Intent Recognition and Plan Adaptation in Human - Robot Interactions

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Abstract

There is enormous potential in Human-Robot interaction and teamwork to improve productivity and living standards worldwide. However, there are equally significant difficulties with human-robot interaction that make it unpalatable and inefficient. The first is that robots are ignorant to the subtle, implicit messages that humans send each other every day. Seamless teamwork and communication involves more than simple command and response interactions. It involves a vast ocean of shared understandings, inferred intentions, and illogical mannerisms. In this paper we explore the optimal way to achieve such interaction in a decision based workflow through the prism of the human experience while implementing the results on actual robots in the lab using intent recognition and plan adaptation for the decisions made by the human.

Introduction

In order to optimize the productivity of human robot teams we wish to create a technical solution that allows robots to be compatible with contingent plans which can incorporate a human's potential actions and react to them accordingly. We call this process intent recognition and plan adaptation. In addition we wish to approach this challenge from the human point of view by analyzing human subjects' interactions with robotic co-workers in a controlled experiment in order to learn the optimal robot mannerisms required for productive teamwork through observations and feedback.

Domain

The scenario modeled in our research on human-robot interaction consisted of a human and robot working together to "set a table" (fig 1). The human makes a choice to get a plate or a cup from the other side of the room. The robot identifies the human's choice and takes the other piece of tableware. The human then chooses to place his Object on one side of the table and the robot places its on the other side, again by recognizing the human's decision and acting accordingly.

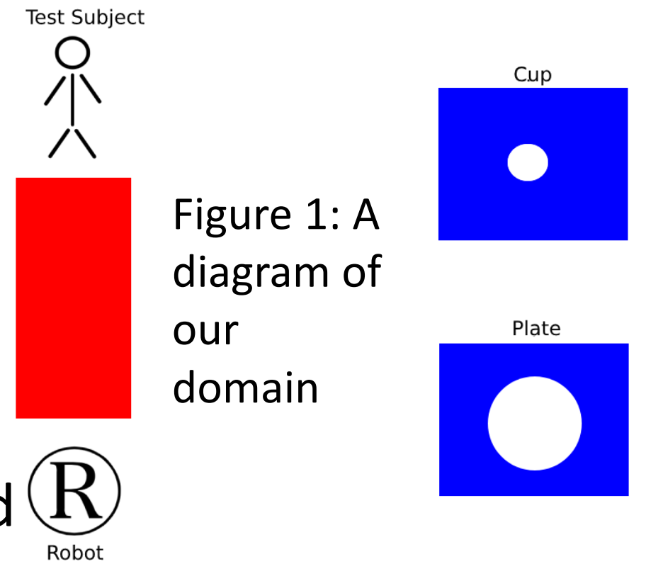

Figure 1: A diagram of our domain

Methods

Two teams were formed in order to work on both programming the robot and conducting the human experiment in parallel.

The experiment team:

In order to design an intuitive and approachable robot that can interact with humans in a more optimal way, it was necessary to first find out how different people react to an autonomous robot. However, due to lack of a fully autonomous robot from the start, the Wizard of Oz scheme was adopted in order to convince the test subjects that the robot was making its own choices.

The Wizard of Oz scheme involves a robot that is manually controlled by a person who is out of the test subject's sight. We used the robot TIAGo as our "autonomous" agent in this experiment, since it has human-like features, and has the ability to talk and pick up objects.

The technical team:

Programming a robot that is able to respond to external actions requires the robot to be able to plan for all possible situations. In our domain there are four possible situations deriving from 2 independent binary choices that the human must make.

When presented with the outcome of each decision, the robot must choose the course of action that suits the new situation. This course of action is called a plan. We modeled the problem using a language called PDDL, and executed it using a Python script within the ROS (Robot Operating System) environment. Simulations were also created using the programs Gazebo and Rviz.

Data & Graphs

The following graphs are the analyzed results of the experiment. Focus was put on the effects of speech on test subject's confusion, eye contact on test subject's comfortability, and speech on the test subject's comfortability.

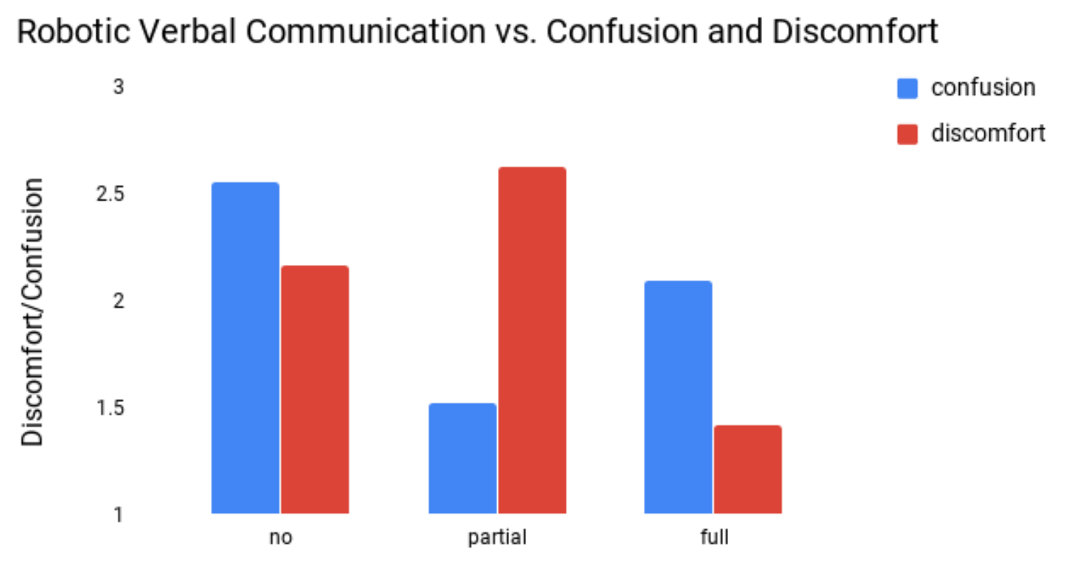

Figure 3

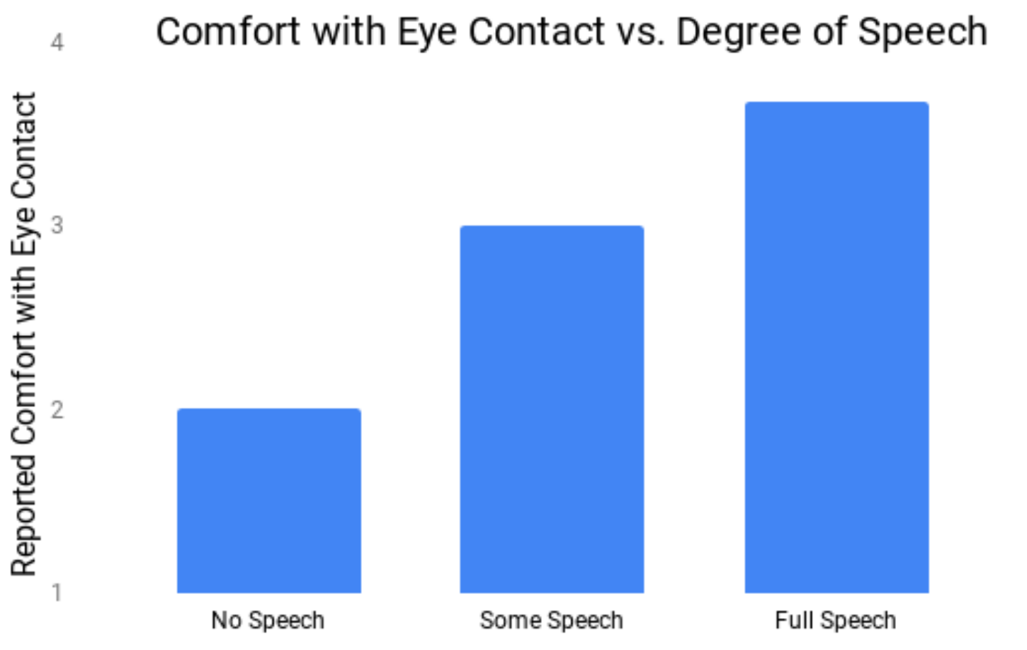

Figure 4

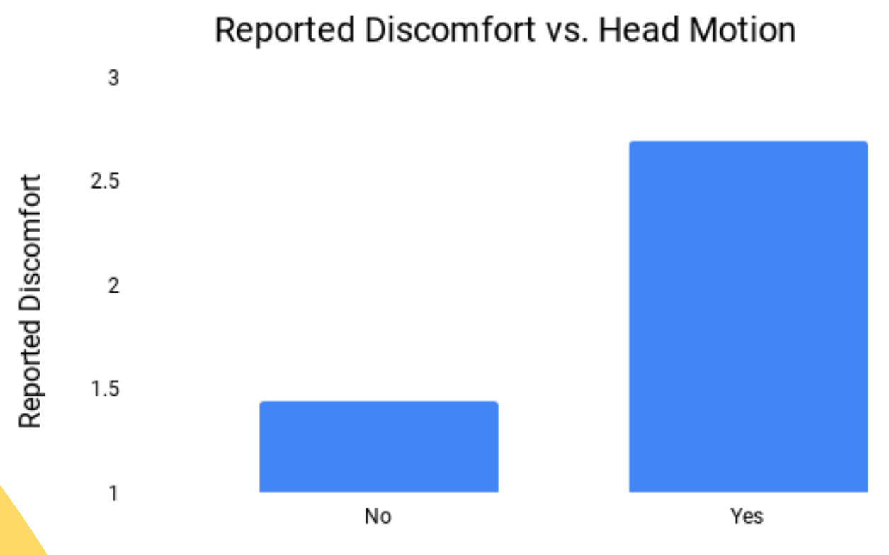

Figure 5

Main Equipment & Software Tools

Experiment

- TIAGo Robot (fig. 2) - multifunctional robot used to survey data from human test subjects
- LogiTech Controller - gaming controller used to control TIAGo
- Legos - building material used to create an environment for the domain

Programming

- ROS - Robot Operating System
- PDDL - Planning Domain Definition Language
- Python - Programming language used to control the robots.
- TurtleBot - robot used in simulation to enact the plan.

Figure 2 : The TIAGo robot

Discussion & Conclusions

By observing test subjects and analyzing their questionnaire inputs indications were found that head motion is positively correlated with test-subject discomfort (fig. 5) and is amplified when head motion is the sole method of communication. Participants who experienced no speech from the robot at all exhibited more confusion than other test groups. Limited robotic speech was seen to increase discomfort in test subjects but decrease confusion. Consistent dialogue reduces discomfort further, but reveals a tradeoff with confusion (fig. 3).

Figure 4 shows a strong correlation between the amount of speech the robot used and the comfort of the test subjects with eye contact.

In conclusion our experiment suggests that humans are often unsettled by robotic head motion and eye contact. However, verbal communication by the robot reduces the discomfort, and is required for optimal results. This implies that humans are more comfortable interacting with robots with anthropomorphic qualities.

Excessive speech was shown to reduce discomfort, but raise confusion. Our claim is that the optimal amount of speech is somewhere between only as much as needed to accomplish the objective and a bit more and varies between different test subjects. The necessary amount of speech is domain specific and cannot be reasonably generalized.

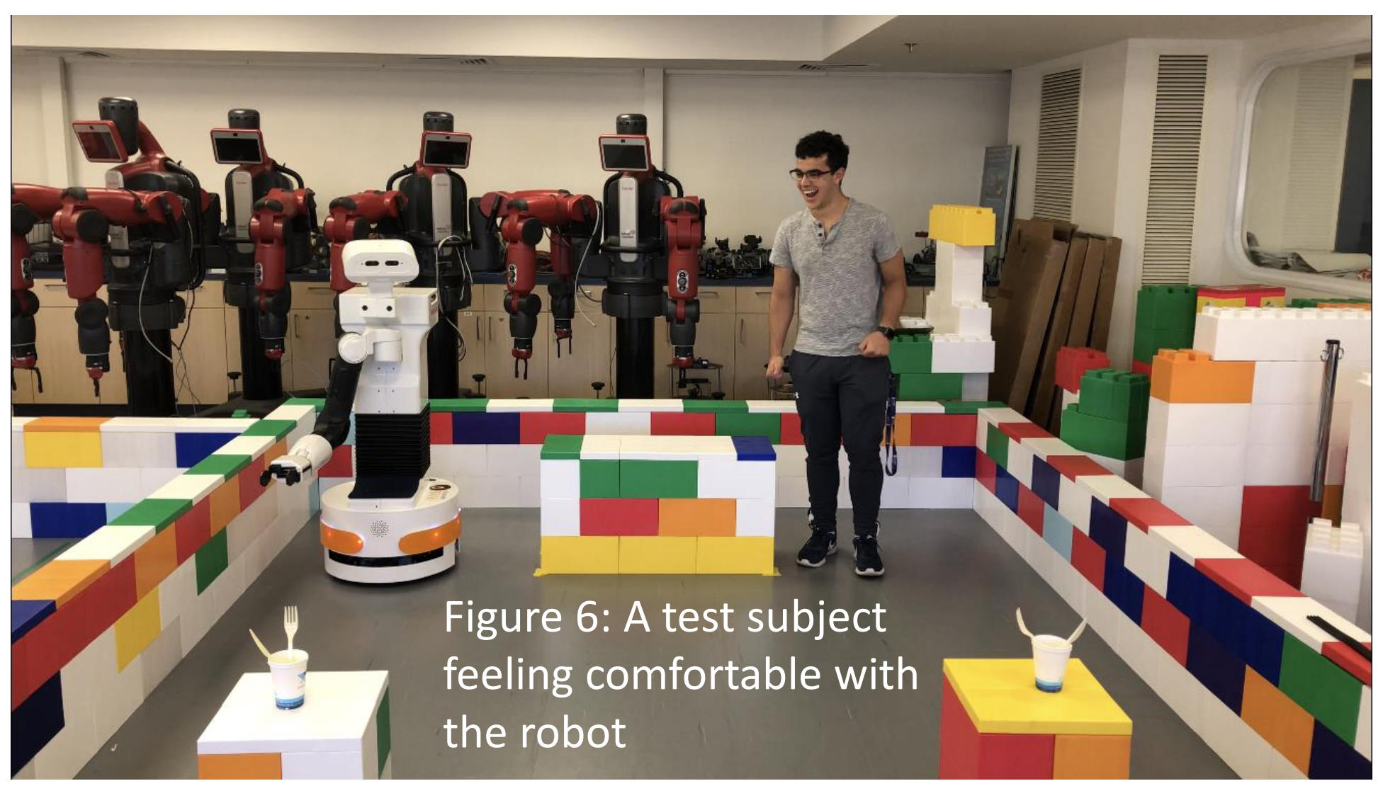

Figure 6: A test subject feeling comfortable with the robot

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