Soft capacitive tri-axis tactile sensor based on level sensing

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Ⅰ. Introduction

Recently, soft tactile sensors have been developed to integrate into soft robots or wearable devices. However, most conventional soft tactile sensors have stiff materials embedded in soft materials, reducing flexibility and durability [1]. In this study, we propose a soft capacitive tri-axis tactile sensor. The proposed tactile sensor has four chambers and channels in a silicone rubber body and encapsulated air and water in the chambers and channels. An applied force to the tactile sensor causes the displacement of the interface. The interface displacement is measured as the capacitance change of the sensor detection part using level sensing. Also, the capacitive tactile sensor based on level sensing does not require ohmic contact between a contact part and detection parts and contributes to improved flexibility and durability. The proposed tactile sensor has four capacitances at the detection part. The combination of the four capacitance changes depends on the direction of the applied force. Thus, the proposed tactile sensor can detect the direction of applied force using a combination of the four capacitance changes.

Ⅱ. Implementation & Operation Principle

Figure 1 shows the implementation image of the proposed tactile sensor. The proposed tactile sensor consists of a soft contact part using silicone rubber and a detection part. Four chambers and channels are formed into the soft contact part and are encapsulated air and water. The detection part consists of 3D printed components to which copper electrodes are attached. The detection part is attached, sandwiching the channel and detecting the air-water interface's displacement as capacitance change by level sensing. Figure 2 (a) represents the state in which no force is applied to the sensor. When the normal force is applied to the sensor, the chambers deform, and the water in the chambers flows into the channels because of its incompressibility, as shown in

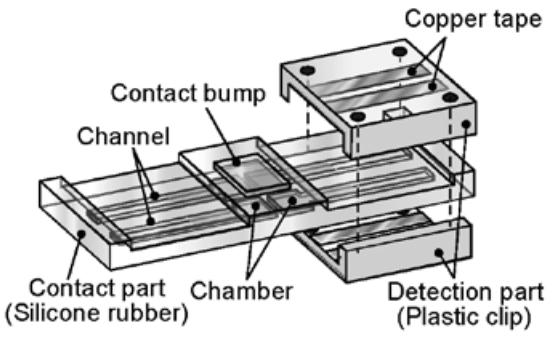

Figure 1. Implementation image of the sensor

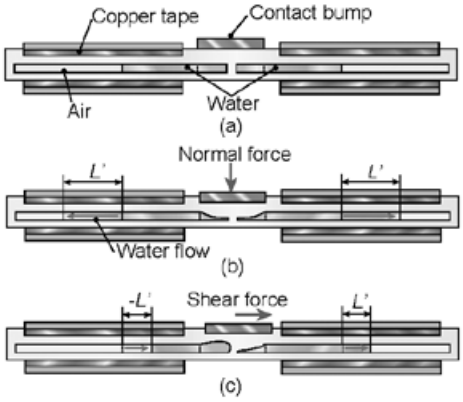

Figure 2. Operation principle of the sensor; (a) without force, (b) applied normal force, and (c) applied shear force.

Figure 2 (b). Then, the air is compressed, and the interface between air and water is moved. The four capacitances of the sensor increase equally the interface between air and water position is displaced equally in all channels. On the other hand, when the shear force is applied to the sensor, one side of the chamber is compressed, and the other side is expanded. The displacements of the interface between air and water are different depending on each channel. Therefore, each of the four capacitance changes depends on the direction of the applied force. The proposed sensor can estimate tri-axis applied force using a combination of four capacitance changes.

Ⅲ. Conclusion

We proposed a soft capacitive tri-axis tactile sensor using displacements of the air-water interface. The proposed tactile sensor forms four capacitances and measures capacitance changes caused by the applied force. We will evaluate the response characteristics of the proposed sensor under an applied force in future works.

References

[1] S. Hamaguchi, T. Kawasetsu, T. Hirii, H. Ishihara, R. Niiyama, K. Hosoda, and M. Asada, (20202) , Soft Inductive Tactile Sensor Using Flow – Channel Enclosing Liquid Metal, *IEEE Robotics Automation Letters*, 5 (2), 4028-4034