Robot-based Therapeutic Protocol for Training Children with Autism

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Abstract— Robots are commonly used artificial agents with powerful capabilities in navigation, perception and execution in the physical world. One interesting question is how well robots can assist and engage individuals with social and behavioral deficits (such as autism) to acquire new skills? Preliminary studies in autism research demonstrate that in many cases individuals with Autism Spectrum Disorder (ASD) interact more actively and engagingly with robots than humans. As there are limited investigations for utilizing robots in social and behavioral treatments of individuals with ASD, we designed and evaluated a robot-based intervention protocol using a social robot (NAO) to deliver behavioral training mechanism for children with ASD. Results of our pilot study on seven verbal children with high functioning autism show behavioral response improvement, including pointing and facial expression recognition in the majority of the participants as a consequence of the behavioral intervention delivered directly through the robot. Results also show that individuals were able to engage in these learned skills during human-human follow-up sessions.

I. INTRODUCTION

Robots with unique mechanical capabilities and artificial intelligence features have been designed at much higher rates in last decade than before. Many of these robots have a small body with several sensors and Artificial Intelligence (AI) capabilities targeted toward human interaction. Such attributes have enabled researchers to utilize such robots in different applications, such as behaving like social companion-bots and personal assistants. Two of the robots that have been recently introduced to the market are Jibo (small table-top assistant robot) [1] and Pepper (humanoid robot that speaks in four languages) [2] that will be released in 2016. With this emergent number of companion-bots and improved hardware capabilities, researchers can investigate the uses of robots in a wider range of applications. As an example, health care and therapeutic treatments involving social aspects are categories where robots can potentially be applied in a large-scale. In this paper, we introduce a longitudinal robot-based therapeutic protocol to monitor the social engagement of individuals with autism and provide subject-dependent therapeutic feedback.

Autism Spectrum Disorder (ASD) refers to a developmental disorder that affects social and communicative behaviors. As reported by the Center for Disease and Control Prevention 2014, one in 68 American children has been diagnosed with ASD with an approximate annual increase of 10 to 12 percent [5]. According to *The Diagnostic and Statistical Manual of Mental Disorders* [3], individuals with ASD experience deficits in social-emotional reciprocity, verbal and nonverbal communication behaviors, and deficits in development and maintenance of relationships [3]. Characterized as an early brain developmental disorder, ASD can be diagnosed in an individual as young as 2 to 3 years of age [19], [7] and early intervention on social and communication skills at a young age result in better outcomes for children with ASD [24].

With this increase in prevalence and need for early intervention, various interventions have been developed for treating children and young adults with ASD [28]. In the 2014 National Autism Center Report, 27 interventions with well-documented evidence exist for behavioral intervention of ASD [28]. Each of these interventions consists of Applied Behavior Analysis (ABA) techniques using systematic ways of producing replicable procedures [28]. Although the majority of existing interventions are delivered through human-to-human interaction, the most recently accepted intervention utilizes Technology-aided Instruction, where technology is referred to as any electronic item/ equipment/application/or virtual networks [20]. While technology-based intervention has been a relatively new intervention procedure, it has been growing rapidly due to the recognition that many children with ASD show a collective interest toward technology [23]. With the advancement of robotic technology, investigation on the use of Socially Assistive Robots (SAR) for treatment of ASD has grown recently [11], [4], [6], [21]. Studies such as [16] have shown that children with ASD increase responsiveness and interaction with a human when paired with a robot rather than with another human or computer screen. As noted by [11], it is hypothesized that the robot's advantage is likely due to its simplified social complexity versus a human. Thus promising results in the use of robots for treatment of ASD has promoted further study of clinical applications for interactive robots.

A few quantitative studies have been published that investigate the use of robots for teaching or improving social skills [23]. Some of these include Duquette et al. [11] and Warren et al. [26]. [11] compared the efficacy of using either a human or robot mediator (Tito) for different social skills. Results show that the two children diagnosed with ASD were better capable to imitate body movements when interacting with a human mediator than those paired with Tito. However, [11] noticed that participants had a heightened interest to their robotic mediator than the human explained by the attracting characteristics of the robot such as lights, color,

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