Can I GetToyIn? : A Box Interface Connecting Real and Virtual Worlds

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Abstract
Dollhouse play promotes children's creativity and sociality. Implementing a virtual dollhouse in a computer screen offers a more attractive type of play because it removes restrictions on the movements of dolls and the settings of play. However, this method typically compromises the benefits of real doll play. By combining real doll play with a virtual dollhouse, it is possible to incorporate the advantages of both types of play. We develop a virtual dollhouse in a computer display that can be used with real doll play on a tabletop. To connect the real (tabletop) and the virtual (computer display) world, we created a device named "GetToyIn" for users to move their toys (dolls) in and out of the virtual dollhouse. Observations of children aged 4 to 10 years old playing with our dollhouse confirmed that they could understand and operate the design model.

Author Keywords
Dollhouse; Toys to life; Children; Mixed Reality

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces.

Introduction
Pretend play using dolls is expected to develop an ability for problem-solving and sociolinguistic competence [2].

Dollhouse play, which enables children to reproduce scenes of lives using miniature dolls and small items, promotes growth through pretend play. However, as traditional dollhouse toys have restricted neck, arm, and leg movements, children need to manipulate the dolls with their hands. Additionally, preparing a wide variety of stages with various furniture and decor is not always affordable. To solve this problem, a virtual dollhouse can be created using 3D computer graphics (hereinafter called CG), which can be used to display a CG character of a doll with lively motions in a computer display. The virtual dollhouse also makes it possible for users to access an unlimited number of rooms, dolls, and parts without worrying about storage and purchase costs. However, compared to tangible dolls in the real world, the virtual dollhouse has disadvantages of insufficient physical presence. Therefore, we aim to offer play spaces in both real and virtual worlds by providing an interface device that connects both worlds naturally. We thus developed an interface device named "GetToyIn" for users to move their real toys in and out of the virtual world.

Related Work

In a study on an augmented dollhouse using computer technology, Hinske et al. [4] implemented a play environment for children using dolls and items with RFID tags, and they showed the guidelines for designing augmented toy environments. Freed et al. [3] proposed a remote communication method between children via dolls by incorporating communication functions such as voice over a telephone in their dollhouse. Furthermore, Avrahami et al. [1] proposed a method of presenting scenes such as mealtimes by detecting the position and angle of the doll and changing the display of the tablet computer. In other game products, such as Amiibo[1] and Skylanders[2],

[1] https://www.nintendo.com/amiibo/
[2] https://www.skylanders.com/

Figure 1: Virtual dollhouse and GetToyIn device.

CG characters corresponding to real dolls (also known as figurines) appear on the display. These approaches are categorized as "Toys to Life." However, in these products, the dolls act as triggers that allow the characters to appear in the game world. After the appearance of CG characters in the virtual world, the real dolls are still visible although they are essentially abandoned for the purpose of play. In this research, we propose an augmented dollhouse by providing an interface device through which dolls move between the real and virtual worlds.

Regarding interaction using augmented reality, Robert et al. [5] proposed a system using automatic doors that strengthens the identity between a real automatic robot and a virtual CG character projected on the screen. In this study, we use a general display and propose a method to connect the real and virtual worlds seamlessly without hiding a part of the CG world by setting a box device next to the display.

GetToyIn

GetToyIn is an interface device that connects the real and virtual worlds seamlessly. Figure 1 shows a virtual dollhouse in a computer display, a real doll play tabletop setting, and the GetToyIn device connecting the virtual

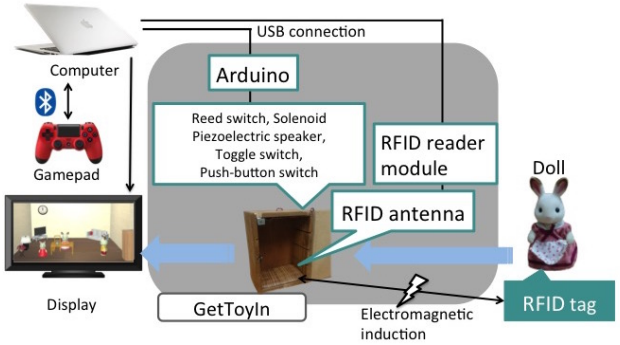

Figure 2: The system overview.

Figure 3: RFID Tags attached to sole of a doll (upper) and small items (lower).

dollhouse and the tabletop. In Fig. 1, a doll sent from the real world appears as a CG character in the computer display. The box-type device with a door (hereinafter called the box) is placed in contact with the edge of the computer display. A part of the box is also drawn on the CG screen, thus producing the effect that the real-world box is connected to the virtual world. When a user puts a doll in the box and closes the door, the CG door in the display opens and the corresponding CG character appears and walks out of the CG box. When the user puts multiple dolls in the box, the CG characters corresponding to each doll appear and walk in sequence. When the user puts small items, such as a book, a slice of bread or a watering can in the box with a doll, the CG character brings the item with them when they leave the box in the CG display. The user can get the doll out of the CG world by pushing a doorbell switch attached to the box. A chime sounds, and the CG character walks towards the CG door and enters the box. When the CG door is closed and the CG character becomes invisible, the door of the box opens automatically, and the doll appears in the real world.

Implementation

Hardware

Figure 2 shows the system overview, which consists of a computer (hereinafter called PC)[3], a 24-inch liquid crystal display (1920 × 1200 pixels), a Bluetooth gamepad[4], and input devices including the box (H 16.5 cm × W 10.5 cm × D 6.8 cm) into which a doll is to be placed. A reed switch, a push type solenoid, a piezoelectric speaker, a toggle switch, and a push-button switch are mounted in the box. These are controlled by a microcomputer Arduino UNO. The box is also equipped with RFID antennas and a reader module[5] . The Arduino UNO and the RFID reader module are connected to the PC via USB. For dolls and small items, we use toys from the "Sylvanian Families"[6] series. To identify them, a 4 × 4 mm RFID tag[7] is affixed to the bottom surface of each doll and item as shown in Fig. 3. In this system, the communicable distance between the reader and the tag is about 1 cm. Since this RFID system supports reading of multiple tags, it can recognize when two or more dolls and items are placed in the box.

Software

The virtual dollhouse was implemented using Unity, and to link the box with the virtual world, we developed C# script, which runs on Unity. This script performs serial communication with Arduino UNO and the RFID reader module connected to the PC via USB. This script also executes the previously mentioned scenario of doll movement, plays the corresponding sound effects, and responds to the user's actions. For example, when the user knocks on the box, the CG characters jumps, and when

[3] MacBook Air, 1.6 GHz Intel Core i5, OS X 10.11.6
[4] CUH-ZCT2J
[5] TAKAYA Corporation TR3-A302 and TR3-C202, 13.56MHz
[6] EPOCH CO., LTD. http://sylvanianfamilies.net/uk/
[7] RF37S114HTFJB-Tag-it HF-I Type 5 NFC

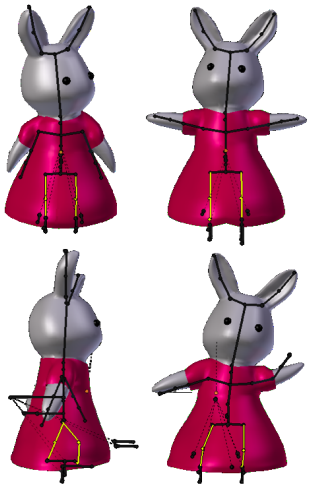

Figure 4: CG characters modeled using Blender.

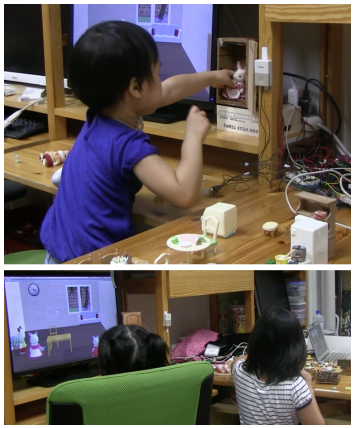

Figure 5: Girls playing with our system.

the user operates the toggle switch, the dollhouse room is changed with up or downward scroll as if the user is looking from an elevator cargo. The script also receives input through the joystick or button of the gamepad, thus allowing the user to operate the CG characters. To create CG characters, we used Blender to model 3D objects with the same shape as the real dolls (see Fig. 4). Animations such as walking and turning are assigned to the CG characters.

User Study

To confirm that users can understand the design model, we observed children playing with the dollhouse using GetToyIn (see Fig. 5). In consideration of the target user of the dollhouse, four girls aged 4 to 10 were selected. Because two of them were sisters, they participated in the experiment together. The other two children participated individually.

First, to get used to the dollhouse play, the children played with the Sylvanian Families toys for 10 minutes freely. After that, we observed the children for about 30 minutes as they combined the real world and the virtual dollhouse through GetToyIn. When closing the door of the box, the children said to the dolls "Goodbye" or "See you later," and when the door opened automatically, they said "Welcome back." These words indicate that the children could distinguish between the CG character appearing in the virtual world and the real doll in the box. All of the children were able to understand the movement of the doll to the virtual world via the box and operate the system easily. The experimental results thus confirmed that children could understand and operate the design model of GetToyIn.

Some of the children's mothers suggested that children would enjoy sharing the virtual dollhouse with a friend located far away. Sharing a virtual dollhouse between friends in remote places could extend the possibilities of dollhouse play to foster interpersonal communication skills. We are considering introducing remote dollhouse sharing functions to the current system.

Conclusion

In this research, we proposed an interface device called GetToyIn that seamlessly connects the real and virtual worlds. We implemented a virtual dollhouse application using this device, and observed children aged 4 to 10 years combining the real and virtual dollhouse worlds using this system. As a result, we confirmed that children can easily understand and operate the design model of GetToyIn. In future, we plan to increase the interaction between the real and virtual worlds so that users can make real dolls interact with CG characters.

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