Pumping Life: Embodied Virtual Companion for Enhancing Immersive Experience with Multisensory Feedback

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Figure 1: We introduce Pumping Life, a dynamic flow system for enhancing the virtual companion with multisensory feedback. The users can feel following feedback from the dolly: (a) shape deformation while dolly breathing, (b) shape expansion and happiness while dolly drinking/eating, (c) thermal feedback when dolly blush, (d) vibration and sadness while dolly hiccuping, and (e) shape contraction and madness while dolly shooting the laser.

ABSTRACT

With the advance of virtual reality (VR) head-mounted display, the appearance of the virtual companion can be more realistic and full of vitality, such as breathing and facial expression. However, the users cannot interact physically with the companions due to they do not have a physical body. In this work, our goal is to enable the virtual companion with multisensory feedback in the VR, which allows the users to play with the virtual companion physically in the immersive environment. We present Pumping Life, a dynamic flow system for enhancing the virtual companion with multisensory feedback, which utilizes water pumps and heater to provide shape deformation and thermal feedback. In this work, to show the interactive gameplay with our system, we deploy the system into a teddy bear and design a VR role-playing game. In this game, the player needs to collaborate with the teddy bear to complete the mission, which would perceive the vitality and expression of the teddy bear with multiple tactile sensations.

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CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Haptic devices**.

KEYWORDS

Multisensory Feedback, Prop-based Haptic, Shape Deformation, Thermal Feedback, Virtual Reality

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1 INTRODUCTION

Virtual Companion has been adopted in many games and applications, which assist the users to get immersed in the scenario and complete their tasks. To enhance the virtual companions in the virtual reality (VR), giving them a physical body to interact with it is an intuitive approach. Real Baby-Real Family[5] is a virtual baby interaction system, which utilizes a physical baby doll to provides baby nursing experience in the virtual environment. Although the system can simulate the looks, sound, and shape of the virtual baby in VR, the virtual doll is a passive prop that could not give the feeling of life. To activate the passive prop, previous researches have shown the potential of utilizing prop-based haptics in the Mutual Turk[3] utilize shared prop connected by both users

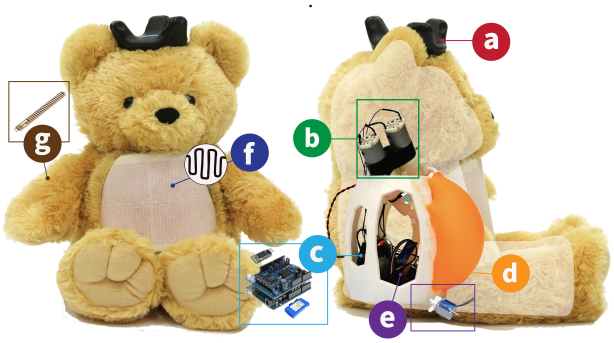

Figure 2: Hardware design: (a) Vive tracker (b) Water pump, (c) Arduino with bluetooth and battery, (d) expandable water bag, (e) Solenoid valve, (f) Heater, and (g) Pressure Sensor

so that the forces they output become an input to the other user. iTurk[2] turn the passive haptics into active haptics by making the users reconfigure props in VR. ChainForm[6] has shown a shape changing interface also could be used to change the pose of the doll. Additionally, to allow the users to perceive the other sensation from the virtual companion, utilizing multiple tactile feedback to enhance the immersive experience is a useful approach[4].

To simulate the energy of life, breathing is one of the behaviors that every creature will do when they are alive. Relaxushion[1] utilizes a mechanical structure in the pillow to guide the users breathing by shape deformation, which the users can perceive the shape deformation when holding the pillow. However, they cannot simulate the flexibility of muscle due to the deformation is caused by the rigid structure. Besides, every creature has its thermoregulation, which is other physical states could be enhanced via the thermal feedback. To create the virtual companion with multisensory feedback, we need to simulate the physical body, breathing, and body temperature for the enhanced immersive experience. In this paper, we design a dynamic flow system installed inside the doll body to enhance the physical doll, which allows the users to perceive the shape deformation and thermal feedback simultaneously.

2 IMPLEMENTATION

In this work, we design a dynamic flow system for enhancing the virtual companion with multisensory feedback. The hardware design is shown in Figure 2. In order to design a portable device, we utilize an Arduino with Bluetooth (Figure 2c) for the communication between Unity and our device. To track the real doll, we mounted a VIVE tracker (Figure 2a) on the top of the doll to acquire the position and rotation. The multisensory feedback is divided into two parts: shape deformation and thermal feedback. To provide shape deformation feedback, we simultaneously control two water pumps (Figure 2b) connected to the expandable water bag (Figure 2d). We control the fluid by the water pump to make the fluid flows in and out as the breathing frequency. Furthermore, we can adjust the frequency for different situations such as deep breathing. To prevent the backflow of the fluid when the pumping is stopped, we set a solenoid valve (Figure 2e) on the water pipe that connects the water bag. Therefore, we can maintain a certain degree of expansion or contraction when deforming the shape. To provide thermal feedback, we installed the polyimide film heater near the dollâĂŹs belly (Figure 2f), which can increase the temperature up to 40°C. Moreover, when moving the doll hand, the pressure sensor will receive the signal to react to the movement in the VR.

3 APPLICATION: IMMERSIVE TEDDY BEAR

To let the users experience virtual companion with multi-sensory feedback in VR, we designed a role-playing game, which the player needs to complete the mission with the teddy bear as Figure 1. In the game, the player will perceive the expression with multiple tactile sensations. When the player holds the teddy bear, the player can feel the teddy bearâĂŹs breathing with a slight heat. The first mission is to take care of the teddy bear, which the player can feed teddy bear drinks and feel the expansion of the teddy bearâĂŹs belly. With more drinks, the belly will expand more obviously, and body temperature increases. Besides, the user can see the bear blush and feel the heat when he is drinking too much beverage. Suddenly, the teddy bear shows an uncomfortable expression because of the flatulence. To help him, the player needs to tap the back of the teddy bear. Then, the teddy bearâĂŹs belly will contract, and the temperature will decrease to normal. In the last level, the player and the teddy bear are surrounded by enemies. The player needs to cooperate with the teddy bear to shoot enemies via pressing his hand.

4 DISCUSSION AND FUTURE WORK

In this work, we present a dynamic flow system for enhancing the virtual companion with multisensory feedback, which allows the users to interact with the virtual companion physically. Through holding the Pumping Life, the player can perceive the physical state of the character by the combination of shape deformation and thermal feedback. Furthermore, applying the concept presented in this work also could be used in other interactive applications such as health care. In the future, we will gather user feedback to inform researchers, game makers, and practitioners the playful uses of this technology.

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