Learning to Deliver Robot-Mediated Behavioral Intervention

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What we Accomplished

We present a learning-based framework that uses a partially observable Markov decision process (POMDP) to model the decision making process of a therapist in a typical intervention setting.

Introduction

- Contemporary research has not only identified that individuals with Autism Spectrum Disorder (IwASD) possess a quantitative interest in interacting with robots, but has also shown the potential for that interest to be focused on learning new and beneficial behaviors.
- Robot mediated Intervention (RMI) research remains limited by its reliance on tele-operation. Automation is a requirement of bringing RMI to a clinical setting.
- Similar work focuses on populations that are more predictable than IwASD and only investigates reactive interactions. IwASD poses many atypical responses and our solution looks at interventions that last multiple time steps.

Figure 1: The NAO humanoid robot greeting a participant.

Applied Behavior Analysis

Applied Behavior Analysis (ABA) has proven popular for designing BIs for IwASD to teach new skills such as social greetings. The intervention we investigated asked the participant to respond in a particular manner, rewarding them if they complied and prompting them further if they did not.

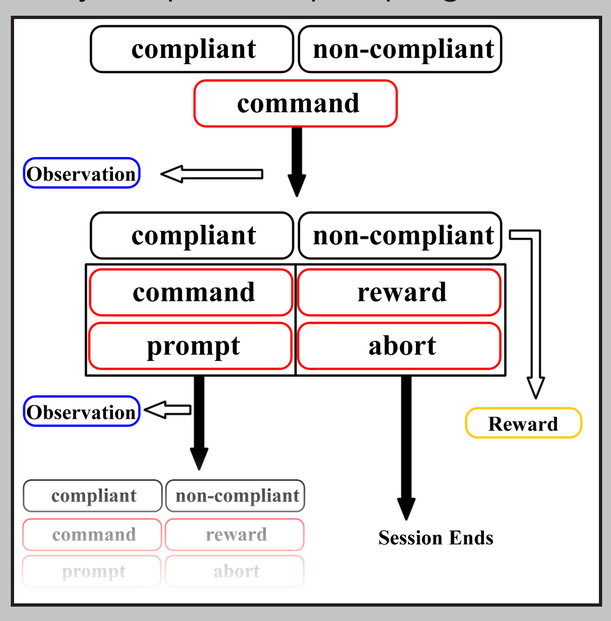

Figure 2: The POMDP model

User Study

- We performed an IRB approved User Study with 11 volunteers without ASD.
- We tele-operated the interaction in order to generate demonstration sessions to train our system.
- Participants performed a combination of compliant and non-compliant interactions.

(a) (b)

A POMDP to Model Social Greeting Intervention

- We used three features to obtain observations from the interaction: gaze location, gestural response, and auditory response.
  - **Gaze Location**: Whether the participants gaze is focused on the robot or not.
  - **Gestural Response**: Whether the participants waved or not.
  - **Auditory Response**: Whether the participants responded by saying "hello".
- From the user study we obtained the probabilities that specific observations and state transitions would occur.
- We used the Perseus POMDP solver to generate an alpha vector policy that listed the action to perform given a specific belief.

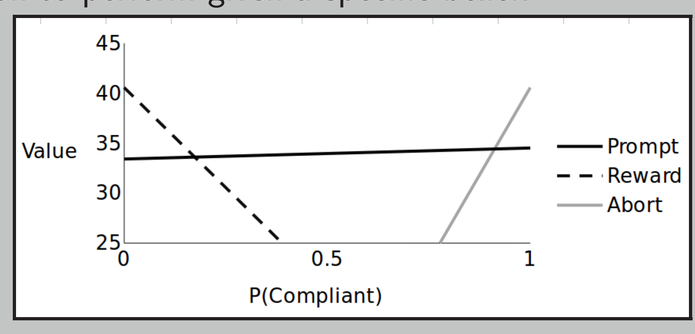

Figure 3: Alpha vectors of the POMDP policy

Evaluation

- Quantitative performance metrics showed that our system was capable of correctly identifying compliant from non-compliant sessions.

Metric	Value
Precision	1.0
Recall	0.925
F_1	0.947

Table 1: Quantitative Performance Metrics

- Results from a subjective measure found that:
  - The robot was easy to use and enjoyable to work with.
  - The naturalness of the interaction was poor

#	Question	Score
1	The robot accurately assessed the state I was trying to emulate.	$\mathbf{3.8 \pm 1.0}$
2	The robot ended the session in a reasonable amount of time.	$\mathbf{4.2 \pm 0.4}$
3	The robot prompted me an appropriate number of times.	$\mathbf{4.0 \pm 1.1}$
4	The robot was easy to understand.	$\mathbf{4.8 \pm 0.4}$
5	Interactions with the robot felt natural.	$\mathbf{3.4 \pm 0.8}$
6	Interacting with the robot was easy.	$\mathbf{4.4 \pm 0.8}$
7	Participating in the robot mediated therapy was enjoyable.	$\mathbf{4.4 \pm 0.5}$

Table 2: Questionnaire Results

Conclusion

- Tele-operatied RMI is not a viable method for delivering BI to IwASD in a clinical setting.
- We have presented an A-RMI that uses a POMDP to model a therapist's actions and their interpretation of observations over several time steps.
- Our system is quantitatively accurate and was commended by volunteer participants.
- Future work will investigate the effectiveness of deep learning techniques.
- We hope to introduce our A-RMI to IwASD.

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