Nonverbal Communication for Human-Robot Interaction

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Socially assistive robots help people through social interactions, such as tutoring, home assistance, and autism therapy. In my work, I develop socially assistive robots that can recognize and use typical human communication, including nonverbal behaviors such as eye gaze and gestures, to interact naturally and easily with naive human users. My research focuses on modeling users’ mental states to identify what nonverbal communication will be most effective. These models learn to recognize and generate nonverbal cues in human-robot interactions using observations of human performance. This research makes contributions to the fields of human-robot interaction, artificial intelligence, and cognitive psychology. Future work involves real-time adaptation of these computational models of nonverbal communication to personalize the behavior of socially assistive robots to account for goals, environments, and human user preferences.

General Terms: Robotics, Cognitive Modeling, Artificial Intelligence

Additional Key Words and Phrases: Human-robot interaction, nonverbal communication, service robots, assistive robotics

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1. INTRODUCTION

I build assistive robots that make interactions with users less frustrating by understanding and responding to nonverbal communication. Intelligent, autonomous robots can improve people’s lives by providing social assistance: acting as one-on-one educational tutors for children, providing home care assistance for the elderly, and performing as therapeutic agents for people with autism.

During these interactions, people communicate both verbally and nonverbally, using cues like gestures and eye gaze to convey additional information, reveal their mental state, or support verbal communication. To have natural, intuitive interactions with human users, socially assistive robots must be able to understand and generate such nonverbal cues as well.

However, recognizing and generating appropriate nonverbal cues depends on a number of factors, including interaction context, task-related goals, and user preferences. To address this, I develop context-sensitive models of nonverbal behavior that can improve human-robot interactions in socially assistive applications.

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2. CURRENT WORK

Robotics has already improved lives by taking over dangerous, time-consuming, and repetitive jobs, freeing up human capital for safer, more skillful pursuits. For instance, autonomous mechanical arms weld cars in factories; physical rehabilitation patients are aided by robots in performing their physical therapy exercises; and autonomous vacuum cleaners keep floors clean in millions of homes.

The next frontier for robot assistance lies with social, rather than physical, tasks [Feil-Seifer and Mataric 2005]. Robot teaching assistants can make teacher time more effective by allowing students to practice a one-on-one, personalized lesson outside of the classroom. Robot therapy assistants can act as social conduits between those with social impairments, such as autism, and their caretakers or therapists [Scassellati et al. 2012]. Robots at home can help elderly users with tasks of daily living, allowing them to age at home and increasing their independence and quality of life.

To be good social partners, robots must understand and use existing human communication structures. A large part of human communication occurs nonverbally, through eye gaze [Argyle 1972], gestures [McNeill 1992], and other cues. However, nonverbal behaviors cannot be pre-scripted or prerecorded, because socially assistive interactions are dynamic, nonlinear, and often highly personalized to a user. My research focuses on developing models of human nonverbal communication that robots can use during socially assistive tasks to recognize nonverbal communication from a human partner and to generate appropriate nonverbal behaviors in turn.

For these nonverbal behavior models to be flexible in a variety of social situations and for a variety of users, I apply a data-driven approach to learning nonverbal behaviors. I use machine learning techniques to train robot behavior models based on observations of actual human behavior [Admoni and Scassellati 2014]. Although other models generate nonverbal behaviors from human examples, my model allows the reverse process as well: the robot can apply the same learned model to understand the context of newly observed behaviors. This allows robots to not only communicate through nonverbal behaviors, but also understand a human user's communication. This bidirectionality is a critical part of social interaction. Without it, a robot may produce the right kinds of nonverbal behaviors, but is essentially blind to human communication, making it an ineffective social partner.

My joint background in computer science and cognitive psychology enables me to conduct carefully-controlled experiments that quantitatively measure the impacts of robot nonverbal behavior on human-robot interaction. I have studied people’s millisecond-level responses to robot faces as compared with human faces, and have found evidence that robot faces are processed differently from human faces in the first several hundred milliseconds of a person’s attention, even when those robots appear highly anthropomorphic [Admoni et al. 2011]. However, when people can be induced to attribute intentionality to a robot’s gaze, I’ve shown that people understand and respond to robot eye gaze as expected [Admoni et al. 2014b]. I’ve also shown that robots can appear as though they’re “paying attention” to people better when the robots use short, frequent glances rather than longer, infrequent stares to look at people [Admoni et al. 2013]. When conflicts arise between a robot’s verbal instructions and its nonverbal gaze communication during collaborative tasks, people’s performance improves with helpful robot gaze, but does not suffer from incorrect gaze compared to having no gaze cue at all, supporting the benefit of nonverbal communication cues for human-robot interaction [Admoni et al. 2014a].
3. FUTURE VISION

My future focus is on building more sophisticated models of nonverbal communication as a way of learning to recognize and generate appropriate nonverbal cues in collaborative interactions. These models should be able to adapt to their user and environment, and should interface well with models of verbal communication.

Real time machine learning using observations of human behavior enables personalized interactions by adapting the behavior models with interaction-relevant information. Good partners will adapt their own behavior based on cues from others. My model provides the capability to do real-time behavior adaptation through the same learning mechanism that trains the model in the first place. Currently, however, the model is trained on data that is hand-annotated offline. The main challenge of real-time adaptation is autonomous behavior recognition.

Natural language is a primary mode of communication, and nonverbal behavior often serves to augment it. By tying together my nonverbal behavior models with state-of-the-art models in NLP, I look to build robust and application-ready systems that can understand all facets of natural human communication.

Being able to recognize and generate nonverbal behaviors opens up a large avenue of communication for social robots. I anticipate that this contribution will progress the adoption of robots in social environments by increasing peoples’ comfort and trust of social robots, allowing robots to positively impact many lives.

REFERENCES


