Course Syllabus

Algorithmic Human-Robot Interaction
Virginia Tech
Spring 2022

1 Description

Self-driving cars, assistive prostheses, and surgical robots are already here — but in order for these robots to succeed, they must seamlessly interact with the humans around them. This course provides an introduction to human-robot interaction. More specifically, this course discusses state-of-the-art learning and control algorithms that enable robots to intelligently collaborate with humans. We will start by developing the mathematical tools needed to model humans and learn from human behavior. We will then extend these tools to enable robots to infer the human's intent and predict how humans will behave. This course will cover safe planning and control algorithms for robots in close proximity to humans, as well as how robots can share control with their human partners. Finally, we will discuss data-driven methods to embed high-dimensional human behavior into low-dimensional latent spaces, and then leverage these embeddings to understand teams with multiple humans and multiple robots. The overarching goal of this course is to formalize human robot interaction. Each student is required to perform a course project that applies this formalism to practical human-machine systems. Students are welcome to propose a project related to their own research; a set of appropriate projects will also be available to choose from. This research project will be treated as a conference submission: students will write a six page paper using IEEE conference format, and then give a 15 minute presentation following the guidelines of the IEEE International Conference on Robotics and Automation.

2 Learning Objectives

Having successfully completed this course, the student will be able to:

1. Articulate the challenges of developing algorithms that support human-robot interaction.
2. Appraise and implement different methods that robots use to learn from human demonstrations.
3. Use Bayesian inference to detect human intent and autonomously assist humans.
4. Apply safe and optimal controllers so that the robots can safely but efficiently operate around humans.
5. Combine human and robot control inputs for assistive autonomy tasks.
6. Plan, conduct, and analyze a user study that involves human-robot interaction.
7. Assess the scientific merits and weaknesses of human-robot interaction research published in scholarly journals.
8. Communicate scientific content to a peer audience.
9. Carry out a research project that involves human-robot interaction and applies course concepts.

3 Instructor

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4 References

- Thomaz, A., Hoffman, G. and Cakmak, M. (2016). Computational Human-Robot Interaction. Foundations and Trends in Robotics. Download here.
- Russell, S. and Norvig, P. (2020). Artificial Intelligence: A Modern Approach. Prentice Hall. Download here.

5 Tentative Schedule

Week	Topics
1	Markov decision processes
2	Cognitive models of humans
3	Bayesian inference
4	Imitation learning and behavior cloning
5	Inverse reinforcement learning
6	Learning from human preferences
7	Human intent detection and prediction
8	Safe planning for human-robot interaction
9	Control strategies for physical human-robot interaction
10	Sharing autonomy between humans and robots
11	Latent representations of humans
12	User study design and statistical analysis
13	Multi-agent teams and decentralized control
14	Student presentations