Towards an Embodied Simulator of Autistic Child Behaviors: an Improved Method for Selecting Simulated Behaviors

Kim Baraka
Robotics Institute, Carnegie Mellon University, Pittsburgh, PA, USA
INESC-ID / Instituto Superior Técnico, Universidade de Lisboa
Lisbon, Portugal
kbaraka@andrew.cmu.edu

Francisco S. Melo
INESC-ID / Instituto Superior Técnico, Universidade de Lisboa
Lisbon, Portugal
fmelo@inesc-id.pt

Manuela Veloso
Machine Learning Department, Carnegie Mellon University
Pittsburgh, PA, USA
mmv@cs.cmu.edu

ABSTRACT

We built a behavioral simulator of structured interactions with autistic children of different severities. Our simulator, named ABASim, uses a behavioral model from the state-of-the-art diagnostic tool for autism, namely the Autism Diagnostic Observation Schedule (ADOS-2). On the other hand, we built a prototype of a customizable robot exhibiting typical autistic behaviors according to a restricted version of the same ADOS-2 model. The robot can be customized to display different severities and forms of autism, and autonomously responds to predefined multimodal stimuli, emulating an interaction with a child with autism. We present here an additional step towards interfacing the ABASim simulator with an embodied agent such as a humanoid robot. We specifically contribute an improved algorithm for selecting behaviors from a dataset according to the features characterizing the simulated child based on conflict resolution between behaviors unlikely to co-occur. This contribution brings us closer to our long-term goal of having a fully embodied simulator of behavioral responses of children with autism of different severities under structured interactions, which may have a number of applications including improved therapist training, novel autism therapy tasks involving robots, and education.

KEYWORDS

Behavioral simulation, Autism, Social agents

1 INTRODUCTION AND BACKGROUND

This works builds upon a series of previous works on simulating behaviors of children with Autism Spectrum Disorders (ASD) of varying severities, in the context of structured interactions used for ASD diagnosis. We foresee several real-world applications to the idea of embodied simulation of ASD behaviors in agents such as humanoid robots. Current therapist training for ASD diagnosis, ignoring the important interactive and embodied component of diagnostic procedures, may greatly benefit from additionally utilizing interactive robots capable of exhibiting typical ASD behaviors in response to standard stimuli. Also, such robots could be used for educational purposes such as classrooms or museums to educate people about potential behavioral differences in individuals with ASD. Last but not least, the ability to simulate expected behaviors of children with ASD has the potential to inform the autonomy of robots used for autism therapy, potentially enabling automated adaptation and personalization mechanisms.

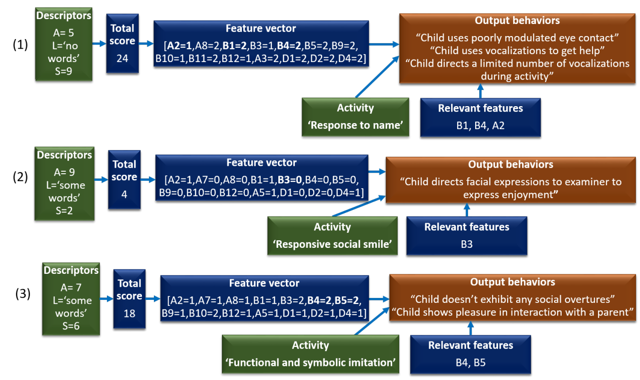

Figure 1: Three examples of ABASim simulating behaviors for specified child descriptors and activity. We show the pipeline from inputs to output, which is based on models from the ADOS-2. For more information, please consult [2].

1.1 Simulator overview

We built a simulator, named ABASim [2], based on a behavioral model from the state-of-the-art diagnostic tool, the Autism Diagnostic Observation Schedule (ADOS-2) [3]. It algorithmically reverses the diagnosis pipeline to stochastically output behaviors starting from high-level descriptors of the child, namely the age (A), language ability (L), and ASD severity (S), as illustrated in Fig. 1.

1.2 Customizable 'autistic robots': an embodied behavior visualization

In addition, we designed and validated a set of robot behaviors that correspond to behaviors typically observed in children with varying ASD severities. We integrated those behaviors as part of an autonomous agent running on a NAO humanoid robot. Features can be controlled directly by the user and influence the responses of the robot to the different standard stimuli used, inspired by the ADOS-2 activities. Fig. 2 summarizes the architecture of our system.

2 METHOD FOR BEHAVIOR SELECTION

In our previous work [2], we output behaviors by first constructing a subset of relevant behaviors, given the feature values to be simulated and the relevant features for a specific activity. From this subset, the algorithm selected behaviors randomly (one for each relevant feature). This method had some issues since it often

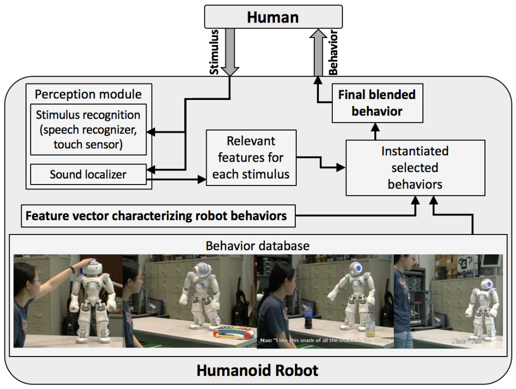

Figure 2: Architecture of our customizable 'autistic' robots. For more information, please consult [1].

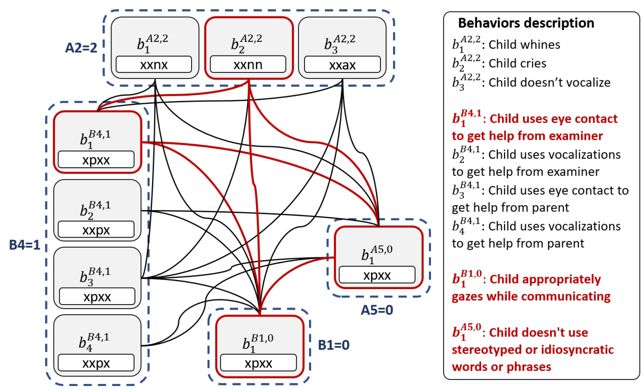

Figure 3: Sample behavior compatibility graph for instantiated feature values. Behavior $b_i^{f,v}$ corresponds to feature f with value v, and indexed i. In red: choice of pairwise compatible behaviors.

outputted behaviors that were incompatible, in other words, whose descriptions somehow contradicted themselves. Examples of incompatible behaviors are: "Child exhibits an odd cry and **no other vocalizations**." and "Child **vocalizes** to be friendly", or "Child uses **poorly modulated eye contact** to initiate social interaction." and "Child uses **eye contact** to get help.".

2.1 Graph representation of behaviors

We introduce a graph representation of behaviors, where nodes represent behaviors and the presence of an edge between two nodes signifies that the two corresponding behaviors are compatible. Due to the large number of behaviors, we cannot possibly define by hand the compatibility of every two pair of behaviors, so we have to automate it. Figure 1 shows a sample graph for four features, namely A2 ('Frequency of vocalizations'), B4 ('Integration of gaze during social overtures'), B1 ('Unusual eye contact'), and A5 ('Stereotyped use of words'), considered relevant for activity 'Response to name'.

2.2 Building the behavior compatibility graphs

For each activity and combination of feature values, one can build the compatibility graph containing relevant behaviors as nodes, with edges between compatible nodes that don't belong to the same feature. As an approximate solution for specifying behavior compatibilities, we introduce *behavioral channels*, corresponding to dimensions of social behavior in relation to an embodied agent. The behavioral channels we consider are: Body motion, Gaze, Speech, Emotion/Facial expression, but could differ according to the agent or simulation purpose. On each of those, we define 4 possible values:

- x: no mention of specific behavioral content on channel
- a: specified absence of behavioral content on channel
- p: presence of 'positive' behavioral content on channel
- n: presence of 'negative' behavioral content on channel

To each behavior, we associate a behavioral channel vector consisting of four values, one for each channel, listed in the order above under each node in Fig. 3. Compatibilities are determined according to valid combinations of the above values (n, p, and a should not co-occur on the same channel for two compatible behaviors).

2.3 Work in progress: Evaluation

We are currently working on evaluating our behavior selection algorithm against a baseline, as well as behaviors observed in real ADOS-2 sessions. The study will involve trained therapists looking at simulated scenarios and answering questions subjectively based on their experience with real scenarios.

3 CONCLUSION

This work has presented a step towards a realistic embodied simulator of behaviors of children with ASD in the context of structured interactions, inspired by the ADOS-2 diagnostic tool. In particular, we described an improved method for selecting behaviors from a dataset of possible behaviors, which takes into account compatibility between pairs of behaviors.

In the future, in addition to evaluating our method as well as the feasibility of its numerous applications, we are designing robot-led activities for children with ASD, inspired by the ADOS-2, where we could use the ABASim simulator as part of an agent controlling the robot's actions to adapt to individual differences

ACKNOWLEDGMENTS

This research was partially supported by the INSIDE project, funded by the CMUP-ERI/HCI/0051/2013 grant, and national funds through Fundação para a Ciência e a Tecnologia (FCT) with reference UID/CEC/50021/2013. The views and conclusions contained in this document are those of the authors only. The authors would like to thank the contributors of the ABASim code, as well as the team at the Child Development Center of the Hospital Garcia de Orta in Almada, Portugal, for their precious collaboration.

REFERENCES

[1] Kim Baraka, Francisco S Melo, and Manuela Veloso. 2017. 'Autistic Robots' for Embodied Emulation of Behaviors Typically Seen in Children with Different Autism Severities. In *International Conference on Social Robotics*. Springer, 105–114.
[2] Kim Baraka, Francisco S Melo, and Manuela Veloso. 2017. Simulating behaviors of children with autism spectrum disorders through reversal of the autism diagnosis process. In *Portuguese Conference on Artificial Intelligence*. Springer, 753–765.
[3] Catherine Lord, Michael Rutter, Pamela Dilavore, Susan Risi, Katherine Gotham, and Somer Bishop. 2012. *Autism diagnostic observation schedule, second edition*. Western Psychological Services, CA.