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MEASUREMENT OF FABRIC HAND FEELING BY SCANNING FIBER WHISKER WITH PSD

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Abstract: Fabric hand feeling is an important property used in apparel industry. This paper shows a sensing method to output a fiber whisker's stick slip vibration by scanning it on the fabric. Then the vibration waveforms are transformed to the Symmetrized Dot Pattern images. Experimental results show that SDP images of fiber whisker's stick slip is potentially useful to the detection of fabric hand feeling values.

Keywords: Whisker sensor, Optical fiber, Stick-slip, PSD, Fabric hand feeling

1 INTRODUCTION

In order to evaluate fabric hand feeling value objectively, some convenient tools such as hand ring tester and handle tester have been used. They indicate the resistance when cloth was lead to pass through the ring or the narrow space of two boards. There are also some instruments which are used to measure physical characteristic values of fabrics, like tensile and shear testing, bending and compressing testing and surface testing machines. But skilled experts just scrub their fingers with cloth to get hand values of different fabrics. Since fabric hand feeling value is a complicated property, the instrument system should output a complex signal, which can be used to describe the characterization of different fabrics.

In this paper, a fiber whisker touch sensor is constructed, as a means for gathering fabric hand value information. When fiber whisker scans on the fabric surface, it vibrates relatively to the scanning motion. This stick slip vibration movement of the fiber tip is detected optically by Positional Sensitive Device.

Four different fabric samples were tested. The amplitude and period of the stick-slip motions is different depending on the fabric, and they are variant with the same fabric when fiber length or tension varies. These experimental results are displayed by Symmetrized Dot Patterns on polar coordinates to distinguish the four different fabrics visually.

2 FIBER WHISKER SENSOR SYSTEM

2.1 Instrument of fiber whisker

Tactile whisker sensor is mainly used on robot to measure the shape or surface properties of object. Mostly it detects whether the touch is on for the aim of avoiding an obstacle. Tactile stylus is a representative to measure surface roughness. But it measures the perpendicular displacement when stylus is scanning on horizon direction. In this study, we use a 1mm diameter and 4 ~ 6mm long optical fiber as a tactile whisker sensor. Its tip touching on the fabric surface, was cut and ground to a plane that is 45° oblique to the axis of fiber. The cutting plane was covered with gold film by vacuum evaporation. A modulated laser light going through the fiber core emits from the tip perpendicularly to the fiber axis.

Fig.1 shows the setting of fiber whisker and experimental system diagram. While scanning on the fabric surface, fiber whisker does a vibration relatively to the scanning motion called as stick-slip vibration. This stick slip motion of fiber tip is detected optically by Positional Sensitive Device. In this case, detected displacement is on the same direction with the scanning, differently from usual surface stylus.

As shown in Fig.1, PC controls the plotter's moving, and gets the PSD output signal through AD convert while whisker is tracing on the fabric. Photo1 shows the fiber whisker sensor with PSD, and Photo2. shows the four fabric samples :cotton, linen, silk and wool.

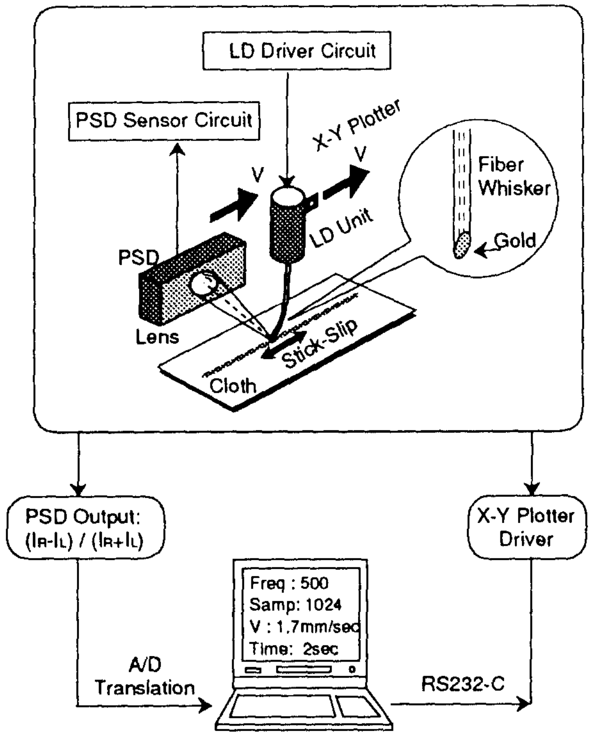


Fig.1 Fabric hand feeling measurement with fiber whisker sensor

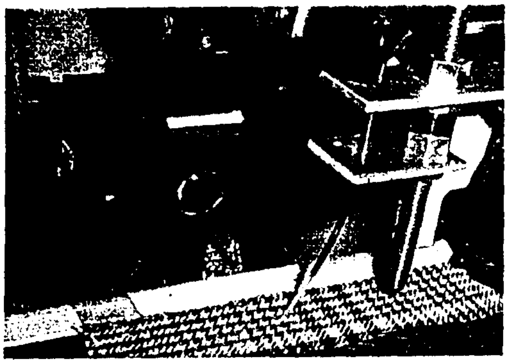


Photo1 Fiber whisker and PSD

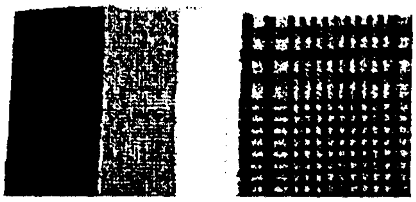


Photo2 Four fabric samples

Fig.2 shows the experimental results for the two fiber length 20mm and 40mm with four fabric samples and paper as a reference. The stick-slip vibrations is different depending on the fabric, and variable with the fiber length or bending.

2.2 The stick slip fluctuation and fabric hand value

Fig.3 shows the details of the stick slip for fiber whisker on fabric.

The stick slip fluctuation is determined by the balance between the static friction and dynamic friction. Generally, it is easy to stick slip when spring constant is small and driving velocity is low.

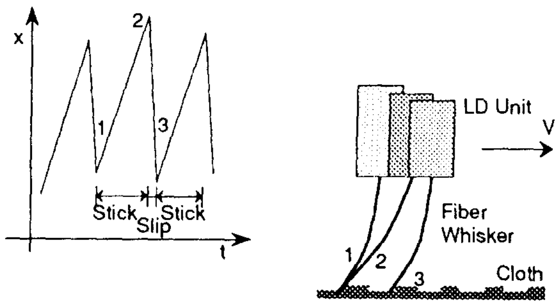


Fig.3 The stick-slip motion of fiber whisker

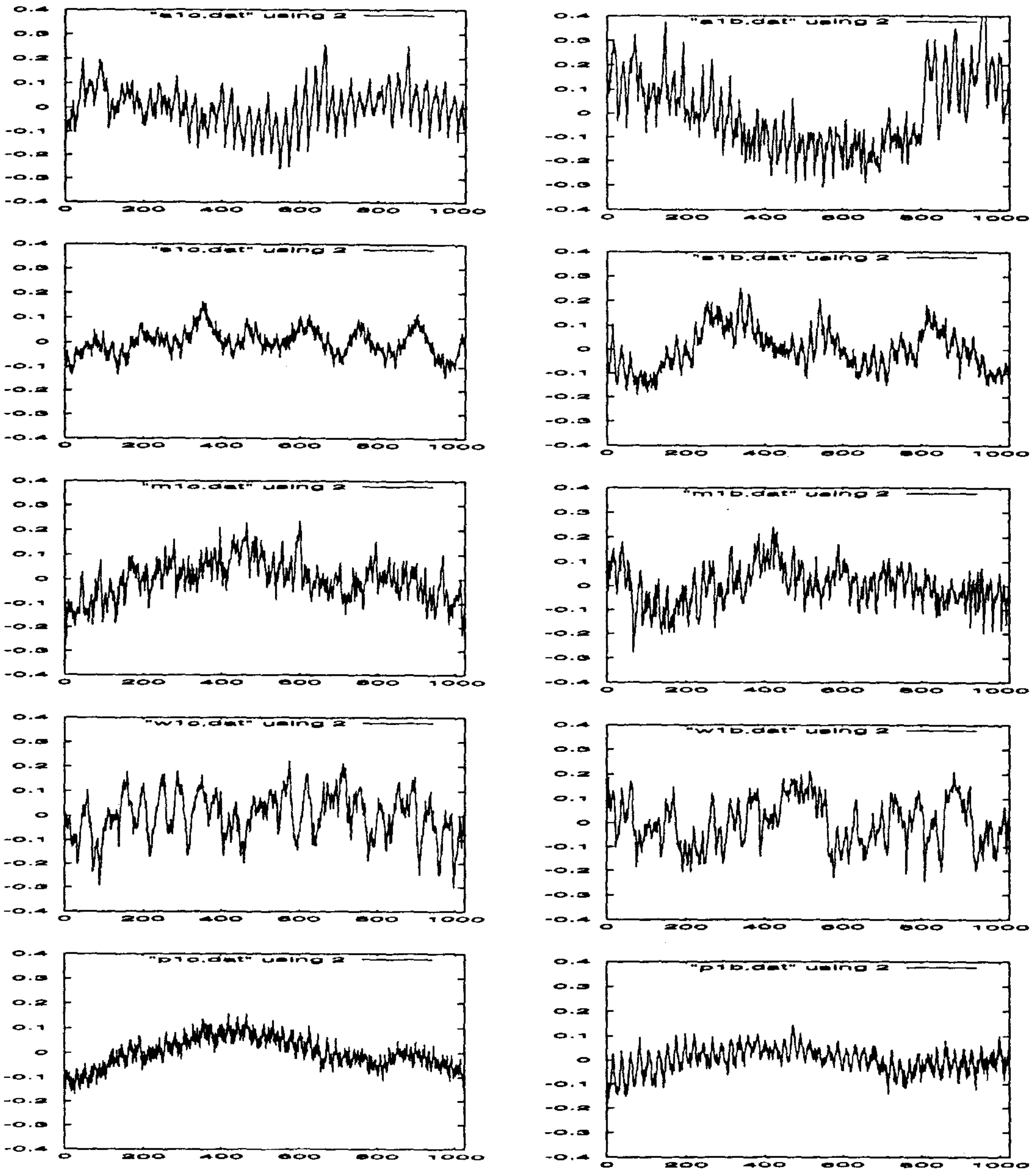
But when the fiber is longer, then the spring constant is smaller and the force to compress the fabric is weaker. At this condition, seeing Fig.2, the stick-slip fluctuations not only got larger but also smaller differently depending on the fabric. In the case of linen, when fiber is short, the force compress fabric is big, fiber whisker do a large vibration because the clear mesh and the stiffness of linen.

On the other hand, fabric static or dynamical friction coefficient doesn't mean the fabric surface smoothness or wax-like. They are induced by many factors, not only fabric surface contour and friction, but also surface wool-like, and even resilience or extensibility. All of these factors are represented in the stick slip motion complicatedly, and play important roles in fabric hand feeling. The complications in the vibration movements suggests us a possibility and potentiality to sense the fabric hand value.

3 SIGNAL PROCESSING

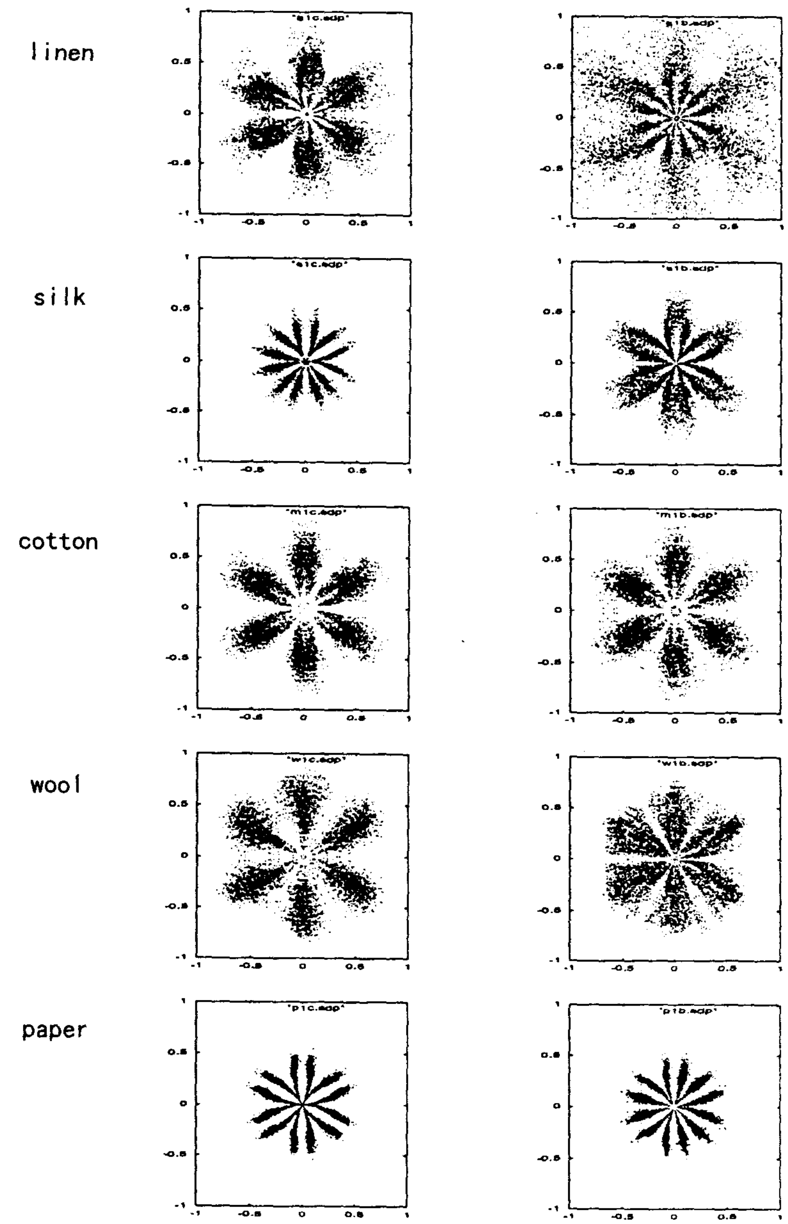
3.1 SDP transformation

Symmetrized Dot Pattern is developed for discriminating the phoneme, like [AH], [OO] or [EA] etc. Fig.4



(a) 20mm (b) 40mm

Fig. 2 Fiber whisker sensor outputs



(a) 20mm (b) 40mm

Fig. 5 SDP images for the fabrics

shows the transformation from time series signal to the polar coordinates of SDP, which radius component shows the amplitude of time i, the angle component means that of the neighboring time i+k, The computation algorithm is shown in equation (1)(2)(3).

$$r_j = \frac{F_j - L}{H - L} r \quad (1)$$

$$\Theta_{ij} = \Theta' + \frac{F_{j+k} - L}{H - L} \xi \quad (2)$$

$$\Phi_{ij} = \Theta' - \frac{F_{j+k} - L}{H - L} \xi \quad (3)$$

ただし

$$j = 1, 2, 3, \ldots, N-1$$
$$\Theta' = \frac{360°}{m} i$$
$$i = 1, 2, 3, \ldots, m$$

N is the number of all time points, m is the number of axis of symmetric images, L and H are the minimum and maximum, r and ξ are the maximum radius and maximum angle, k is the internal of the two attentive points.

Notice that the high dot density near the symmetrized axis means that the probability to be the same value simultaneously is high. On the other hand, separated dot distribution from the axis indicates a low correlation. Therefore, observing the image overlap between one dot image and its mirror dot image on the neighboring axis by adjusting k or ξ would make clear the frequency range.

Since SDP image provides a stimulus in which local visual correlations are integrated to form a global percept, and a circular symmetrized image is easier to understand for human being, SDP images can be applied to the detection of fabric hand feeling.

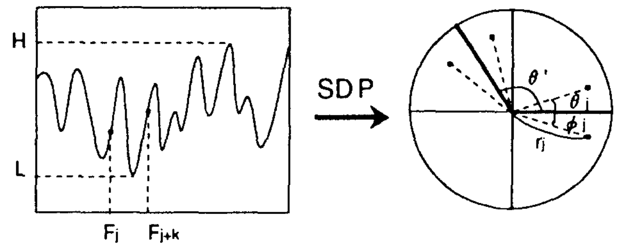


Fig.4 Transformation for SDP

3.2 SDP images of fabric

Fig.5 shows the SDP images corresponding to Fig.2. The k in Fig.5 is determined by referring to the peak interval shown in Fig.3. The SDP image seems to be a flower. The soft and woolly fabric like wool has expansive flower petals in SDP. The stiff fabric with a deep mesh like linen or cotton has a sharp flower heart. The thin and smooth fabric like silk shows a small flower because whisker vibrates a little on it. SDP make differences more obvious than sensor output waveform. Using different length fiber whisker scanning on a fabric sheet or a folded sheets will be the variations of this measurement to enhance the discrimination of fabric hand feeling.

4 CONCLUSIONS

The measurement method to capture fabric hand value using fiber whisker scanning is proposed. Experimental results demonstrates that the stick-slip vibration of optical fiber whisker shows the fabric properties. And displaying on SDP images is an effective technique to classify fabric hand feeling.

Further work is required to extend fiber whiskers array with several conditions of stick-slip variation, and improve the mapping between human hand feeling evaluation and fiber whisker measurement.

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