Tactile Presentation with Air Suction and Electrical Stimulation*

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I. Introduction

There were various attempts at producing a compact haptic device to simulate skin touch each with its own strengths and weaknesses. Skin suction by negative pressure can provide stable pressure sensation, but lacks spatial resolution and responsiveness [1]. Electrical stimulation has high spatial and temporal resolution, but it causes pain after prolonged stimulation and is difficult to provide a stable pressure sensation [2].

In this study, efforts were made to combine both electrical stimulation and suction pressure to utilize the stable pressure sensation of suction pressure while electrical stimulation provide the hint of spatial resolution and hides the slow responsiveness of suction pressure cues. With this system, not only simple contact sensation is possible, but the direction of force such as a bias of force exerted on a particular area of a surface can also be replicated.

II. Implementation

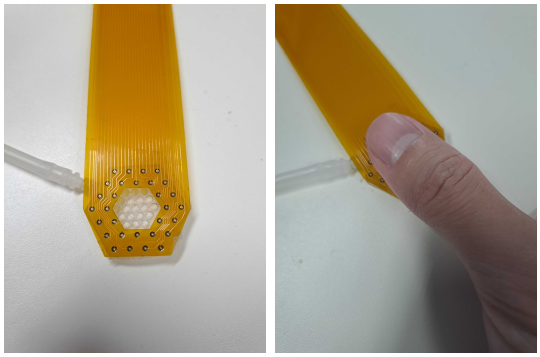

Fig. 1. Combination of electrotactile and suction pressure head

Fig. 1 Shows the hardware setup of the suction pressure and electrical stimulation device. For both parts, an ESP32 micro-controller was used to communicate with the PC. It is connected to a flexible electrode sheet consisting of 30 electrodes arranged in a hexagonal manner with a hole in the middle for the suction pressure head which was attached by tape to provide the suction pressure sensation. The pressure inside the suction pressure head is controlled by an electric valve, vacuum pump and air pressure sensor.

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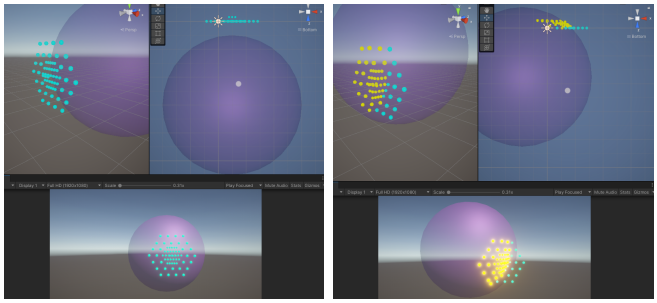

Fig. 2. (Left) Hexagonal arrangement of sensors in virtual environment. (Right) Sensors partially submerged onto virtual object and activates haptics

A virtual environment was prepared in the Unity game engine, with a set of small rigid bodies that acts as sensors in a hexagonal arrangement. On contact, each sensor are displaced from its arrangement and may conform to the object's shape. The distance between its original position and displaced position will be interpreted as the amount of force exerted. For electrical stimulation, each sensor corresponds to each electrode in its appropriate position and the force exerted is translated to the strength of the electrical stimulation, and its high accuracy of positional stimulation is responsible for presenting force direction. For suction pressure, the amount of sensors that detected force are averaged and is then translated to the pressure inside the suction pressure head, such that a lower pressure causes higher suction force.

III. Ongoing and Future Work

To further utilize the higher definition contact sensation, other potential tactile sensations including softness presentation and moving textures will be implemented. Softness presentation can be achieved by presenting a wider contact area with electrodes [3]. Surface movement can be presented by having combining moving pattern by electrical stimulation and pressure force by air suction [4].

References

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