Making Pretense Visible and Graspable: An Augmented Reality Approach to Promote Pretend Play

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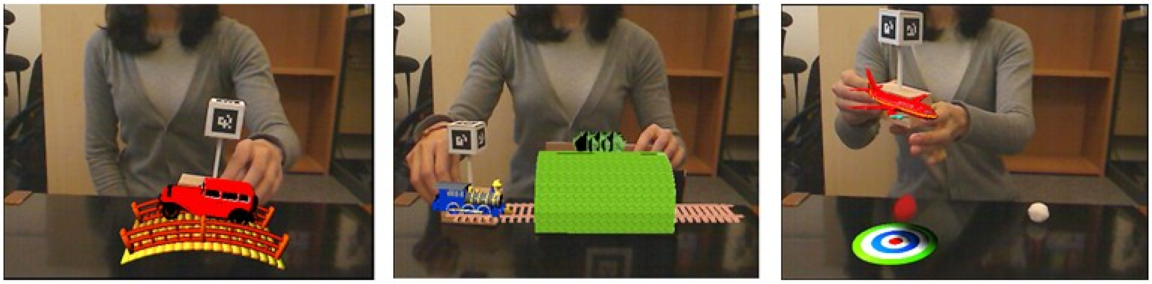

(a) (b) (c)

Figure 1: Three play themes of the AR system. The user pretends that the block is (a) a car and pushes it over a bridge (b) a train and pushes it through a tunnel (c) an airplane and throws cotton balls as bombs to hit the animated target.

Abstract

Children with autism are often found to lack facility for pretend play. It is believed that this deficit is linked to linguistic, social and creativity competencies in autism. We observe that both Augmented Reality (AR) and pretend play involve processing of information that is coupled with real scenes while not necessarily being directly perceived. This research therefore examines the potential of using AR technologies to promote pretend play behaviors in children with autism. As an initial outcome, we present the design and implementation of an AR system that aims to enhance the comprehension and flexibility of object substitution during pretend play.

Keywords: Augmented Reality, pretend play, autistic children.

Index Terms: H.5.1 Multimedia Information Systems: Artificial, augmented, and virtual realities.

1 Motivation

Autism is a neurodevelopmental disorder that affects about one percent of children in the UK. It is associated with impaired social communication, social interaction and imagination [1]. Difficulty in sharing imaginative play (also called pretend play or symbolic play) is one of the American Psychiatric Association diagnostic criteria for autism [2].

Pretend play, by Leslie's definition [3], involves three forms of pretense: (1) object substitution; (2) attribution of absent/false properties; (3) presence of imaginary objects. When compared to either normally developed or mentally challenged children, children with autism suffer a severe deficit in spontaneous pretend play, with regard to frequency, duration and diversity [4]. Since the development of pretense, language, and mental representation all begin between ages one and two, researchers believe that there is a strong interaction among these competencies. Substantial research effort has therefore been focused on interventions to develop pretend play for autistic children [5].

According to developmental psychology research, the cognitive process of pretense involves maintaining two representations simultaneously: the primary representation, which directly represents situations in the world (objects, properties and their physical presence), and the secondary representation, which is imaginary and different from the actual situation. This is analogous to AR, which represents both the physical world and associated virtual content. The initial motivation is to use AR technologies to promote pretend play behaviors by enriching the physical world with imaginary content, which would otherwise be imperceptible.

The ability to comprehend the mechanics of pretense in children with autism is either impaired or developmentally delayed. Our hypothesis is that there may be some benefit to make imaginary scenes visible to children with autism. First, by seeing a representation of imaginary content overlaid on the real world, children may make sense of pretend play more easily, compared to the approaches of modeled gestures and verbal descriptions used in conventional therapies. Second, the AR system enables children to receive immediate feedback as a result of controlling the pretense, by either directly manipulating its physical counterpart, or changing the correspondences underlying the pretense. In this way, they are encouraged to explore ideas more flexibly, an ability that is often impaired in autistic children. Third, the visible augmentation helps to avoid potential inter-subjective ambiguity about the intention of pretense, which could assist children with autism to play with normally developed peers and family members, while remaining comfortable with a structured and predictable technical artefact.

As a starting point, we would like to examine the potential positive impact of AR technologies in object substitution during pretend play for young children with autism. This paper presents the design and the implementation of the proposed system.

2 System Design

The core design concept is to make an object substitution by superimposing an imaginary object over the physical object for which it is to be substituted. The child perceives visual feedback

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of the imaginary object by observing the screen and tangible feedback of the physical object by grasping it in his or her hand. Following common practice in experiments involving pretend play for autistic children, we deploy a set of junk toys that reveal little specific function (e.g. foam blocks, cardboard box, cotton balls), in order to make it easier for children to apply different pretend ideas.

In order to help the child understand the object substitution, we provide three pretense themes that are common in early childhood play: car, train and airplane (Figure 1). Initial interaction with the AR system is encouraged by simulating appropriate behavior of the virtual object (e.g. wheel or propeller rotates) when the physical object is moved around by the child. To reinforce pretense and encourage situationally appropriate manipulation, a set of theme-related augmentations are added into each scene, in the form of additional object substitutions (e.g. box as a garage) and imaginary objects (e.g. virtual bridge).

For the purpose of promoting flexibility in pretend play, children can choose from alternative themes (car, train or airplane) before starting the play. During the play the same junk toy is substituted with (1) a different pretend object (e.g. foam block as a gas pump in the car theme, but a traffic light in the train theme) (2) the same object in different states (e.g. the car is clean vs. dirty). In addition, the AR system provides supplementary visual indications to reinforce children's use of junk toys as something else. One example is to superimpose an animated moving target on the surface of the table in the airplane theme, which aims to encourage the child to engage in air raid play by picking junk items as bombs and throwing them from the aircraft (Figure 1(c)).

3 System Implementation

The system is implemented using a locally modified version of Goblin XNA open source, developed by the Computer Graphics & User Interfaces Lab in the Columbia University [6].

3.1 Tracking and Registration

Marker-based tracking is chosen to track junk toys in preference to other computer vision-based tracking for two reasons: (1) flexible to extend: it is easy to attach and detach markers from physical objects. Therefore it is flexible to extend the number of trackable objects comparing with model-based tracking which requires 3D models that must be constructed for each junk toy; (2) avoid hand occlusion: the way the child manipulates an object in his/her hand is arbitrary. By installing the marker displaced from the target object, hand occlusion can be largely avoided, although it may slightly affect how the child manipulates the physical item.

Figure 2(a) shows the marker cube and how it is attached to the junk toy. The virtual object is registered to the marker and then translated and rotated to overlay on top of the actual physical object. The double exponential smoothing method is used to reduce jitter.

There are also several theme-related imaginary objects to be registered in the scene, such as the bridge, railway and runway. Since those objects are meant for the vehicle to move across, occlusion is unavoidable if we simply put a 2D marker on the surface of the table. The workaround is to register imaginary objects with a phantom marker, whose transformation matrix is pre-recorded and remains unchanged during the play (Figure 2(b)).

3.2 Physical Setup

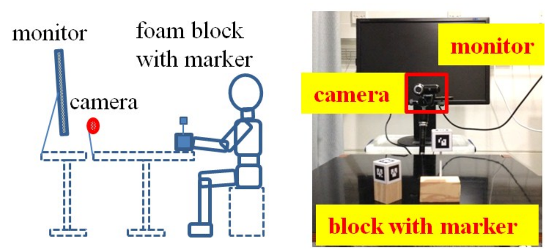
The physical setup includes a large monitor, a camera facing the user and junk toys with markers attached (Figures 3(a) (b)). The magic mirror metaphor [7] is applied in the way that children look into the display as if it is a mirror which lets them "see" the physical world and overlaid imagined scene. There are three main advantages of the mirror display comparing with a see-through display: (1) it frees both hands of the child to manipulate the junk toys; (2) there is no barrier between the child and the junk toys; (3) it is extensible to support self-directed pretend play scenes that are commonly used in treatment and assessment (e.g. pretend to brush one's teeth with an imaginary toothbrush).

4 Application Evaluation

We received positive feedback during preliminary evaluation of the system from autism experts. A pilot study with two neurotypical children age 4-5 was conducted and the results confirmed the usability of the system and indicate a potential positive effect of promoting simple situationally appropriate pretend play as compared to a natural play environment. Next, we will add extra situational cues that are conducive to more play ideas and then conduct the formal experiment with high functional autistic children with an equivalent mental verbal age.

(a) (b)

Figure 2: Marker-based tracking (a) the marker cube attached to a block (b) the registration to the phantom maker



(a) (b)

Figure 3: System setup (a) profile illustration (b) actual user view.

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