Music-Based Emotion and Social Interaction Therapy for Children with ASD Using Interactive Robots

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Abstract: With the number of children being diagnosed with Autism Spectrum Disorder (ASD) on the rise, finding new therapeutic approaches - especially in the domain of emotional and social interaction - is becoming more of a concern. The purpose of this research is to develop and evaluate a multisensory robotic therapy system to stimulate the emotional and social interactivity of children with autism and to integrate music into the learning environment in hopes of observing if and how it could help children in relating body movements and gestures to specific emotions.

I. Introduction

Autism Spectrum Disorder (ASD) is a broad spectrum of disorders that can, to varying extent, bring social, communication, and behavioral challenges. [1] The number of cases has increased in children born between 1992 to 2002 with 1 in 150 children being diagnosed in 1992 to 1 in 68 children in 2002. On average, as of 2014, Autism services cost U.S. citizens between $236-262 billion annually. [2] These various services include school district costs towards servicing special needs children, including children with ASD. [3] Studies have shown that early diagnosis and intervention can cut these national costs by as much two-thirds. One such early intervention service is sensory integration therapy. Through the exposure of sensory elements such as sights, sounds, and smells, a child can learn and develop methods to deal with irritations and sensory overload at an early age.

Past studies have shown that robots excel in singling out and “articulating” emotions to autistic children when compared to humans. Conversely, humans can sometimes display multiple emotions at once. A human’s body movements, when coupled with contradicting facial cues, often complicate an autistic child’s ability to distinguish the intended emotion leading to a wave of sensory overload. Recent studies have shown a strong connectivity within the neural domains for emotion, music and motor skills. This research aims to integrate music into the learning environment in hopes of observing if and how music could further help children in relating body movements and gestures to specific emotions.

II. Methods

Our interactive robotic framework involves two robots: one humanoid robot and one iPhone-rover type robot. The humanoid robot displays dynamically varied body movements and gestures as shown in Fig. 1, while the iPhone-rover type robot displays facial cues corresponding to specific emotions. The original face on the iPhone application tied with the rover type robot was a googley-eyed monster-looking creature, shown in Fig. 2, whose facial features would bounce around the screen while displaying emotions. This didn’t seem to be either child friendly or conducive to pinpointing specific facial emotional cues. Therefore, the application was modified to display the face of a more child friendly penguin whose facial features remained in place when displaying emotions, shown in Fig. 3.

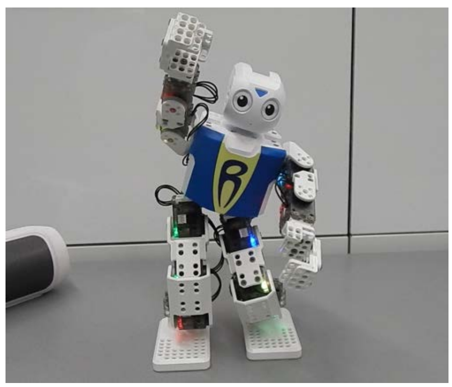

Figure 1. Humanoid robot displaying body movements associated with happiness.

 

Figure 2 (Left). Original design showing monster-like face.
Figure 3 (Right). Modified design showing penguin face.

The testing method will begin with the child observing each robot separately as each displays emotional cues corresponding to specific emotions with music playing simultaneously in the background. The hope is that the music will help the children retain the correlations they observe. The child will then watch as each robot is guided through through a maze with specific sections that would normally invoke a sensory overload during hearing, smell, taste, sight, and balance scenarios, as shown in Fig. 4. The child can then see which emotions each robot uses to react to these scenarios and will hopefully mimic what the robots do in a real life scenario.

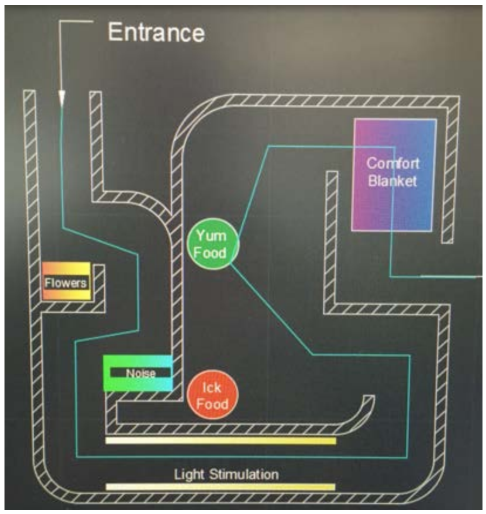

Figure 4. Course design of sensory overload stages.

The aforementioned course was designed to mimic a Lego/Lincoln Log aesthetic so as to build a fun environment familiar to the child, as seen in Fig. 5. With logistics in mind, each component of the course was also designed to be detachable and and easily stored. For the Sight and Hearing stages, a sonar distance tracking program is implemented on a Raspberry Pi to sense when the robot is nearing the sound or sight overload scenarios to either play a sound or shine a light, respectively, as shown in Fig. 6.

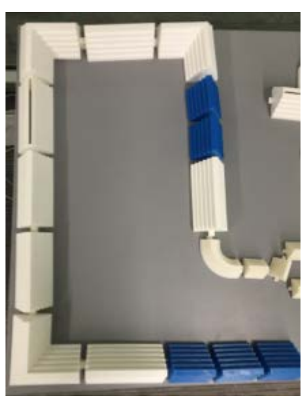

Figure 5. Section of course as an example of the design and layout.

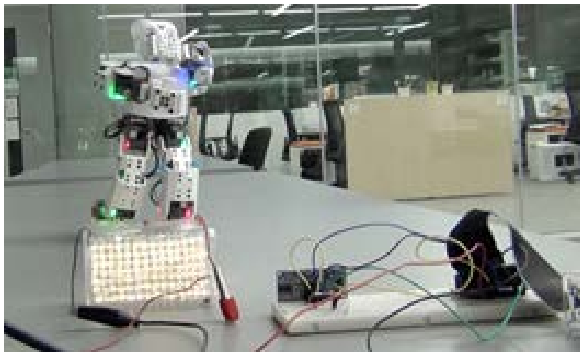

Figure 6. Raspberry Pi sonar distance sensor turns light on as humanoid robot approaches.

In order to assess the effectiveness of the robot's interaction with the children, the emotional state of the child will be monitored over the time in which the child is interacting with the robot. This will be done using a Kinect-based motion detection system that two other lab members are currently developing, and a speech analysis system. These systems will be able to analyze speech patterns and motion sequences in order to determine the level of engagement the child has with the system, as well as their emotional state. By knowing the child's engagement level and emotional state, the system will be able to interpret this information and make corrections accordingly. This will also help the system modify the emotions being displayed if the child is determined as being in distress, in order to help alleviate the child's emotional state. This process is shown in block diagram form in Fig. 7. These analysis components are currently in the development stages. Currently, analysis of interaction takes place after the course has been completed. Looking forward, the system will become fully autonomous so that it can be easily sent to clinics to start trials with autistic children.

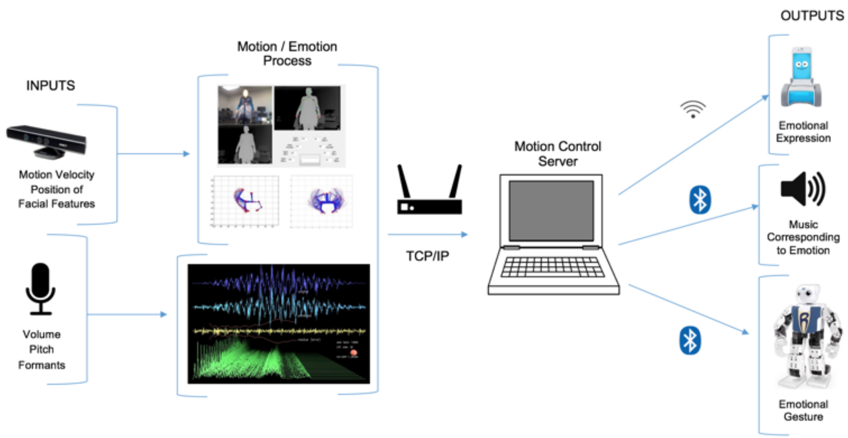

Figure 7. Block diagram showing the inputs and outputs of the system.

V. REFERENCES AND ACKNOWLEDGEMENTS

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