Linking Expressive Behavior and Intention for Robot-assisted Training for Adults with ASD

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1. INTRODUCTION

According to 2011 UK census figures, Autism Spectrum Disorder (ASD) affects 547,000 people over the age of 18 (1.3% of working age adults) [1]. These adults encounter serious difficulties in their everyday life, particularly in securing and maintaining employment. The unemployment rate among adults with ASD is higher than 85%, which is nearly double the unemployment rate of 48% for the wider disabled population and compares to the UK unemployment rate of 5.5%. One reason for this is that people with ASD struggle to correctly interpret social signals, i.e., the expressive behavioural cues through which people manifest what they feel or think (facial expressions, vocalisations, gestures, etc.). This leads to difficulties in correctly interpreting interactions with coworkers and supervisors.

Behavioural Skills Training (BST) [2] is recognized as one of the most effective training approaches for the effects of an ASD. BST is a behaviourist training approach involving phases of instructions, modelling, rehearsal, and feedback in order to teach a new skill [3]. It has been used to teach social skills to people both with and without disabilities [4]. However, BST is too labour- intensive to be widely applied. If robots could be used to help deliver BST, this could reduce the effort required by human trainers and lower the cost of BST application.

While focusing on the particular case of BST for subjects with ASD, this research contributes to the long-term vision of social robots able to seamlessly integrate into our everyday life, opening the way to a multitude of domestic, educational and assistive applications. We argue that the development of successful long-lived human-robot relationships requires transparency of the robot's motives, goals and plans so that its intentional stance is clear to human interaction partners.

2. INTENTION AND EXPRESSION

We will be looking at employer-employee office-based scenarios, aiming to train high-functioning ASD individuals to decode communication signals from their employer. We will focus on broader groups of emotions such as approval (positive) and disapproval (negative) expressions [5]. We will gradually increase the dynamic component of expressions whereby a continuous internal state is reflected by the robot as opposed to the more commonly used discrete expressions [6]. The goal is that the resulting social signals are more "human-like", posing the advantage of increased ecological validity [7] and hence enabling transfer of learning from robot to human incrementally in line with the Reduced Generalisation Theory [8].

While major components of this project concern the recognition of social signals [9] and the low-level production of expressive behavior by the robot, this paper concerns the decision-making and high-level behavioral policies that will determine the robot's expressive responses to the human interaction partner during BST. Our approach to producing policies for the robot is based on the prior work of Broz et al., which used partially observable Markov decision processes (POMDPs) to model socially acceptable behavior for human-robot interaction [10]. The modelling approach taken in this work links a human partner's observable behavior to the unobservable intentions motivating that behavior, allowing the robot to act based on beliefs about the partner's current intention. The agent's own intentions are represented in the reward structure of the model.

One possible extension of this work for this new application area is to expose the agent's reasoning process to the human partner after an episode of interaction. This allows an autistic person to compare their interpretation of the intentions motivating the interaction to the agent's and to correct and learn from misunderstandings during roleplaying. We hope that by modulating the expressive behavior of a robot with a simplified humanoid appearance, we will be able to create ecologically valid training scenarios that allow autistic individuals to repeatedly roleplay common workplace interactions and practice recognizing and interpreting expressive behavior in these contexts. The robot will facilitate this learning by sharing its beliefs about the state progression after an episode of interaction, revealing to the user why certain expressive behaviors were selected. This review may be aided by video playback of the interaction itself in order to allow the user to review the expressive behaviors displayed and focus on important details of the interaction.

3. TRAINING ROLEPLAY FOR ASD

A key component of the approach by Broz et al. was the use of human-human interaction data. In their prior work, humans were instructed to roleplay difference intentional stances in repeated interactions with other people for data collection [11]. While each participant's intention was given for an episode of interaction, their behavior was not prescribed and they were unaware of the given intention of their interaction partner. This roleplaying allowed intentions to be linked to realistic interaction data.

We believe that this human-human roleplay-based approach will also be effective for modelling BST behavioral rehearsal. At a high level, observing human-human roleplay will aid in the understanding of how therapists use expressive behavior during training. Observation of entire episodes therapy will also allow us to understand how therapists give feedback about the link between behavior and the underlying intentions motivating them. Observation of this therapeutic interaction will motivate the design of how the robot should present information about its own internal state and decision-making process to the user after episodes of roleplay.

4. CHALLENGES AND FUTURE WORK

The types of interactions that we need to model for this application are more complex than that modelled in Broz et al.'s prior work, which was evaluated using a simple driving interaction. The range of possible expressive behavior is greater and the possible intentions (and the influence of one partner's intentions on the other's behavior) are likely to be more complex. There are a number of ways in which we intend to address these challenges, both in terms of collecting human data and in terms of dealing with computational complexity.

Our ideal source of training examples is therapeutic roleplaying interaction between therapists and individuals with ASD. However, both of these groups are unfortunately difficult to access in large numbers and for long periods of time. The number of local therapists proficient in BST is relatively small and has a high workload. Bringing members of the community with ASD into a laboratory setting for data collection is similarly difficult.

However, because autism is a spectrum disorder, there is the possibility of using undiagnosed and/or neurotypical members of the public (who are much easier to recruit) as representative of our target groups by classifying them according to where they fall on this spectrum. The tool that we propose to use to do this classification is the Autism-spectrum Quotient (AQ) [12]. The AQ has been shown to be an effective screening tool for ASD [13] which gives a score of 0-50 indicating the prevalence of autistic-type traits in an individual. Research has been conducted showing a degradation in performance in non-ASD individuals corresponding to AQ score for tasks in which ASD is associated with degraded performance (concept formation) [14]. We intend to assign roleplay roles to non-ASD experiment participants according to whether they are low-AQ (employer role) or high-AQ (employee role).

While intentional roles can be assigned, how to accurately characterise the expressive behavior that takes place in human-human roleplay is more difficult. One means of classifying the this behavior is through video coding by experts. This coding of multimodal expressive behavior can also provide ground truth labels for automated social signal processing classification algorithms.

A challenge of applying POMDP planning to complex, realistic interactions is creating models that produce high quality policies that can be solved for in a reasonable amount of time. One potential way of keeping these problems tractable is to take advantage of the fact that part of the state space is observable by modeling the interactions as mixed observability Markov decision processes (MOMDPs) [15, 16]. Another challenge of this modeling approach is defining a reward function that produces socially appropriate behavior. One alternative to tuning reward functions by hand would be to use inverse reinforcement learning with the interaction trajectories from the human-human roleplay to learn reward functions that capture these behaviors [17].

5. CONCLUSION

This research proposes to use a POMDP-based approach to producing behavior for a robot that roleplays BST workplace interactions with people with ASD. The POMDP formalism allows the robot's expressive behaviors to be associated with the unobservable intentions motivating them. By revealing its belief state to the user after episodes of interaction, the robot can make this association between intention and expressive behavior transparent, improving users' ability to learn to interpret the behavior of others from this training. Both therapists and individuals with ASD are groups that are difficult access in large numbers and for long periods of time for data collection. Use of the AQ to classify people by their prevalence of autistic traits will allow human-human interaction data to be collected from a non-specialist population, mitigating the challenge of collecting sufficient data.

6. REFERENCES

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