GRASP OF HARD AND SOFT OBJECTS BY DETECTIING FINGERTIP SLIP USING MULTI FINGERS HAND

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Topics of interest: 16. Sensors and Transducers

Abstract- The paper presents hardware and software architecture of the developed multi-finger hand robot using tactile sensors. The hand has three identical fingers. The fingers can detect hard and soft physical information by the tactile sensors using phase shift method. The soft and hard objects can be grasped and held easily by detecting slipping properties between the fingers and object.

1. Introduction

The development of dexterous robot hand is a very challenging endeavor. Many robot researchers has pursued the dexterous robot hands. Many robot hands have been developed over the past. These robot hands make it possible for the robot to grasp and manipulate objects. The tactile sensors are used for the detection of contact pressure to hold object. It is not possible to control soft object easily because of the very small contact pressure.
In this study, the new tactile sensor of piezoelectric device is developed and the detection of the small contact pressure can be achieved by the phase shift method. The soft object is grasped and held easily by the detection of the slipping property between the tactile sensors and the object.

2. Sensor

The composition of the tactile sensor and the detection principle of the contact force is shown in Fig. 1. As the sensor, the disc-type piezoelectric element is used and the nylon hemisphere is for the tip as a contact maker. When the nylon hemisphere contacts the object, the phase of output frequency from the sensor $\Delta\theta_1$ comes out. The phase $\Delta\theta_1$ is amplified and $\Delta\theta_1$ is changed to $\Delta\theta_2$ using phase correction circuit. It is constituted to become $\Delta\theta_1 + \Delta\theta_2 = 0$. This measurement system can measure the change of the phase as the change of the frequency and the high precise measurement is possible for the contact force of the sensor.

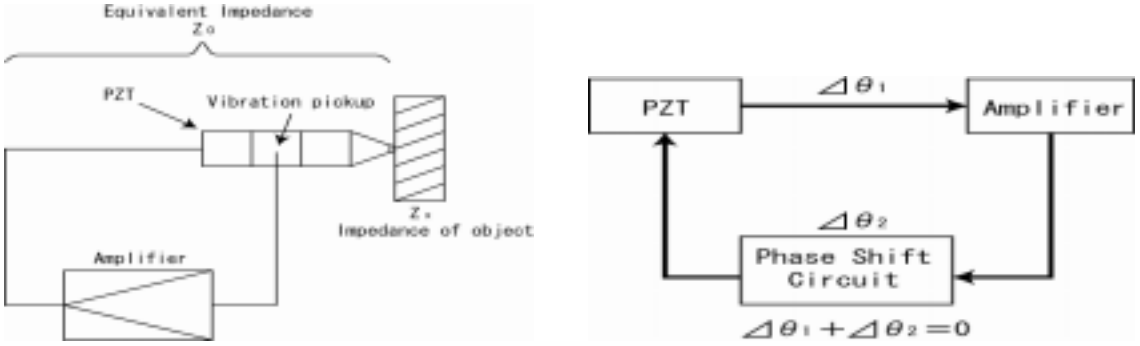


Figure 1. Sensor and measurement principle

3. Multi-fingers hand

The composition of the multi-finger hand is shown in Fig.2. The hand has three fingers. They are two fingers of the three joints and one finger of the two joints. The servomotors and the sensors are installed in the each joint. The servomotors are driven and controlled by the PMM signals. Establishing the servo buffer in H8/3052program, and making the position information of the servomotor in the table have renewed the position of the servomotor. The signal from the sensors is directly reflected to the servomotor by adjusting the collection speed of the data to the driven period of the servomotor. Figure 3. shows the side view of the hand.

Figure 2. Multi-fingers hand

Figure 3. Side view of the hand

4. Experiments

4.1 Detection of slipping at fingertip

When the object is held, the fingertips of the robot hand contact the object and the fingertips are moved to the upper part. The slip between the fingertips and the object is happened at this time. The derivative of the outputs from the tactile sensors at the fingertips changes greatly in the slip. The derivative value is fixed as a threshold, and it is judged that the slip has been happened, if the threshold was exceeded. The holding of the soft object is enabling by applying

the minimum holding force which does not generate the slip. The measuring system using slipping is shown in Fig. 4. The concrete method and procedure are shown in Fig. 5.

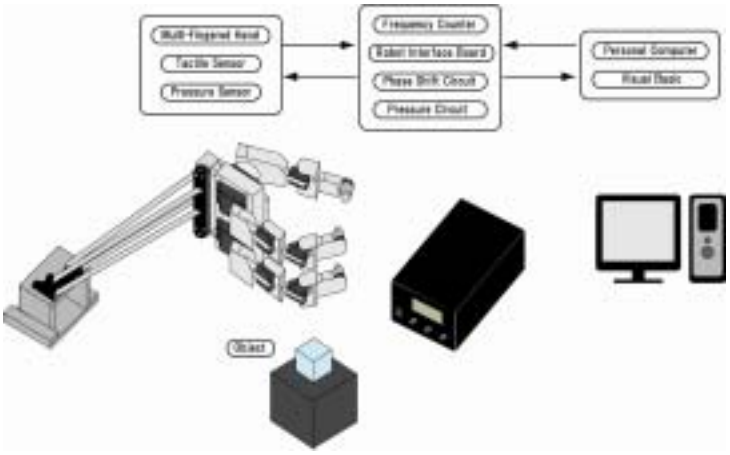
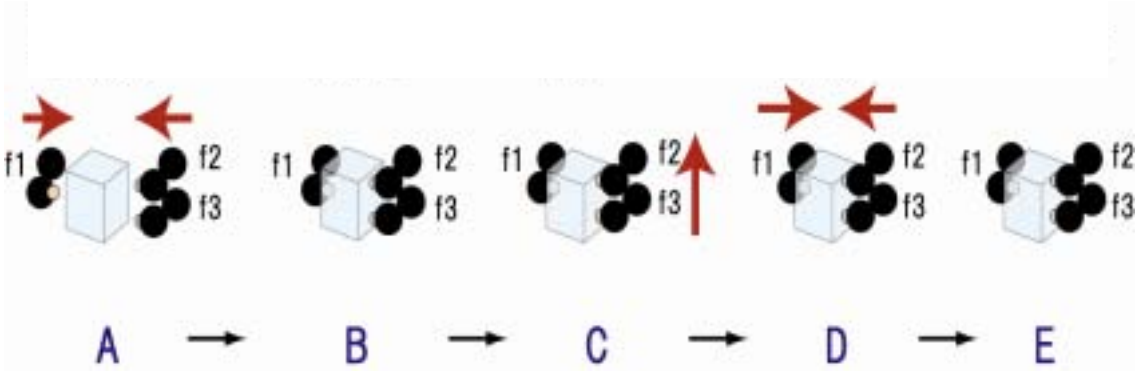


Figure 4. The Slipping force measuring system



A: fingertips move **B:** fingertips contact the object **C:** fingertips move to upper part
D: fingertip move until the slip does not happen **E:** holding the object

Figure 5. Holding procedure of the object

4.2 Holding experiments

The holdings of Tofu shown in Fig. 6 and heart of the pig shown in Fig. 7 are tried. The Tofu is a very soft object and if a large force is added the Tofu is collapsed. The heart of the pig is also the object which needs the attention for handling. The Tofu is a typical Japanese food.

Fig. 6 Holding of Tofu

Fig. 7 Holding of heart of pig

The experimental result of holding the Tofu is shown in Fig. 8. In the figure, from the top they are output of the sensor, derivative of the sensor output, movement of the fingertip to the object and movement of the fingertip to the upper part. The derivative of the output of the tactile sensor repeats the large fluctuation in the slip holding as shown in the figure. This fluctuation is judged the slip in holding of Tofu, and the holding force is added in addition. Until the slip is not generated, the holding of the Tofu becomes possible by the addition of the holding force. The Tofu can be held in the minimum force without the collapsing. The holding of the heart of the pig is also possible in the same way.

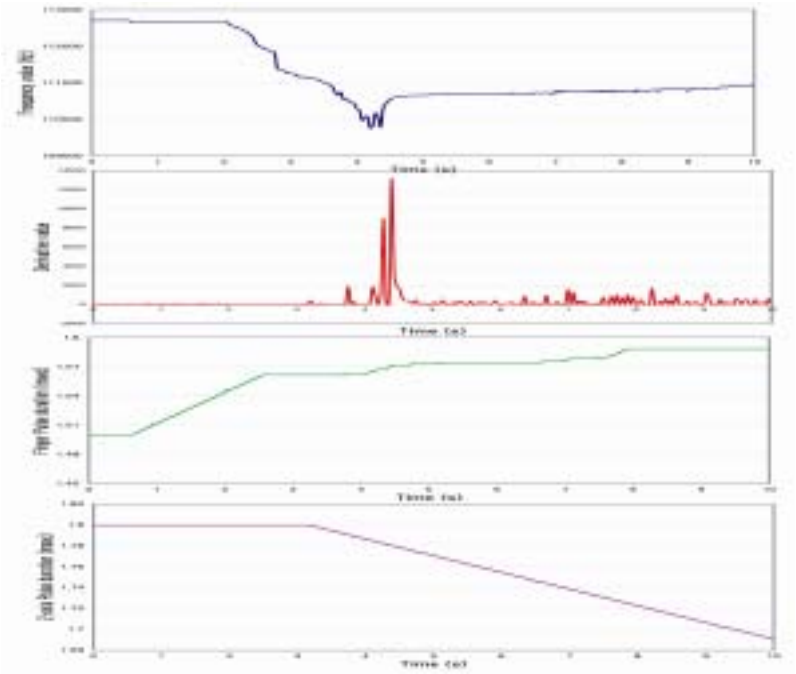


Fig. 8 Experimental result of holding Tofu

5. Conclusions

In this study, the tactile sensor system was composed of the piezoelectric element and the feedback circuit system processed the output from the tactile sensor. This sensing system was applied to the holding the soft and hard objects. As the typical examples, the holdings of the Tofu and the heart of the pig are demonstrated.

It was found that the derivative of the holding force greatly fluctuated, if the holding slip was happened in the holding. The holding of the very soft object is confirmed in minimum holding force using this derivative variable.

In the future, the further development of the surgery by the robot is expected using this sensing and holding system in the fields such as the medical treatments.

References

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