GoBot Dance: An Air Dancer-Inspired Robot For Child-Robot Interaction

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Abstract. A large body of work in both academia and industry focuses on engaging young children in mobile play, but obstacles such as the novelty effect and increasingly sedentary lifestyles make the design of such systems challenging. Our lab's past work has shown modular assistive robots to be one promising solution for encouraging child movement and play. As part of that body of work, we designed GoBot Dance, a music and motion-based robot with a miniature air dancer. We conducted an initial pilot session with GoBot Dance and one child with typical development and found that the child was more engaged with the robot and moved more while the robot was active, compared to during a baseline period. The products of this work can benefit and inform researchers in the child-robot interaction space.

1 Introduction

The design of new research hardware and toys to promote mobile play is important for fighting the rising rates of child obesity [1] and supporting positive developmental outcomes for children [2]. At the same time, keeping young children motivated and attentive during physical activity can be difficult due to short attention spans and novelty effects; accordingly, child development experts have established dual approaches such as the music and movement method, which combines dancing with music, to keep young children engaged while also increasing levels of physical activity [4]. Assistive robots are a natural fit with this type of early childhood intervention. Past robots (e.g., Keepon [5] and KIBO [7]) have used rhythmic and repeatable behaviors to encourage engagement and movement through dance. Our own initial studies analyzed how a TurtleBot2 could use different types of developmentally appropriate stimuli (i.e., bubbles, lights, and sounds) to increase engagement and encourage movement [8]. *Our central research goal is to use assistive robots to promote child motion and engagement.* This short paper presents the design and early testing of GoBot Dance, a custom robot that incorporates a miniature air dancer with popular children's music to encourage engagement with the robot and movement through dance.

2 GoBot Design

The initial design of GoBot Bubbles, as more fully described in our past work [8] and shown in Fig. 1, used custom hardware modules with developmentally appropriate stimuli (i.e., bubbles, lights, and sounds) to motivate child motion during

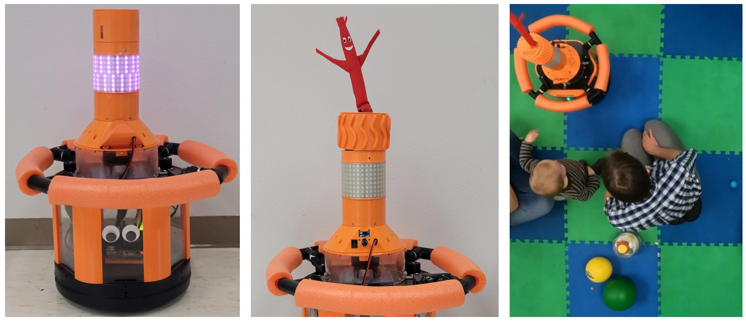

Fig. 1: *Left:* GoBot Bubbles, our custom robot with bubble, light, and sound stimulus hardware. *Center:* GoBot Dance, with air dancer hardware. *Right:* Partial overhead view of play space with robot, participant, and toys.

free play. Children displayed different types of engagement (e.g., following and approaching behaviors) with GoBot Bubbles, but the impact of the robot tended to wane over repeated sessions [8]. As a result, we recognized a need for increased breadth of stimuli and designed GoBot Dance with engagement and movement in mind.

GoBot Dance, as shown in Fig. 1, was designed in collaboration with the Oregon State Social Mobility Lab. We took inspiration from large air dancers, colloquially known as wacky waving inflatable tube men, when designing GoBot Dance. The robot introduces a new upper module atop the lower sections of the original GoBot Bubbles reward module. This new module uses a small radial fan to blow air through the miniature air dancer at periodic intervals, causing a dance-like motion. A raised texture was included on the outside of the module to encourage children to touch and interact with the robot. A Raspberry Pi Pico plays popular children's music through the robot module's speakers and controls the activation of the fan. A Raspberry Pi 4 running ROS Noetic is connected to the Pi Pico and controls the robot's teleoperation and autonomous function modes.

3 Methods

We conducted a pilot session with GoBot Dance and one child participant as an early evaluation of the effectiveness of the robot for keeping a child engaged and encouraging motion. We used two phases (baseline and treatment) to compare typical child behavior with behavior while the robot was active. The study protocol was approved by our university ethics board.

Participant: The pilot participant was a 1.5-year-old male child with typical development. The child had never interacted with GoBot Dance before the session, but had interacted with GoBot Bubbles in previous play sessions.

Measures: Overhead video data of the session was collected from a GoPro Hero Black 10 camera recording at 25 Hz for later extraction of child and robot positional data. Child inertial data was recorded by three GT9X Link Actigraph accelerometers (worn on the wrist, ankle, and hip) at a 100 Hz sampling rate. We used a closing survey with Likert-type and free-response questions to capture parent perceptions of the child-robot interactions. Questions included parent ratings of child engagement with the robot on a scale of 1 (Strongly Disagree) to 7 (Strongly Agree). Free-response questions asked parents about perceptions of the robot and the child-robot interactions.

Procedure: At the start of the session, the Actigraph accelerometers were placed on the right wrist, right ankle, and hip of the participant. Fig. 1 shows an overhead view of the play space, which included developmentally appropriate toys, the robot, and the participant. During the ten-minute baseline phase, the robot was present in the play space but was inactive. During the ten-minute treatment phase, GoBot Dance was active and teleoperated by a research team member. The researcher played music from the robot and operated the lights and air dancer along with the songs. At the end of the session, the parent completed the closing survey.

Analysis: Lens distortion from the overhead video was removed using the Wondershare Filmora 11.6.7 video editing software. Next, we used an OpenCV region-of-interest (ROI) tracking tool to extract post hoc per-frame positional data of the child and robot from the overhead video. This positional data was used to analyze engagement metrics from Howe's Peer Play Scale [3]. We calculated the Euclidean distance between the child and robot for each video frame based on the respective centroids of bounding boxes collected by the ROI tracker. Distance values were scaled using the 2ft$\times$2ft colored play mats in the play space (shown in Fig. 1). From these distances, we computed the percentage of time that the child was less than 3ft from the robot (i.e., in an interaction, based on Howe's Peer Play Scale) during each phase. To estimate the amount of child motion during each phase, we calculated the sum of the change in child position between subsequent frames. We excluded position changes larger than 0.5ft, which we considered to be a highly unlikely displacement value based on maximum child speed from [6].

4 Preliminary Results and Discussion

We used three measurements to begin to understand the child's engagement with the robot: the average child-robot distance, the percentage of time the child was in an interaction with the robot, and the estimated total movement of the child. The results for each session phase appear in Table 1. The average child-robot distance was generally smaller for the treatment phase, and the child spent more time in interaction with the robot during this phase as well. The child also moved more during the treatment phase when compared to the baseline phase.

Qualitative data from the study video and survey supports the engagement results. We observed that the participant approached GoBot Dance several times and spent a majority of the treatment phase near the robot. Parent survey data indicated that the child "watched [the robot] curiously" and "smiled a lot at it, followed the lights, and even grabbed a toy we placed on [the robot]".

Table 1: Child behavior data for each study phase: mean and standard deviation of child-robot distance, percentage of time the child was in an interaction with the robot, and estimated total movement.

	Child-Robot Distance	% Time in Interaction	Total Movement
Baseline	5.67 ± 1.59 ft	1.1%	237.71 ft
Treatment	5.20 ± 3.0 ft	36.5%	268.43 ft

In closing, GoBot Dance is a novel blend of a miniature air dancer and mobile robot base with the potential to motivate engagement and movement. A pilot session with one child showed promising results for GoBot Dance's ability to encourage interaction with the robot. A current limitation of the work is the single test user and small amount of interaction data; in next steps, we will conduct a longitudinal study with more child participants and consider methods for modeling child responses to the robot.

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