Show Me What You Can Do: Capability Calibration on Reachable Workspace for Human-Robot Collaboration

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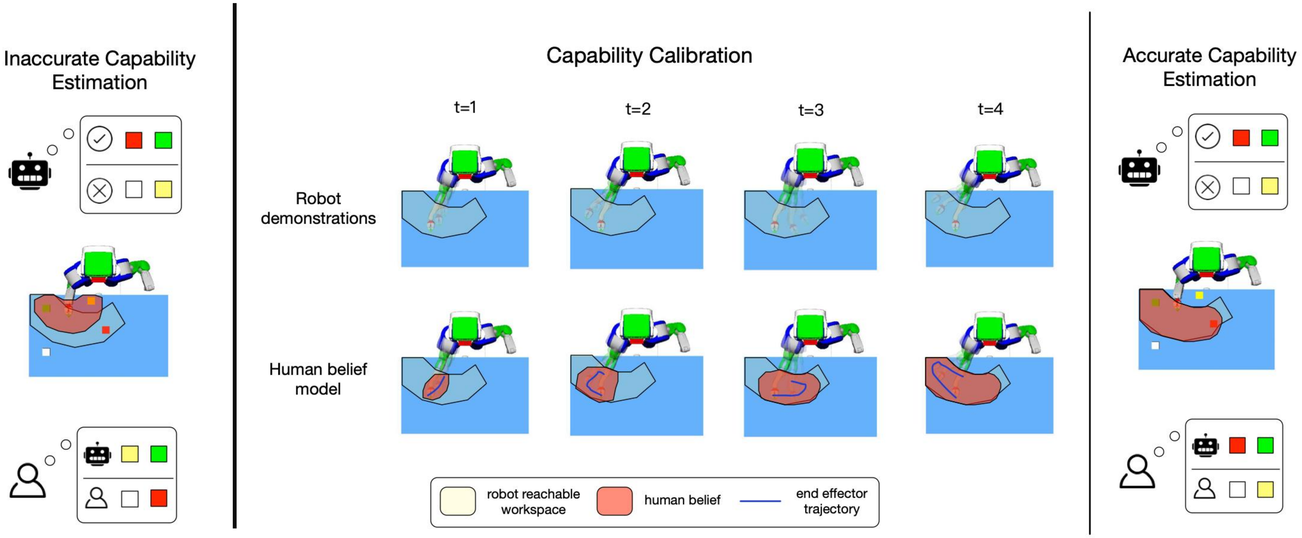
Introduction & Motivation



Objective: To calibrate humans' estimation of a robot's reachable workspace through a small number of demonstrations before collaboration.
Motivation: Calibration trajectories should optimize both target reaching and human belief formation to generate informative trajectory demonstrations.

Reachability-Expressive Motion Planning

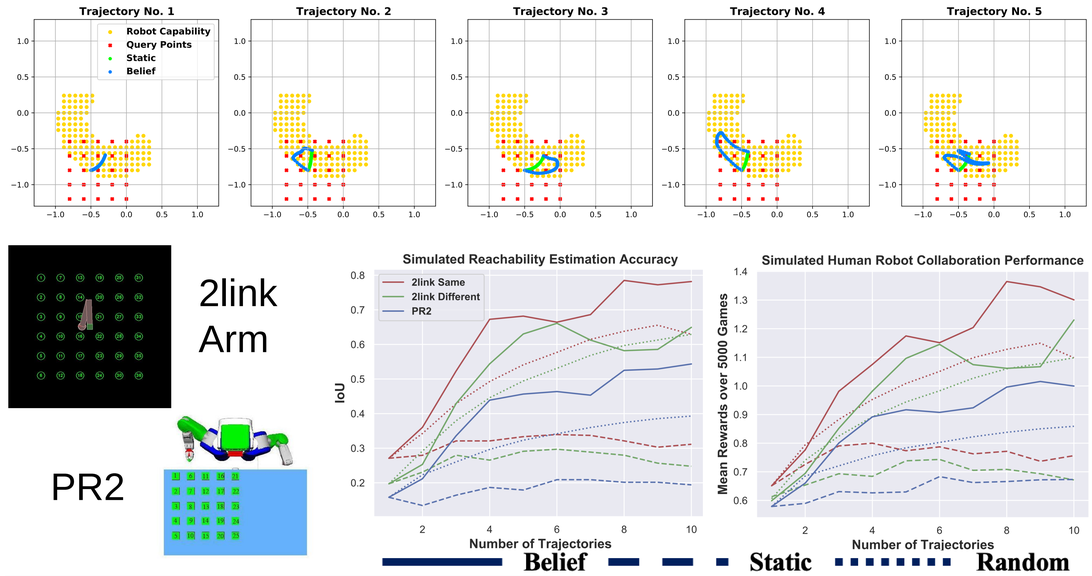
$$\xi^t = \underset{\xi}{\operatorname{argmax}}\, c_b(\xi, b_h^t, f) + \frac{1}{\lambda}\sum_{i=1}^{N} |\xi_{i+1} - \xi_i|^2$$

$$c_b(\xi, b_h, f) = \alpha \sum_i^N e^{\beta[b_h(\phi_{ee}(\xi)) - f(\phi_{ee}(\xi))]}$$

$$b_h^{t+1}(x) \propto b_h^t(x) e^{-\gamma\left(\min_i |\phi_{ee}(\xi_i^t) - x|^2\right)}$$

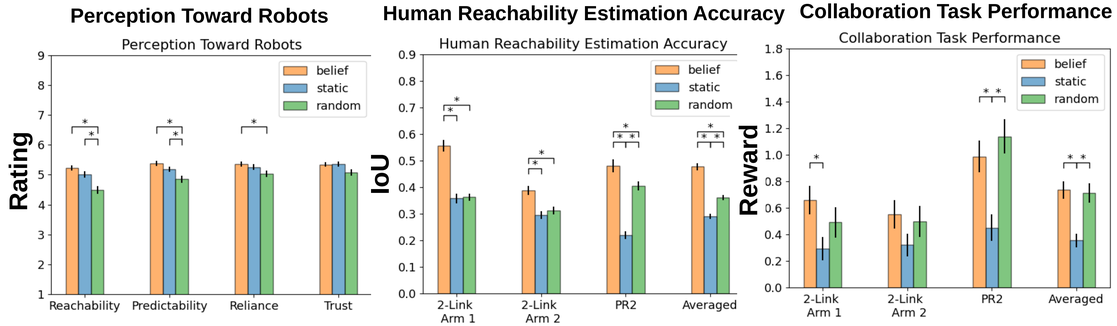
Optimizing a cost function defined on human belief and the trajectory continuation. Trajectories passing **underestimated** ($b_h < f$) regions trigger lower cost and are prone to be selected. If a point is close to an observed trajectory, it is more likely to be considered as reachable.

Simulation



User Study Results

Our user study (N=202) shows a short calibration using REMP leads to (i) better user reachability estimation of the robot; (ii) higher rewards in a subsequent human-robot collaboration; (iii) better user perception of the robot.



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