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Demo

A Pressing Sensation Rendering System in a Semi-constrained Finger State

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Abstract

We propose a pressing sensation rendering system in a semi-constrained finger. A load cell sensor is used for force input, and a virtual finger object moves in response to the pressure. At this time, the virtual finger object fol-lows the target position of the fingertip by PD control. Further, a virtual spring is stretched to the virtual object, and the firmness of the push differs depending on the spring coefficients. Furthermore, when a virtual finger touches a virtual object, an impact sound is generated, increasing the sense of realism. After experimenting with different parameters, we found that users can perceive softness/hardness through visual feedback and sound.

CCS Concepts

• ***Human-centered computing*** → *Virtual reality;* • ***Hardware*** → *Emerging interface;*

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1. Introduction

In recent years, virtual reality (VR) technology has developed rapidly, bringing changes to various fields of society. A sense of pressure is essential for VR users to feel as if they are touching a real object. To present these sensations, various tactile presentation devices have been proposed [WYL21]. To present a reaction force in response to the user's movements, it is required actuators, but it is difficult to expand the range of motion while maintaining the degree of freedom in the force that can be presented. To address this problem, a method has been proposed that completely restrains the user's posture, reads the user's behavioral intentions, and replaces the user's actions with visual presentation [MION22], but tactile perception is not considered. Therefore, we propose a semi-postural, semi-constrained tactile presentation method. Each joint of the user is semi-constrained in an intermediate posture, the force is read by a sensor, and the motion is translated into the avatar's motion through visual presentation. This is expected to produce a pseudo-tactile sensation caused by a mismatch between the user's input and visual presentation, i.e. pseudo-haptics. It is known that pseudo-haptics is influenced not only by vision but also by hearing [KDLH09] [KYKK22].

In this work, firstly the user's finger is semi-constrained, and the posture of the object corresponding to the fingertip position is estimated by force input from the load sensor. Secondly, when the object is pressed, an impact sound is generated and the movement of the target object is changed by parameters. Then, we evaluate whether users can feel the difference in hardness using this method.

2. System Overview

Figure 1 shows an overview diagram of the system implemented in this work.

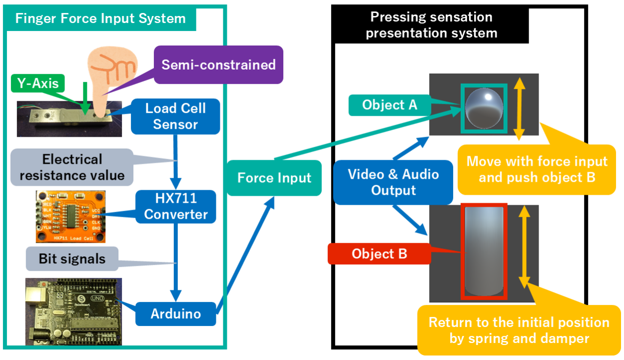

Figure 1: *System overview.*

The load sensor is used as a force input, and the value is used to move objects in a virtual space. In addition, by placing a finger on the load sensor, the finger is put into a semi-constrained state. Object A, which corresponds to the fingertip position, is moved based on the input force, and object B, which has a different hardness, is pressed down. The behavior is displayed as a video and a sound is played when the object collides, giving the sensation of pressing. The configuration of these two objects (objects A/B) is as shown in Figure 1. These objects are fixed on the X/Z axes (front, back, left, right) and can only move in the Y axis (up and down) direction.

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Object A is controlled by PD to follow the input value obtained from the load sensor multiplied by a gain value. Object B is the object to be pushed. The spring and damper allow it to return to its original position even if it is pushed by object A. The stiffness and softness of object B are expressed by adjusting the parameters of the spring of this object. In addition, as auditory feedback, the sound of objects A and B colliding is played, and this sound changes depending on the force of the collision.

3. Implementation results

Three types of parameter settings patterns for the spring coefficient of object B were implemented. The implemented pattern is as follows tab 1. In pattern III, isKinematic in Unity's Rigidbody component is turned ON, so that object B does not move at all.

Table 1: *Spring constant parameters of object B*

	paramI	paramII	paramIII
spring	100	1000	/

Figure 2 shows a graph showing the relationship between the change in Y coordinate of object B in patterns I, II, and III and the force input value.

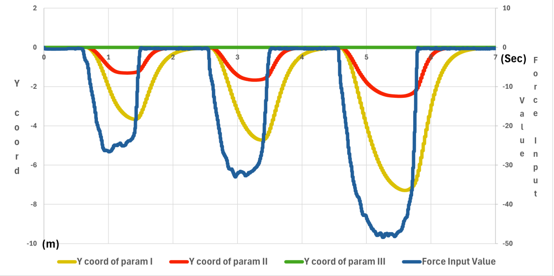

Figure 2: *Displacement of objects corresponding to each finger.*

As a result of these experiments, we found that pattern I felt the softest when pressed, pattern III felt the hardest, and pattern II felt a coordinate change that was somewhere in between. In addition, because the same wave forms were observed for each pattern and the input value, we were also able to confirm that there was a relationship between the coordinate change of the pressed object and the input value obtained by the sensor.

4. Evaluation experiment results

In this experiment, an evaluation experiment was conducted to clarify whether users could feel a sense of hardness or softness when pressing the object through the visual change in position and impact sound in response to force input. The experiment was conducted on five subjects aged 20 to 24 years old, who touched the object to satisfy each of the three parameters of object B, and then completed a questionnaire. The three parameters were the same as in Table 1. They answered the questionnaire on a 10-point scale, with the closer to 1, the softer the sensation when pressed, and the closer to 10, the harder the sensation when pressed. The results of the evaluation experiment are shown in Figure 3.

Figure 3: *Evaluation experiment results.*

The experimental results show that when the spring parameters are changed, the smaller the change in coordinate of object B, the harder the sensation when pressed. Furthermore, even though parameter 1 has the largest coordinate change of the three parameters, not a single person chose 1, which is rated as the softest sensation when pressed. This is likely because the texture of the object and the sound it makes when pressed give the impression of being hard.

5. Conclusions

In this work, we proposed a new method to use a load sensor as a force input and to create the illusion of visually pressing an object while semi-constraining the upward and downward movement of the finger. As a result of evaluation experiments, we were able to perceive hardness and softness through the change in visual position according to the force input.

Future challenges include using metal or rubber as the material of the object and conducting comparative experiments with the real thing. Also, at the moment only objects that move in a straight line have been implemented, but we will also implement objects that move in a non-linear manner, such as mechanical buttons. In addition, by increasing the number of sensors, it is possible to perform not only pushing actions but also pinching and grasping actions, and by increasing the freedom of the fingertips, we can expect to be able to perceive not only hardness but also friction, weight, and shape. We will continue to work on these issues in the future.

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