Measurement of Stickiness with a Pressure Distribution Sensor

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Abstract. We developed and evaluated a device that can be used for the quantitative measurement of stickiness. While a typical pressure distribution sensor can measure a pressing force, it cannot measure a tensile force. We therefore installed a pin array on a sensor, with the pin array applying an offset pressure to the sensor through its weight. We measured the stickiness of natto and baby powder using the developed device.

Keywords: Pressure distribution, Sense of touch, Stickiness, Tactile sensor

1 Introduction

The presentation of human skin sensations has been intensively studied. To reproduce sensations that are more realistic, it is necessary to measure and reproduce the distribution of skin deformation.

Such measurements have been made in several studies. Levesque et al. [1] measured the horizontal displacement of the skin of a finger tracing a glass surface. Bicchi et al. [2] captured the change in the contact area of skin when a finger is in contact with a flexible object. These measurements are closely related to the technique used in the tactile presentation. The measurement of the horizontal displacement of skin is related to the development of devices that present horizontal displacement [3], and the measurement of the contact area has led to the development of a device that presents a flexible feeling by changing the contact area [4].

The present study focuses on the distribution of skin deformation when one feels stickiness. Stickiness (i.e., a sticky feeling) in the present study refers to a sense that one feels when she/he touches and releases viscous or slimy liquids such as natto (which is a traditional Japanese food made from soybeans). Such stickiness affects the impression of daily goods, such as lotion. Moreover, stickiness is known as one of the factors responsible for the wet feeling (i.e., wetness) in fabric perception [5] [6]. The application range of stickiness is thus considered large.

One factor affecting the sticky feeling is the force applied between the skin and material, but we focus on the factors of skin sensation in the present study. Furthermore, although the feeling of frictional resistance on the display surface is expressed as a

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sticky sensation [7], we deal with the stickiness that is felt when one releases a finger after pressing that finger to a material.

Yamaoka et al. [8] observed the relationship between the contact area of an adhesive surface and the temporal change in the pressing force, and found that there is large hysteresis in the contact area. They created a stickiness display based on this finding. However, since the observation was limited to the change in contact area, the detailed force distribution during the period that the sticky feeling was felt remained unclear despite being necessary for the representation of the stickiness sensation using a general pin-matrix tactile display.

In the present study, we build a system for the measurement of the distribution of forces acting between an adhesive material and the skin of a finger. The present paper describes the measurement technique and gives the results of preliminary experiments.

2 Measuring device

To measure the adhesive strength as a pressure distribution, it is necessary to measure the negative pressure distribution when lifting the skin of a finger. However, general pressure distribution sensors measure only the positive force (in the pushing direction).

To solve this issue, we devised a method of inserting a pin matrix between the skin and the pressure distribution sensor and applying a preload using the weight of the pins. The device is shown in Fig. 1 and comprises an acrylic pin insertion plate, spacers, a 10 × 10 stainless-steel pin array, and a pressure distribution sensor (I-SCAN100, Nitta Co., Ltd.). Pins are arranged one-to-one at sensing points of the pressure distribution sensor, and preload the sensor. Using this configuration, the adhesive force can be observed as the decrease in the offset force when the finger is raised.

The sensor elements and pins are spaced at intervals of 2.54 mm. Each pin is made of stainless steel and has a diameter of 2 mm, height of 30 mm, and weight of 0.8 g. It is necessary to increase the preload if the adhesive force is strong, but this is achieved easily by changing the lengths of the pins.

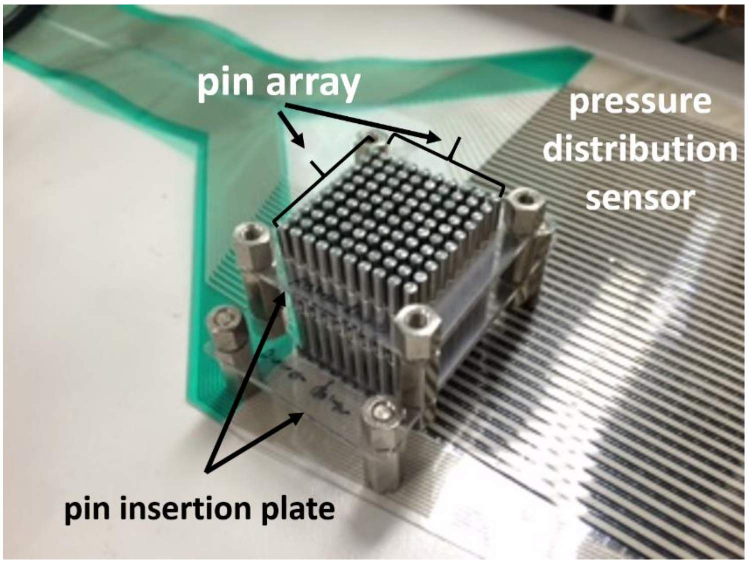

Fig. 1 Measuring device.

3 Experiment

Adhesive material was painted to a fingertip of each participant, and she/he pressed the fingertip to the surface of the pin array. When the finger pressure reached 0.05 N (i.e., the maximum value of the sensor), she/he was asked to release the fingertip in the vertical direction. The lifting process was completed in around 1 second. Measurements were saved as a csv file. In this experiment, we used stickiness of natto stirred 100 times (without soy sauce) as adhesive material, and baby powder as non-adhesive material (Fig. 2).

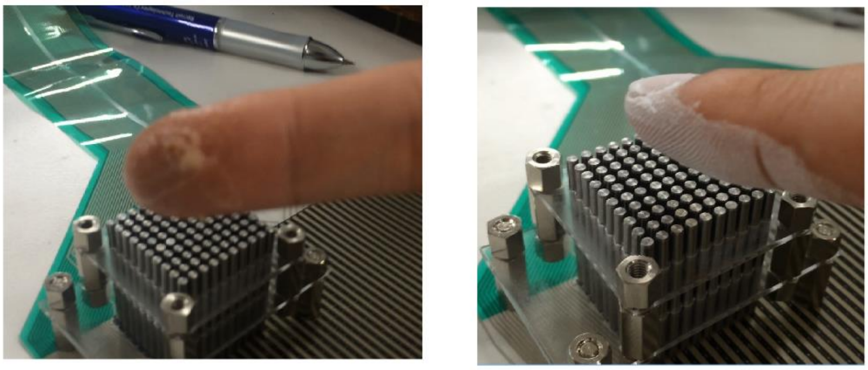

Fig. 2 Natto coating and baby powder coating.

3.1 Experimental results and discussion

Fig. 3 and 4 respectively show the changes in the pressure distributions of the fingertip measured for natto and baby powder. We subtracted the preload from the data, and a pressing force is shown as a negative (vertically downward) value while a pulling force is shown as a positive (vertically upward) value. We can clearly see that baby powder did not produce a pulling force whereas natto did produce a pulling force.

In the case of natto, there was a pressure distribution in the pulling direction (yellow in the figure) from the time the finger was lifted (2.00 s). The pulling force first appeared at two separate locations along the long axis of the finger. The two peaks then moved to the center of the finger pad, and eventually converged. Afterward, the pulling force gradually decreased, eventually becoming zero.

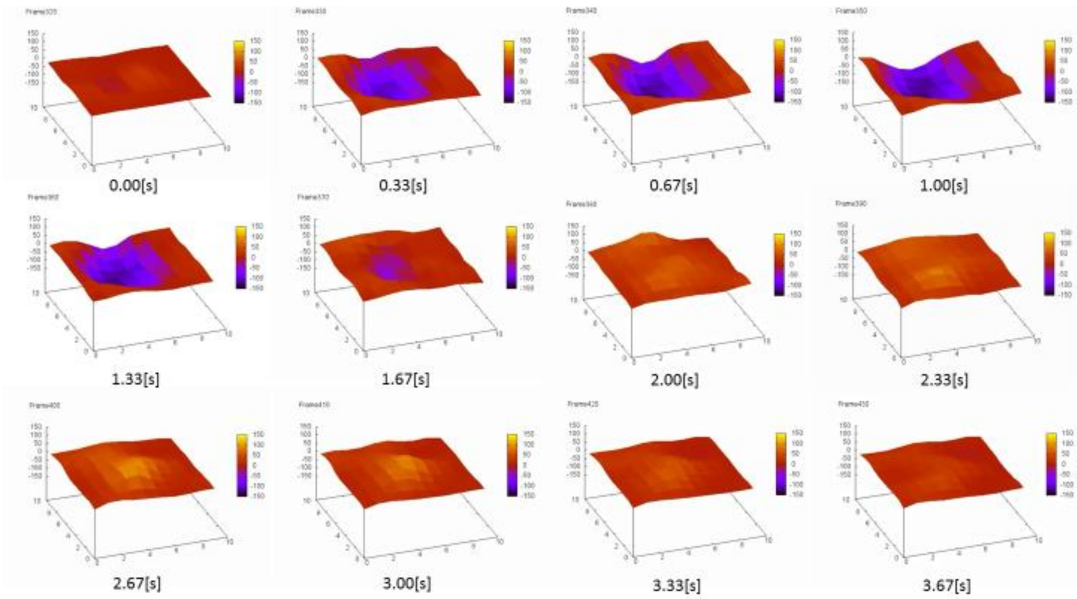

Fig. 3 Change in the pressure distribution for natto.

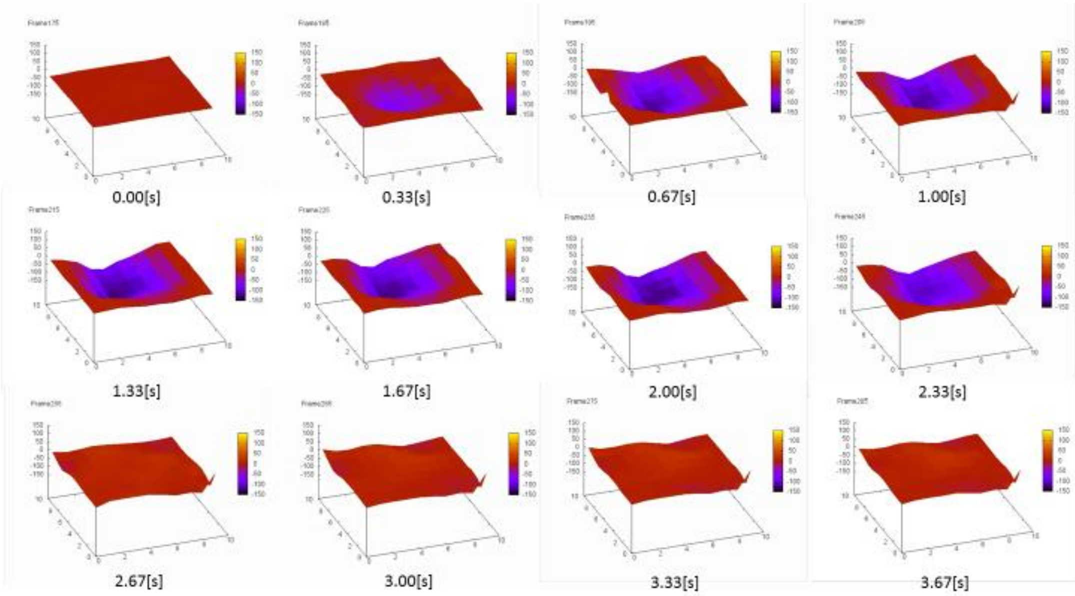

Fig. 4 Change in the pressure distribution for baby powder.

4 Conclusion

We quantified the sticky feeling of an object surface by observing the temporal change in the pressure distribution on the contact surface.

We applied a preload in our experiment because typical pressure distribution sensors measure only a pressing force. This was achieved using a stainless-steel pin array on the sensor. The experiment results were clearly different for adhesive and non-adhesive materials, and interestingly, we found that the pulling force first appears at the edges and gradually converges to the center.

Our future work will include experiments using various materials and the development of a pin-matrix tactile display that reproduces a force distribution and generates a stickiness sensation.

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