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CS6501 Formal Methods and CPS Robots S19

Formal Methods Project Proposal

I. Introduction

One major societal consideration since the initial conception of robots has been robots fulfilling the role of a server or companion. A lot of research has been completed on the usage of robots for tasks that are physically difficult or dangerous for humans; however, not as much attention has been given to robot usage in completing more non-physically difficult tasks, such as serving as human companions for the emotionally unhealthy or even as caretakers. While media such as Hollywood movies portrays progress in robotic technology as being advanced enough for such applications, we are far from having humanoids fulfill such roles in our daily lives. One of the reasons is that humans are unique, complex creatures and there are so many different factors included in human-robot interactions that are mostly related to how humans feel towards certain thing and feelings can not be measured correctly. While researchers are just beginning to look into how atomic pieces of human communication could have various effects in human-robot interaction (HRI) scenarios, no research has been done on how robotic systems could optimize their actions to maximize user engagement or interest regardless of the user.

We were motivated to pursue this project based on our enrollment in a course called Robots & Humans in which we work with NAO robots. Our work with these robots includes experimenting with and evaluating HRI interactions related to speech, vision, social cues, and mood, and many of the research done in this area lacks any synthesis of formal methods, leading to many experiments but not many robust designs.

We have considered several constraints in order to make this project feasible. First, we will develop a system that considers two agents: one robot (Player 1), and one human (Player 2). Additionally, we assume an environment within which the players will operate that will have negligible impact on the interaction (qualities of such an environment may include being known by both agents, maintaining a low volume, and maintaining sufficient lighting such that the agents can see each other). Finally, we assume neither the human nor the robot will displace themselves; while stationary movements are allowed, neither agent can change its position in the environment.

II. Methods

A. Tasks

At a high level, we foresee four components to completing this project. First, we will need to find and read papers related to HRI interactions (particularly interactions focusing on the emotional state of the agents involved) and methods for measuring the accuracy of such interactions. Second, we plan on exploring the libraries of the NAO robot, the motivation and potential case study for this project, paying attention to what it has available to detect and portray emotion and mood. Next, we plan on constructing the architecture of our approach, which we expect to consist of building some MDP structure that consists of human emotional states and transitions depicting robot behaviors. We may also need to map out a game architecture like that in the paper we presented in class, and we will need to develop an algorithm to create policies for the players in the interaction. Finally, we plan on implementing this architecture in a robust program, such as PRISM model checker, and if time permits, use this model to conduct a case study on a real NAO robot.

B. Timeline

Our plan consists of three major delivery points: (1) developing an architecture or approach to solve this problem, (2) implementing and testing this approach in PRISM, and (3) implementing and testing this approach on a real NAO robot. We expect to at least get through the first deliverable and ideally get through the second deliverable; if time permits, we will also pursue the third deliverable. Given we have approximately five weeks to complete this project, we plan on allocating about two weeks to conduct our research. Subsequently, we plan on spending the remaining three weeks on architecture construction and implementation, progressing in the order of the deliverables defined above.

III. References

1. Making Social Robots More Attractive: The Effects of Voice Pitch,Humor and Empathy
2. Emotion Encoding in Human-Drone Interaction
3. Synthesis for Multi-objective Stochastic Games:An Application to Autonomous Urban Driving