Automated Caricature of Robot Expressions in Socially Assistive Human-Robot Interaction

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***Abstract*—Children with autism spectrum disorder suffer from a deficit that prevents them from observing, interpreting, and learning social cues. Clinical studies in social skills training have proposed methods, such as exaggeration, to enhance autism intervention strategies. Socially assistive robotics is an area of human-robot interaction that has the potential to improve social activity. Inspired by several principles of animation, such as *staging*, *exaggeration*, *anticipation*, and *secondary action*, we propose the use of caricaturized behaviors for a robot providing social skills training for children with autism.**

Keywords-Human-robot interaction, socially assistive robotics, autism, caricature, exaggeration, expression, animation.

I. Introduction

Children with autism spectrum disorder (ASD) suffer from a social deficit that prevents them from observing, interpreting, and learning nonverbal behavioral cues present in a "typical" social interaction. The face and body posture often express emotion or engagement. Eye gaze, head orientation, and other pointing gestures are often used to establish joint attention or communicate intent. These cues are sometimes subtle and, for children with ASD, often go unnoticed. However, clinical studies in social skills training have proposed methods, such as exaggeration, to enhance autism intervention strategies [1].

Socially assistive robotics is an area of human-robot interaction that has the potential to improve social activity [2]. Preliminary work in the Interaction Lab has shown that repetition and persistence of a communicative gesture influence the perceptions of a typically developed participant in an interactive game-playing scenario [3]. We follow up on this observation and apply principles of animation to caricaturize expressive behaviors in an interactive robot within the context of social skills intervention for children with autism.

II. Background

In their eight laws of aesthetic experience, Ramachandran and Hirstein (1999) discuss the neuropsychological peak shift principle with regard to caricature in art. The peak shift principle states that an animal will exhibit a stronger response to an exaggerated version of a stimulus, rather than the stimulus upon which it has been trained or is most familiar. The animal learns to identify the stimulus based on distinguishing ("isolating") features, such as shape or proportions [4]. The amplification of a feature creates a starker contrast with other stimuli, making identification more conclusively unique. This amplification is what is most prevalent in caricature.

Brennan (1985) developed an automated method to produce digitized caricatures by "exaggerating the difference from the mean" (EDFM), amplifying proportions of a human face that exceed the norm [5]. Mo, Lewis, and Neumann (2004) noted that all facial features were treated the same in terms of how they were scaled, and extended the EDFM approach to incorporate the variance of each expressive feature [6]. However, unlike facial expressions, there are no well-defined universal or average "kinesic displays" (i.e., nonverbal behaviors pertaining to the body) and, thus, no standards that provide grounds for behaviors to be amplified [7].

The Transporters is an animated series designed to improve emotion recognition in children with autism [8]. Each of the characters is illustrated as a mode of transportation (e.g., a car, a train, etc.) that is bound by the corresponding medium of travel (e.g., a road, a train track, etc.); this systematizes the possible behaviors that the character might exhibit. A human face is digitally superimposed onto each character, providing a means for emotional expression. The emotion is spoken repeatedly (in context) and the facial expression is exaggerated for emphasis in correlation. Researchers have concluded that most of the children that watched the series daily developed face-based emotion recognition capabilities comparable to that of typically developed children in a variety of scenarios [9]. However, expressive and communicative behaviors of the body still remain to be addressed.

III. Approach and Methods

We take inspiration from several principles of animation in the caricature of social interaction behaviors of robots [10]. Initially, we aim to address *staging*, *exaggeration*, *anticipation*, and *secondary action*, and their respective implications with regard to socially assistive robotics.

A. Staging

This principle is the first that we must consider, for it aims to provide some grounding for robot gestures in subsequent operations. Staging—specifically, of the character—is the process of presenting a communicative act in as clear a way as possible by attempting to minimize or eliminate conflicting signals [10]. This involves isolating the features that uniquely identify the content of the expression [4, 7]. Caricaturing in animation highlights such features, providing preliminary building blocks for a clear kinesic display [10, 7]. For example, posture can be parameterized to communicate comfort or confidence [10].

B. Exaggeration

The principle of exaggeration is at the heart of caricature. It involves amplifying the distinct features that identify the kinesic display in order to make the content of the behavior more convincing [10]. Using the feature parameterizations isolated during the staging process, we can apply techniques, such as in [5] and [6], to produce exaggerated expressions. We then exploit the peak shift principle [4], and hypothesize that a child with autism will be more capable of interpreting the content communicated in the expressive behavior.

C. Anticipation

Anticipation suggests that a clear sequence of events is required to adequately communicate an idea or action [10]. Specifically, anticipatory action often indicates or emphasizes the intent of the character [7]. Staging and exaggeration provide insights pertaining to the dynamics of a communicative act, which we utilize to automatically generate motion paths for both micro- and macro-expressions that precede it. We hypothesize that consistent anticipatory actions will provide a child with ASD a better understanding of the intent of his or her social partner.

D. Secondary action

The principle of secondary action provides the most complexity that we are currently considering within the context of autism therapy. It involves the use of redundant signals in an expression to better communicate an idea [10]. Birdwhistell (1970) suggests that most kinesic actions include redundancy and that these signals play a key role in social interaction [7]; however, such signals must be isolated into distinct parts for proper staging, and subsequent exaggeration and anticipation, to occur [4, 10]. We suspect that secondary action has potential with high-functioning children with ASD (particularly, those who have participated in [8] and [9]), but might be overwhelming for children that are far in the autism spectrum.

IV. Robot Platform

The gesture system is being implemented on the Sparky Minimatronic™ robot figure available in the Interaction Lab at the University of Southern California, courtesy of Walt Disney Imagineering Research & Development (http://robotics.usc.edu/interaction/?l=Laboratory:Facilities#humanoid). Sparky uses two servo controllers and 18 R/C servo motors for supermarionation: 4 for each arm, 2 for each leg, 2 for the neck, 1 for the mouth, 1 for the eyes, 1 for the eyelids, and 1 for the spine. The puppet-like structure of this robot allows it to be lightweight and highly dexterous; its movements are fluid and natural. Of particular interest is its articulated spine, which allows us to manipulate Sparky's posture. The robot utilizes an off-board sensor network that includes color cameras, lasers, Nintendo Wiimotes™, and a desktop computer interface. Sparky is currently being used as a conversational tabletop agent, interacting verbally and nonverbally with a user.

V. Experimental Design

We are currently in the process of designing and implementing experiments that test these techniques and hypotheses within the context of a social skills intervention with children with autism. We will first validate, with typically developed children, the expressive behaviors that utilize the isolated features determined during the staging process, and, subsequently, their exaggerated, anticipatory, and secondary counterparts. We will then conduct a comparable study with autism populations to determine the impact of each of the techniques.

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