Robotic Framework for Music-Based Emotional and Social Engagement with Children with Autism

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Abstract

This extended abstract introduces the concepts of a new collaborative effort to develop a robotic framework for interacting with children with autism using auditory cues and music to promote emotional and social engagement and interaction.

1 Introduction

In the United States, the rapid increase in the population of children with autism spectrum disorder (ASD) has revealed the deficiency in the realm of therapeutic accessibility for children with ASD in the domain of emotion and social interaction. There have been a number of approaches including several robotic therapeutic systems (Feil-Seifer and Mataric 2008; Scassellati, Admoni, and Mataric 2012) displaying many intriguing strategies and meaningful results. However, the spectral diversity of ASD is so vast that we still need to push forward research to provide parameterized therapeutic tools and frameworks.

To overcome this challenge, state-of-the-art techniques must still be developed to facilitate autonomous interaction methods for robots to effectively stimulate the emotional and social interactivity of children. We focus on the recent studies that reveal strong relevance in premotor cortex among neural domains for music, emotion, and motor behaviors (Kohler et al. 2002; Molnar-Szakacs and Overy 2006). We propose that musical interaction and activities can provide a new therapeutic domain for effective development in the children's emotion and social interaction.

The objective of the research is to design novel forms of musical interaction combined with physical activities for improving social interactions and emotional responses of children with ASD. We present our initial design schemes of the robotic framework to utilize musical stimulus for initiating engagement and deepen interaction in emotional and social relationships through interactive robotic sessions.

2 Background

A form of auditory stimulus, called rhythmic auditory stimulation (RAS), is well-established in neurological rehabilitation and therapy (Thaut et al. 1999; Kwak 2007). RAS is a method in which the rhythm functions as a sensory cue to induce temporal stability and enhancement of movement patterns by providing a temporal constraint for the patient's internal optimized path of motion. In this sense, RAS can be an effective means for inducing social engagement and emotional activities. Neurological studies (Rizzolatti and Craighero 2004) have shown that activity in the premotor cortex may represent the integration of auditory information with temporally organized motor action during rhythmic cuing. Based on this theory, researchers have shown that RAS can produce significant improvements in physical activities (Pacchetti et al. 2000). Given that music has shown such a long history of therapeutic effects on psychological (Siedliecki and Good 2006) and physical problems (Harmon and Kravitz 2007), we suggest that music, being a metaphysical integration of sound elements formed around emotional flow and thematic context, can serve as the effective and higher-level stimulus for emotional and motor responses of children with ASD.

To effectively utilize RAS with a robotic system for human-robot interaction, we design a framework composed of functional components for 1) music-based robot motion generation for physio-musical stimulus, 2) human emotion detection for emotional engagement estimation, 3) human motion detection for physical engagement estimation, and 4) robot intelligence module for increasing engagement and interaction with activity and emotional interaction. In this paper, we present our initial design of robotic motion generation and human motion detection to effectively engage with children with ASD.

3 Interactive Robotic Framework

For interacting with children with ASD with the intention of having clinical effect on emotional and social interaction, the system needs to be able to detect emotional and social states of a child. Once perceived, it is imperative that the robotic system display appropriate expressive behaviors and stimulating motions to engage in emotionally and socially

based on the sensed emotional and social states of the child.

3.1 Human Motion Detection and Analysis

As popularly used, we use RGB-D depth sensors (e.g. Microsoft Kinect) to monitor the physical activities of a child to estimate the social engagement. To evaluate the participants' physical activities and social interaction, we will incorporate metrics from physical therapy and rehabilitation (Brooks and Howard 2010). For assessing the participants' gestures and small motions, we have determined from the literature that the best approach for our problem is to use the following metrics: range of motion (ROM), path length (PATH), peak angular velocity (PAV), movement time (MT), spatio-temporal variability (STV), and movement units (MUs). Besides these parameters, we will also utilize the child's specific motions or gestures to train the robot for inducing more attention from the child.

3.2 Robotic Motion Generation

For a robotic platform, we will initially utilize a small robot from Romotive.com, called Romo1. As depicted in Figure 1-(a), the robot is capable of displaying various emotions through facial expressions, sound, and motions. We plan to utilize the sensory input from the motion monitoring and analysis module to regulate various parameters of the robot (e.g. speed, volume, and range of motion) toward more enhanced interaction with the child. Mapping between sound/musical signals (to be designed) and robotic motion/behaviors will be based on a simplified version of a two dimensional mapping of affect by Larsen and Diener (Larsen and Diener 1992).
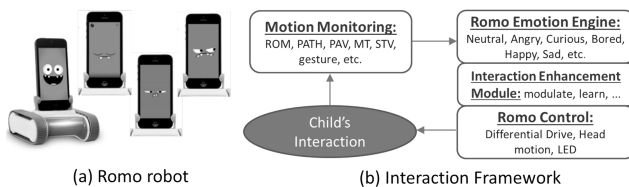

(a) Romo robot   (b) Interaction Framework

Figure 1: Romo robotic platform with emotional facial expressions.

From many previous studies in robotic motion generation with music (Shiratori, Nakazawa, and Ikeuchi 2004; Aucouturier 2008; Hoffman and Weinberg 2010), we plan to integrate robotic intelligence with musical stimuli focused on the therapeutic domain of children with ASD.

4 Future Work and Discussion

This article itself represents our future work, since this is a newly starting research endeavor. However, what the authors would like to keep in mind is the purpose of this robotic study: we ultimately aim to promote human-human interaction through this human-robot interaction framework, and we plan to incorporate as many ideas and comments from clinicians and therapists as possible to better understand and assist the children with ASD through our studies.

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