TAILORED: Training for Independent Living through Observant Robots and Design

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Goal: Create **human-centered robots** to provide **personalized neurorehabilitation** to adults with mild cognitive impairment.

Problem

- **MCI → cognitive function impairments**
  - Problem solving, planning, medication management
- **20% of people >65 have MCI**, many convert to dementia
  - No pharmacological treatments available
- **Cognitive Neurorehabilitation (CN) may slow progression [3]**
  → *Limited accessibility. Can we deliver CN via robots @ home?*

Approach

- **Robot-delivered CN @ home [1, 2]**
  - Co-designed w/ stakeholders
- **New machine learning methods [4, 5]:**
  - Personalized, long-term learning
  - Sustained engagement
- **New methods for stakeholders to easily program robots [1]**

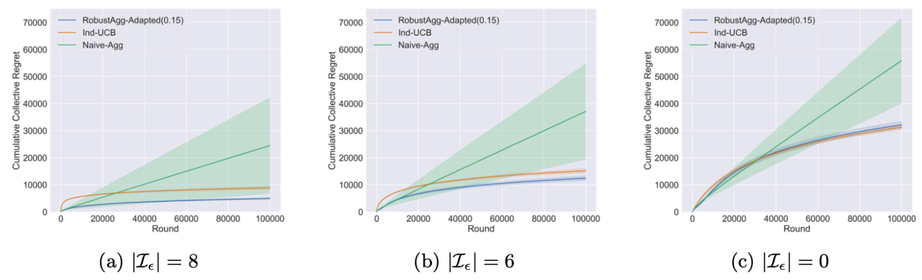
Highlight: JESSIE (Just Express Specifications, Synthesize, and Interact) [1]

For robot-delivered health interventions to be effective, clinicians must be able to easily personalize and program them. JESSIE is a system that enables novice programmers to program robots by expressing high-level specifications. It employs control synthesis + a tangible front-end to allow users to define complex behavior; for which we automatically generate control code. We demonstrated JESSIE in the context of enabling clinicians to create personalized treatments for people with MCI; they did so quickly and without error.

We exhibited JESSIE's reproducibility by replicating a clinician-created program on a TurtleBot 2. As an open-source means of accessing control synthesis, JESSIE supports reproducibility, scalability, and accessibility of personalized robots for HRI.

Source code available: http://github.com/UCSD-RHC-Lab/JESSIE

Highlight: Preference Learning Across Agents [4]



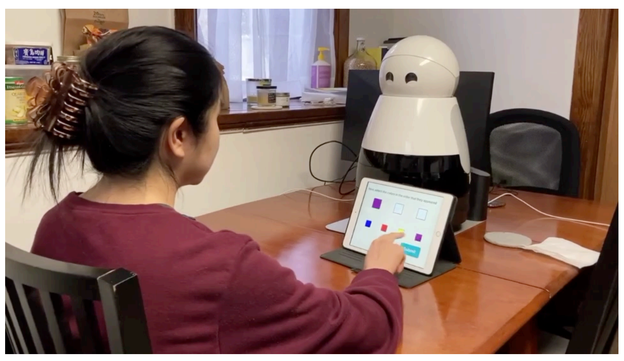
(a) $|\mathcal{I}_\epsilon| = 8$ (b) $|\mathcal{I}_\epsilon| = 6$ (c) $|\mathcal{I}_\epsilon| = 0$

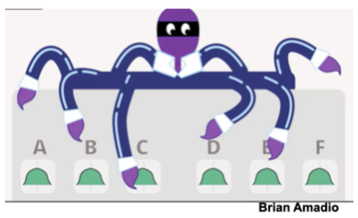
Figure 1: Compares the average performance of RobustAgg-Adapted(0.15), Ind-UCB, and Naive-Agg in randomly generated Bernoulli 0.15-MPMAB problem instances with $K = 10$ and $M = 20$. The x-axis shows a horizon of $T = 100,000$ rounds, and the y-axis shows the cumulative collective regret of the players.

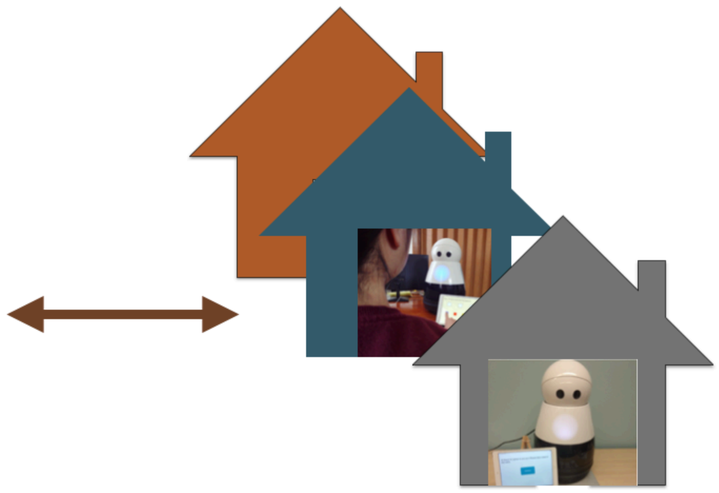
For robots to automatically tailor interventions and adapt to people long term, they need to be able to engage in preference learning. In recent work, we modeled this as a multi-agent multi-armed bandit problem, and designed a new method for preference learning across multiple users. Here, multiple online learning agents are deployed to perform similar tasks and receive similar feedback. We studied how agents can improve their collective performance by sharing information.

We formulated the epsilon-multi-player multi-armed bandit problem as: a set of M players have similar reward distributions, and for each arm play concurrently. Our method adaptively aggregates rewards collected by different players. To our knowledge, we are the first to develop such a scheme in a multi-player bandit learning setting.

Demo and Future Work:







[1] Kubota, A., Peterson, E., Rajendren, V., Kress-Gazit, H., and Riek, L.D. (2020). "JESSIE: Synthesizing social robot behaviors for personalized neurorehabilitation and beyond." In Proc. of the ACM Int'l Conf. on Human Robot Interaction (HRI). [Acceptance rate: 24%].

[2] Guan, C., Bouzida, A., Oncy-Avila, R., Moharana, S., and Riek, L.D. (2021) "Taking an (Embodied) Cue From Community Health: Designing Dementia Caregiver Support Technology to Advance Health Equity". Proc. of CHI '21. pp. 1-24. [Acceptance rate: 26.3%]

[3] Huckans, M., Hutson, L., Twamley, E., Jak, A., Kaye, J., & Storzbach, D. (2013). Efficacy of cognitive rehabilitation therapies for mild cognitive impairment (MCI) in older adults: working toward a theoretical model and evidence-based interventions. Neuropsychology review,

[4] Wang, Z., Zhang, C., Singh, M., Riek, L.D., and Chaudhuri, K. (2021). Multitask Bandit Learning Through Heterogeneous Feedback Aggregation In Proceedings of The 24th International Conference on Artificial Intelligence and Statistics (AISTATS). [Acceptance rate: 29%]

[5] Kubota, A. and Riek, L.D. "Methods for Robot Behavior Adaptation for Cognitive Neurorehabilitation". (2021). Annual Review of Control, Robotics, and Autonomous Systems.

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