# NRI: INT: COLLAB: Collaborative Task Planning and Learning through Language Communication in a Human-Robot Team


**IIS 1830244: Joyce Chai, Language and Interaction Research Lab, Department of Computer Science and Engineering, Michigan State University**
**IIS 1830282: Julie Shah, Department of Aeronautics and Astronautics, Computer Science and AI Lab, Massachusetts Institute of Technology**

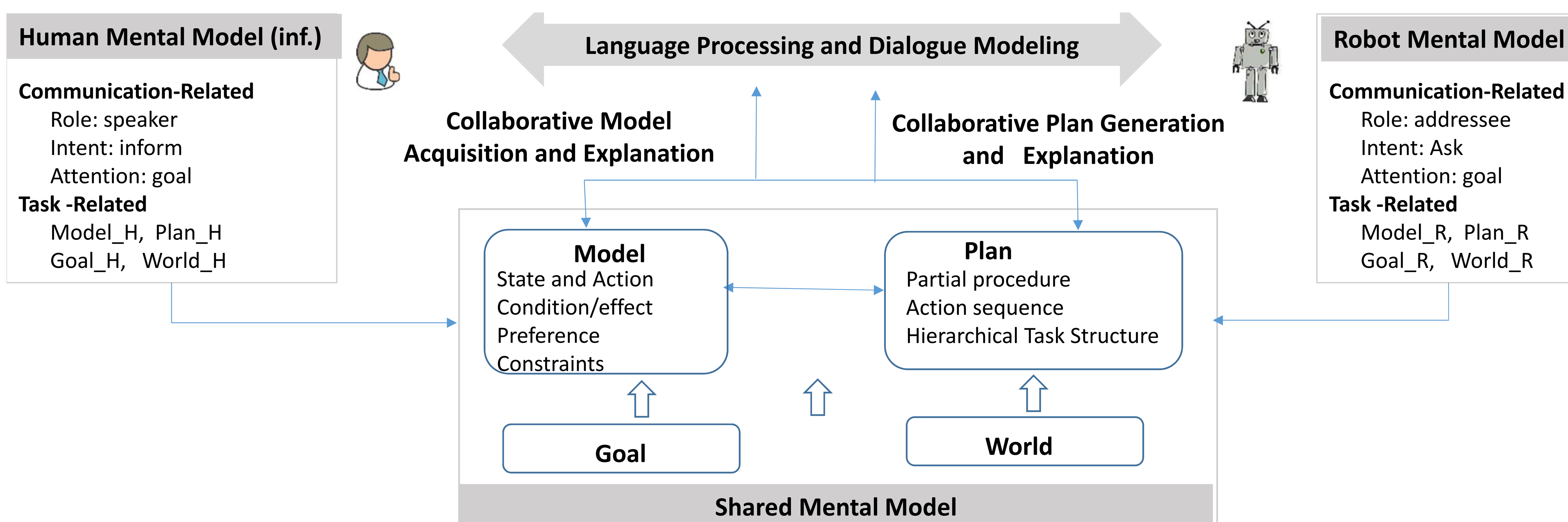

## Motivation and Overall Objectives

**Challenges**

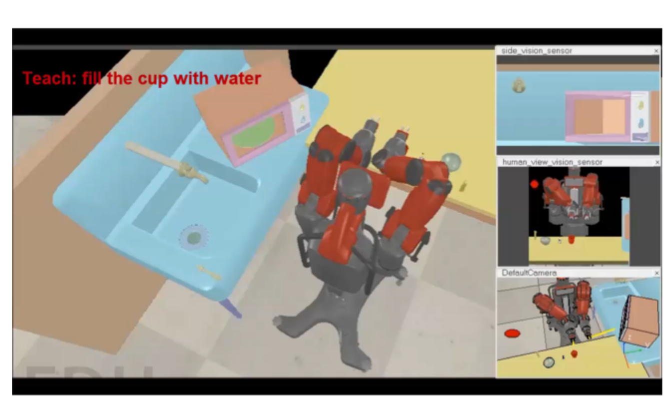
- Most robotic planning systems operate based on a closed set of representations. However, in reality robots are not likely to have a complete set of domain models and will often encounter new situations or new tasks they don't have any knowledge or experience about.
- Even given sufficient state and action representations, automated planning is still computationally challenging. Designing planners that can generate high quality plans and perform efficiently across various domains remains an open problem.

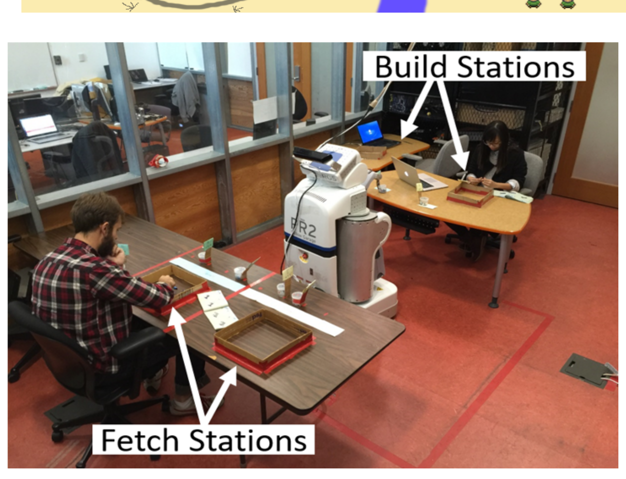
**Overall Objective**

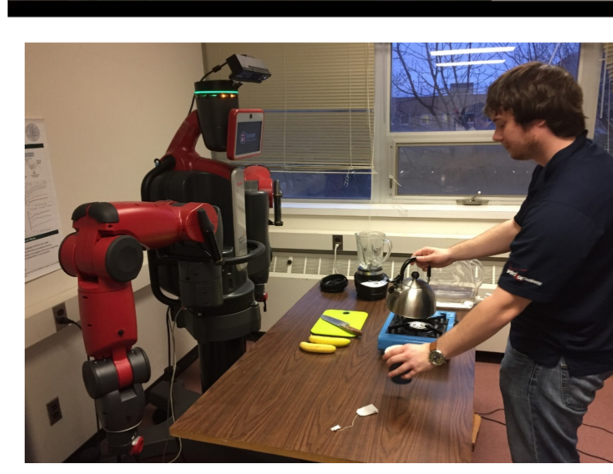
Develop a novel framework that tightly links language and dialogue processing with the robot's underlying planning system to support collaborative task planning and learning in a human-robot team.









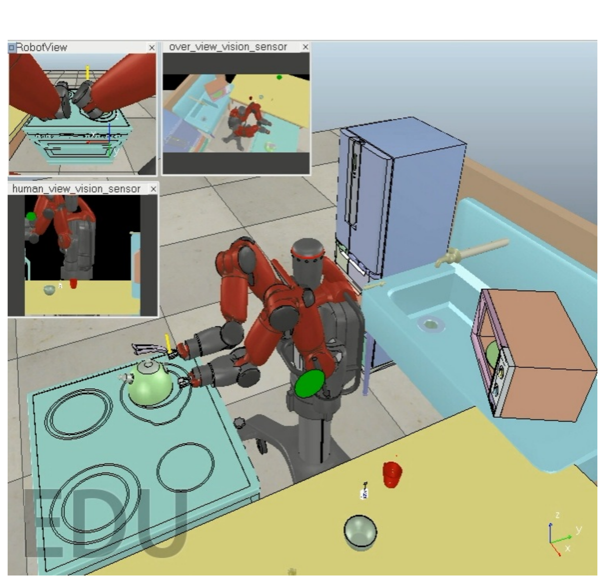



**(1) Empirical Studies.** Develop several scenarios and manipulate various levels of disparities between humans and robots in their respective representations of the goal, the domain model, the world, and the plan. Study how humans and robots make extra effort to collaborate with each other to strive for a shared representation and joint plan.

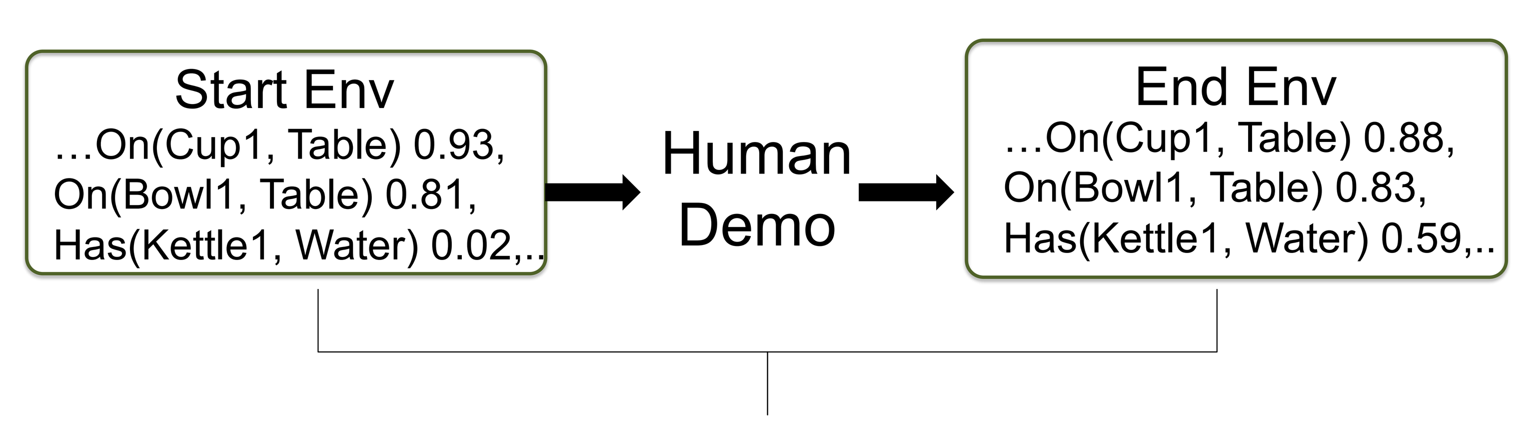
**(2) Computational Models.** Develop a computational framework that integrates language and dialogue processing with the underlying robot planning to allow humans and robots to mediate disparities in their representations and enable collaborative model acquisition and plan generation.

**(3) Evaluation.** Evaluate the framework in terms of consistency of shared understanding, plan quality, and situational awareness. Design new scenarios to evaluate customizability and scalability.

## Interactive Learning Grounded Verb Semantics



H: Fill the kettle with water.
R: I don't know how to do it, could you teach me?
H: Sure. This is how you do it. (*human moves the kettle into the sink, turns on the faucet, turns off the faucet.*)
R: (acquire the meaning representation of the verb phrase).

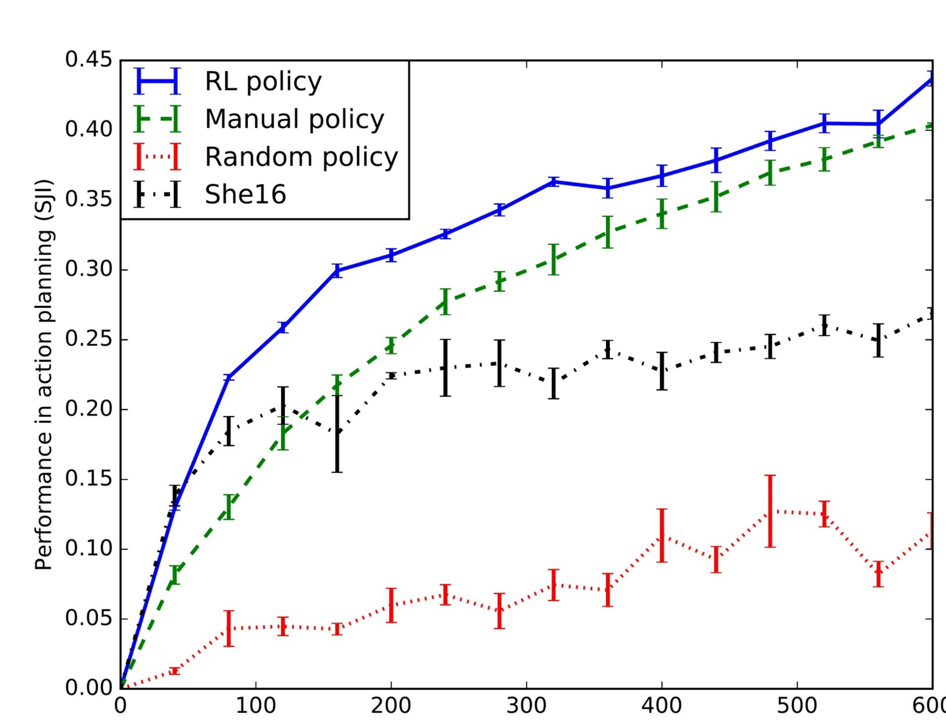



Learning from Interaction by asking good questions

*$\lambda x \lambda y$ Fill(x,y): $\lambda o_1 \lambda o_2$ Grasping(x)^Has(x,y)^In(x,$o_1$)^ $\neg$On(x, $o_2$), $x \in$ Kettle_type, $y \in$ Water_type, $o_1 \in$ Sink_type, $o_2 \in$Stove_type*

Apply reinforcement learning to learn a policy that selects an optimal question to ask at each state to maximize the long-term rewards.

| Action | Question Example |
|---|---|
| Ask for the grounding of a np. | *"Which is the cup, can you show me?"* |
| Confirm the grounding of a np. | *"I see a silver object, is that the pot?"* |
| Confirm a predicate in current environment. | *"Is the microwave door open?"* |
| Confirm whether a predicate *p* should be in the final environment. | *"Is it true the pot should be on the counter?"* |
| Choose a hypothesis to use as goal and execute. | |






L. She and J. Y. Chai. Interactive Learning of Grounded Verb Semantics towards Human-Robot Communication. *Proceedings of the 55th Annual Meeting of the Association for Computational Linguistics (ACL)*, pp. 1634-1644, Vancouver, Canada, 2017.