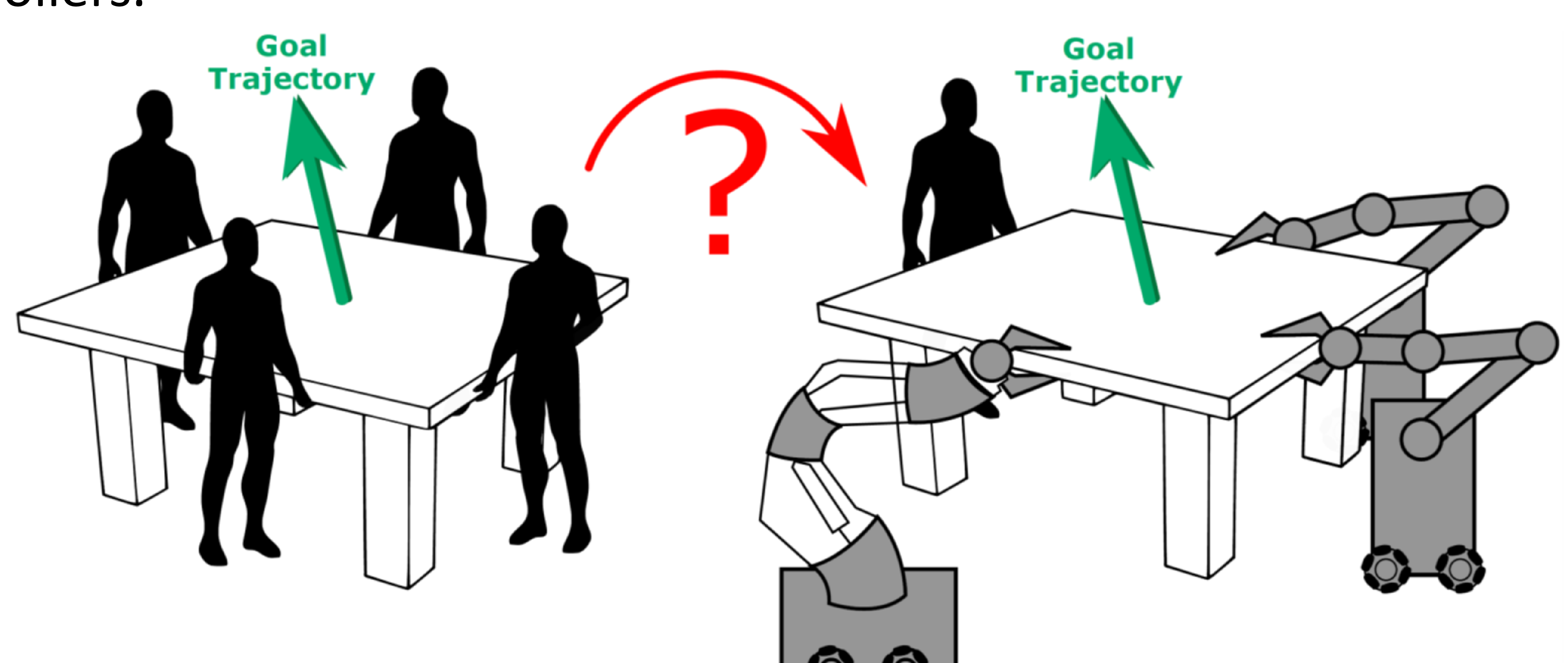
Studies we performed from 2015-2018 showed that for human-human and human-robot dyadic co-manipulation, haptic information is sufficient for many non-trivial cooperative tasks.

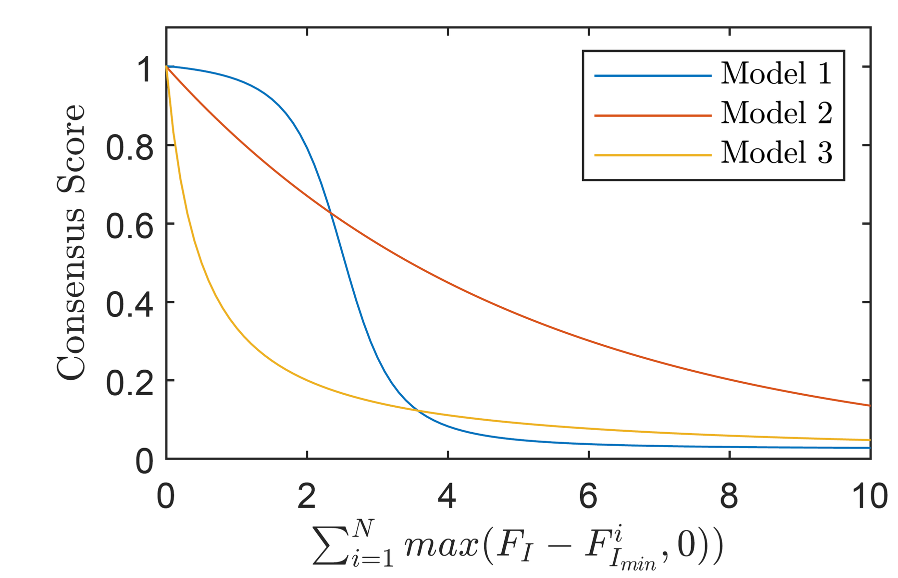
We have developed necessary infrastructure (obstacles, sensors, Virtual Reality integration) to enable multi-agent studies in the near future.



By building on sampling-based optimal control methods, we can leverage inherent uncertainty in a co-manipulation task with soft robots to find robust cooperative solutions.

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



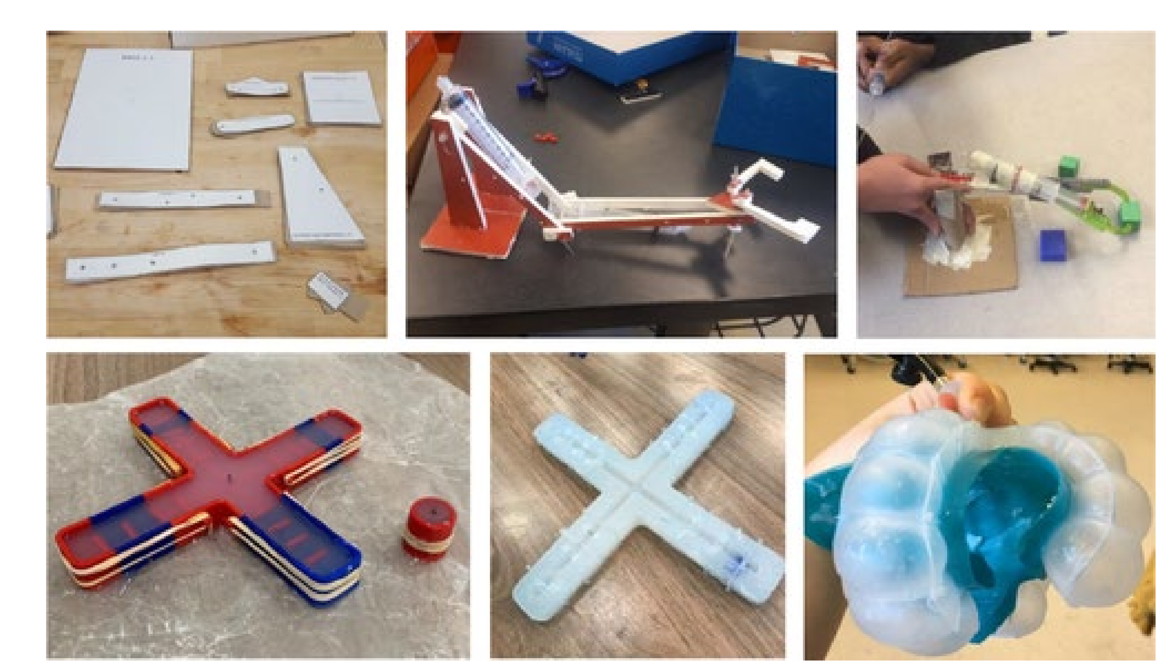


By developing explicit consensus models based on interaction forces that occur during co-manipulation, we can use robot actions to simultaneously improve consensus and reduce uncertainty.

https://nikkiritcher.com/sar-helo-training/ - Nikki Ritcher Photography

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.

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



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

Educational Outreach: Planned exchange with underrepresented undergraduate students to help develop and implement soft robotics education program developed at Yale.

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