NRI: FND: The Robotic Rehab Gym: Specialized co-robot trainers working with multiple human trainees for optimal learning outcomes

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Challenges

How a team of robotic trainers supervised by a human expert can efficiently teach multiple skills to groups of human trainees over a long time period.

- Dynamic multi-robot task assignment with uncertainties.
- Training outcome estimation from trainees' current training performance.
- Human-robot collaborative planning of rehabilitation training.

Scientific Impact

- Contributions to artificial intelligence techniques that can autonomously guide training for groups of humans.
- Contributions to autonomous agents that work collaboratively with a human expert to support each other's decision-making and policy learning.
- Contributions to techniques that enable robots to more precisely quantify human motor skill and potential for improvement.

Solution

- A fully automated multi-robot task allocation and scheduling algorithm based on mixed integer nonlinear programming[1].
- A learning-based approach to train neural networks for dynamic task assignment using human expert demonstrations without complete knowledge about trainee and robot characteristics[2,3].
- A learning-based approach to train neural network models predicting stochastic skill improvement to guide dynamic task assignment[4].
- A framework for human-machine collaborative scheduling to allow continuing learning and adaptation of neural network schedulers.

Broader Impact on Society

Artificial intelligence methods created in this project will be adopted in rehabilitation gyms to enhance training outcome and will be beneficial in other applications of machine intelligence-aided group learning such as sports, surgery, and language therapy. Software was made available to society.

Broader Impact on Education and Outreach

- Project provided training to three graduate students and project results were used to develop interdisciplinary courses in both PIs' universities.
- Results dissemination via international conference, invited lectures and talks.
- Virtual lectures for community college students.

Broader Potential Impact

The project is likely to have an impact on other human-computer interaction areas where autonomous agents interact with and teach skills to groups of humans, and may provide guidance on how human therapists could effectively work with groups of patients in motor rehabilitation.

Publications

[1]Miller, B. A., et al. "Automated patient-robot assignment for a robotic rehabilitation gym: a simplified simulation model." *Journal of NeuroEngineering and Rehabilitation* 19.1 (2022): 126.

[2]Adhikari, B., et al. "Learning dynamic patient-robot task assignment and scheduling for a robotic rehabilitation gym." *IEEE International Conference on Rehabilitation Robotics (ICORR)*, 2022.

[3]Adhikari, B., et al. "Learning skill training schedules from domain experts for a multi-patient multi-robot rehabilitation gym." *to be submitted to Journal of NeuroEngineering and Rehabilitation*, 2023.

[4]Miller, B. A., et al. "Automated patient-robot task assignment in a simulated stochastic rehabilitation gym." *IEEE International Conference on Rehabilitation Robotics (ICORR),* 2023, under review.

2023 FRR & NRI Principal Investigators' Meeting
May 2-3, 2023

Award ID#: 2024813