Development of touch sensor system of silicone-type artificial skin for an interactive android robot

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*Abstract***:** This paper presents a touch sensor system of an android robot developed by authors. In our android, touch sensors are embedded under artificial skin which is composed of special silicone. Also the thickness of the skin is about 5 to 20 mm in the face and hands. In general, as the skin is thicker, the recognition rate of conventional resistive touch sensor is worse. In addition, irregular artificial skin surface does not guarantee the recognition of various touching movements. To improve the recognition rate of touch sensor, we developed capacitive touch sensors with touch controller module. In order to verify the effectiveness of our touch sensor system, we test it in various conditions of thickness and touching movements. Also we show some applications of interactive communication using our touch sensor system between human and android robot.

Keywords: Android robot, Capacitive sensor, Touch sensor, Flexible Tactile sensor**.**

I. INTRODUCTION

Using the touch-sensor technology is contacted by the human often has been applied to many mobile devices. This technology is shown in Figure 1 applied to the Android robot or Humanoid robot was also used.

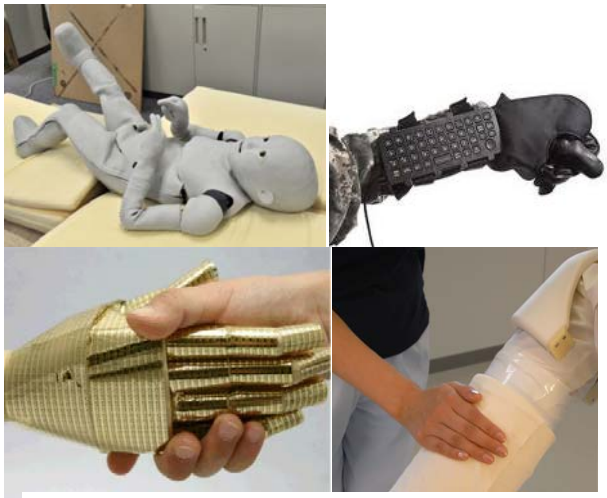

Fig. 1 Robots using tactile sensors

However, the general robot used touch-sensor technology in the purpose for which power was measured. Touch-sensor technology in the android robot, rather than for the purpose of measuring the force for the purpose is to interact with human. In the case of android robots are composed of thick artificial skin. The force exerted from the outside is difficult to be passed inside the touch sensor pad. In addition, the android robot out of the artificial skin should not be exposed to the touch sensor pad. Also more than 10mm in thickness artificial skin was used in the general robotics and force-based touch technology is difficult to apply. The outer surface of the android-robot is complex as Figure 2 shows the typical force-based touch sensor using a

Fig. 2 Ever-2 Head : inner structure and face

variety of movements can not be guaranteed. Therefore, various facial expressions are critical problems in the android robot.

In this paper, a touch sensor system for android robot interaction is about the development. Change in capacitance value due to contact with the human body to detect and obtain data from each of the touch sensor pad for the touch sensor module; Touch sensor module to collect the data obtained by the various touch-operation results can be transferred to the host device, the touch module controller; Analysis of the data received from the touch module controller for the robot to determine whether any act came in, the robot is to do as a result of behavioral patterns were selected to generate a corresponding control command signal sent to control the target controller, the host processor(PC: personal computer) unit program Includes.

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II. OPERATING PRINCIPLE OF CAPACITIVE TOUCH SENSORS

Capacitive touch sensors that measure the variation in capacitance of the touch sensor pad and the humidity,

pressure, location, etc. can be measured. Pressure sensors, touch sensors, accelerometer sensors, etc. are typical.

Common measurement for capacitance sensor can range from the tens of pF is pF. In this paper, we apply the touch sensor SoC(System On Chip) is used to model the NTS1006 product by NextChip Ltd. Chip capacitance measurement precision and resolution has 0.1pF capacitance also has six input channels. In this paper, in an SoC was used the two capacitive input channels.

General formula of capacitance relationship between PAD size and relative permittivity are as follows.

$$C = \frac{\varepsilon S}{d} = C = \frac{\varepsilon o \varepsilon r S}{d} \quad (1)$$

εo : Vacuum Permittivity, εr : Relative Permittivity, S : Size, d : Distance

Touch sensor pad occurs in the size of the capacitance in the above formula (1) and the same, the touch is inversely proportional to the distance and is proportional to the pad size. In addition, the touch pad and the contacts between the relative permittivity capacitance can be a significant change in capacity.
Typical relative permittivity of the acrylic 2.5 ~ 3, FR4 PCB 4.3 ~ 4.6, 2.0 to 3.5 rubber, air 1, the water has 80 properties. Silicone artificial skin on the android-robot picks up the attributes on the relative permittivity constant of 2 to 3.5 typically rubber like material properties and the mixing ratio varies depending on the value. Low relative permittivity and complex face various forms of internal structure of the metal frame is mounted. Thus, the capacitive touch pads are difficult to operate reliably in the android robot. Between touch pad and is particularly close to a thick artificial silicone skin, due to the low relative permittivity constant is difficult to obtain sufficient capacitance. To overcome these problems, this paper has developed a touch sensor pad size of 10X12mm. Also, SoC RF Noise in a number of input channels to prevent the incoming input channels were mounted in front of the LPF(Low pass filter). As a result, a touch sensor operates from a variety of RF Noise was an error does not happen. The SoC delta detection algorithm based on the threshold algorithm is applied to a variety of changes in capacitance values could be obtained quickly.

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III. DESIGN OF TOUCH SENSOR SYSTEM

The authors have developed a touch sensor system is shown in Figure 3. Two touch pad with a touch module, comparative data for each touch pad may be sensing the moving action. Touch module was applied to a high-performance SoC(NTS1006), and I2C communication with the touch module controller is connected. 400KHz and 100KHz to 100KHz of the speed of I2C communication used.

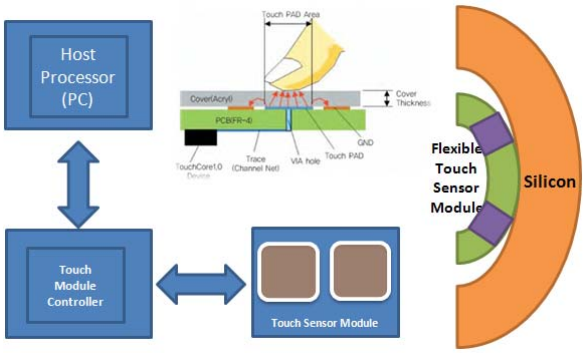

Fig. 3 Touch Sensor System

Communication speed is too high for the sampling period is short, touch-sensing value is acquired abnormal value by experimental and applied to the communication speed of 100KHz. Calibration of touch module, initialization, and communications functions are programmed in the touch module controller. Contact with touch sensor pad have a relative premittivity capacitance occurs as should perform calibration. The reference value is set to occur as the capacitance and capacitive touch operation changes the value of accurate sensor reference value must be deducted from the acquisition can be.

Communication mode UART / USB / CAN approach can be used, but in this paper for easy multiple access CAN2.0A version was used.

Host device (PC: personal computer) 25ms intervals from the touch module controller touch sensor pad for each data value is obtained within the sensing. Obtained touch data based on the behavior patterns which determine whether the touch and judge the results shown in the touch module was mounted on the LED.
In this paper, the behavior patterns of touch PAD1, PAD2 a 25ms cycle Data obtained from the touch-verify the data obtained were analyzed based on the behavioral patterns of touch. In the developed touch sensor system can distinguish between various touch behavior patterns that looked out through the following experiment.

IV. EXPERIMENT

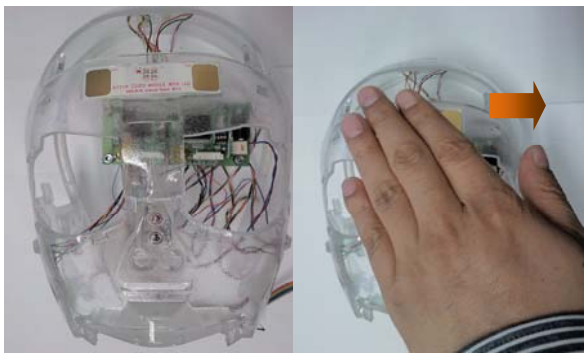

Fig. 4 Touch operation on the touch sensor pad

Exposed as shown in Figure 4 on the touch sensor pad touch action was tried. Touch sensor pad exposed in the middle do not have a relative permittivity capacitance value could be obtained as the results shown in Figure 5.

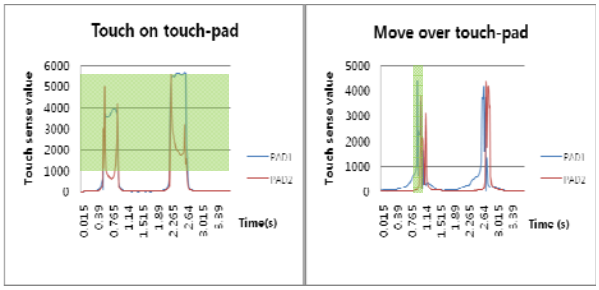

Fig. 5 Touch operation on the results of the touch sensor pad

Touch sense value, as shown in Figure 5, the sensing range is 1000-5500, and after a touch more than 100ms in case of move has a time-shift operations, sensing that a well could be confirmed by experiments.

Fig. 6 Touch operation on the artificial silicon skin

Figure 6 shows a touch sensor and a relative permittivity between the chains in the presence of artificial silicon skin the experimental data shown in Figure 7. Android robots face a common area of artificial silicon skin thickness has a thickness of about 0.5cm ~ 1.4cm.

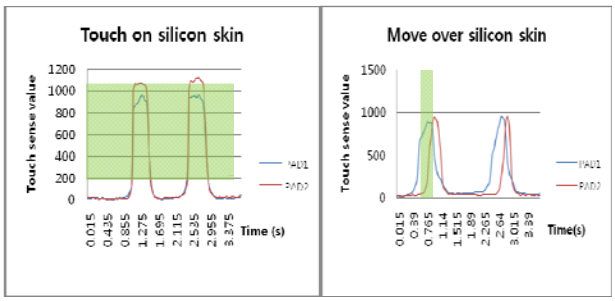

Fig. 7 Touch operation on the results of the artificial silicon skin

As shown in Figure 7 500-1000 range between the sensor data and experimental results in Figure 5 confirmed that more data can be reduced in scope. Distance increases and the relative permittivity as described in Formula 1 is the reason. However, as shown in Figure 7 from the touch sensor operates sufficient change in capacitance could be confirmed. Figure 7 is stable to have been confirmed by comparison with Figure 5.

V. CONCLUSION

In this paper, for Android Robot capacitive touch sensor system was developed. Android robots applied to the face above the thick artificial silicon skin that stable operation is performed through the previous experiments could be confirmed. Android robots through experiments and a variety of human interaction can be sure that it could be seen. In this paper, the perfect interaction with the robot did not perform. If further studies continue to design the entire touch sensor will be mounted on the robot. Through this pattern, corresponding to various natural touch interaction research is carried out is expected to continue.

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