• 1 in 68 children have been diagnosed with autism spectrum disorder (ASD). ASD is the fastest growing developmental disorder.
• Treatment is classified into: focused interventions that produce behavior or developmental outcomes, and comprehensive treatment models (CTMs). One of the most widely used CTM interventions is Applied Behavioral Analysis (ABA).
• ABA therapists use discrete trial training (DTT) in which tasks are broken down, and appropriate behavior is reinforced to the child.
• Robotic technology is a promising approach for ASD applications for its affordability, multimodal interaction, and ability to provide repeatable, standardized stimuli while quantitatively recording and monitoring performance progress of the child.

THE PABI ROBOT

• We developed a humanoid social robot, PABI (© Dickstein-Fischer) which stands for “Penguin for Autism Behavioral Intervention” as part of our efforts to investigate the potential of robotics as diagnostic, therapeutic, and early-intervention tools for children with neurodevelopmental disorders.
• The PABI is a penguin-like humanoid robot that is unique in that it was purpose-built for this application (Fig. 1).
• Through facial expressions, body motion, verbal cues, vision-based tracking, and a tablet computer, the robot is capable of interacting meaningfully with an autistic child using the architecture in Fig. 2.

IMPLEMENTED CTMS

• Implemented Matching to Sample (MTS) application where the child interacts with stimuli presented on a touch screen tablet computer wirelessly interfaced with the robot (Fig. 4-left).
• The tablet application is developed as an Intelligent Tutoring System (ITS) to accompany the PABI robot and also provides the therapist with comprehensive logged data for easy access and modification of the therapy.
• The robot makes meaningful gestures, expressions, and utterances
• Uses cameras in eyes to track the child, assess gaze direction, and maintain eye contact (Fig. 3-right).
• Uses an RGB-D camera to assesses affect and gestures, and track pointing direction (Fig. 3-right).

ADAPTIVE ABA THERAPY THRU RL

• Implementing an adaptive ABA therapy that develops a model of the autistic child’s skill level and adapts the therapy accordingly.
• Exploring the use of reinforcement learning (RL) to optimize the therapy session to improve the child’s learning and progression through the treatment plan thru:
  • Type, number, and order of stimuli presented
  • Type and level of prompting and cues provided
  • Social interaction between the robot and child
  • Reward presented to the child during the session
• We anticipate that RL with a common goal structure (symbiotic learning) will result in a child better learning behaviors and the robot better learning to successfully teach those behaviors.
• The policy of the robot, within the constraints of a DTT curriculum, is intended to maximize the likelihood of a child successfully progressing through the states of the curricular workflow.

In traditional ABA, the child is rewarded for correct responses and successful completion of curricula milestones. In RL, the system accumulates reward based on its performance towards a given goal. The proposed treatment modality represents a unique case, wherein there is a common reward structure for the child and the robotic therapist. We anticipate that the use of RL with a common goal structure will result in a child better learning behaviors and the robot better learning to successfully teach those behaviors. We are beginning clinical trials and looking to accumulate sizable datasets.

Acknowledgements: Thank you to Dr. Gregory Fischer and Ayesha Fathima from Worcester Polytechnic Institute in collaborating on hardware system development.