A Sensing Technique for Data Glove Using Conductive Fiber

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ABSTRACT

We demonstrate a sensing technique for data gloves using conductive fiber. This technique enables us to estimate hand shapes (bend of a finger and contact between fingers) and differentiates a grabbing tag. To estimate how far each finger bends, the electrical resistance of the conductive fiber is measured; this resistance decreases as the finger bends because the surface of the glove short circuits. To detect contact between fingers, we apply alternating currents with different frequencies to each finger and measure the signal propagation between the fingers. This principle is also used to differentiate a grabbing tag (each tag has an alternating current with a unique frequency). We developed a prototype data glove based on this technique.

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Figure 1: Grov prototype. The white strings are conductive fiber. The weight of the device is 70 g including the circuit and battery; the glove part weights 17 g.

CCS CONCEPTS

• **Hardware** → **Sensors and actuators**; *Tactile and hand-based interfaces*; • **Human-centered computing** → *Mobile computing*; Ubiquitous computing.

KEYWORDS

Wearable; on-body computing; hand gesture; virtual reality.

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INTRODUCTION

Data gloves are wearable hand-shaped sensing devices that can be used for various purposes such as hand gesture recognition and remote robot manipulation. Compared with camera-based hand shape sensing techniques (e.g., [4, 7]), data gloves do not suffer from occlusion problems or limitations due to shot range. Moreover, they can be used to estimate hand shapes in more detail than electromyography [6, 10]. However, due to the presence of specific sensors, previous data gloves were heavy, non-stretchable, expensive and non-washable. To solve these problems, we demonstrate Grov, which is a system for hand shape estimation and grabbing tag differentiation that uses a conductive fiber knitted glove as a sensor, requiring no additional sensor.

This conductive fiber knitted glove is commercially available, inexpensive, and is used for touchscreen operation and static elimination. As the glove is used as the sensor, Grov is lightweight, stretchable, low cost and washable. Furthermore, Grov can estimate finger bend, detect contact between fingers, and differentiate a grabbing tag. Figure 1 shows our prototype data glove.

RELATED WORK

Many types of data gloves have been proposed, including systems based on strain gauges [3], piezoelectric sensors [2], inertial motion sensors [5] and optical fibers[1]. However, these types require additional sensors. Compared with these works, our technique only requires conductive fiber, which is included in the glove, for sensing.

Previously, electric contact points have been added to gloves to estimate the positions of contact between fingers [8, 9]; Grov, however, measures the propagation of alternating currents (ACs) between fingers. In addition, Grov can also estimate finger bend and differentiate a grabbing tag.

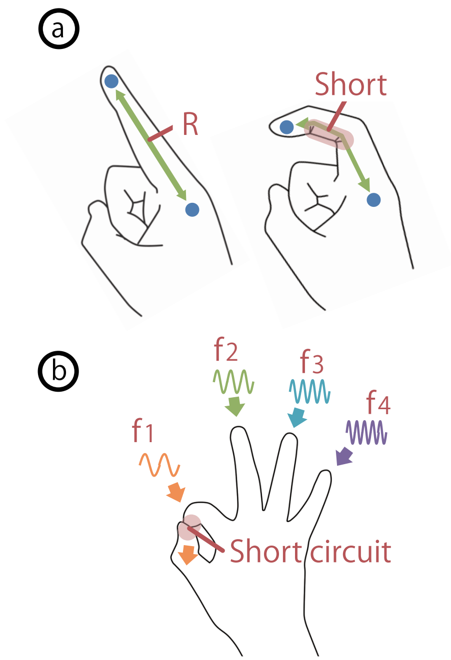

Figure 2: Principles of Grov: (a) finger bend estimation, (b) finger contact detection.

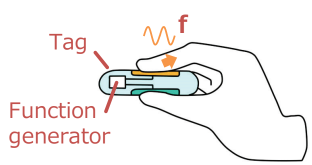

Figure 3: Principle for differentiating a grabbing tag. The tag has a function generator and propagates signal to the glove.

GROV

Grov estimates the bend of each finger and detects contact between fingers by measuring currents through conductive fiber in the glove. Moreover, Grov can identify which of several tags is being grabbed.

Finger bend estimation

Grov estimates finger bend based on electrical resistance of conductive fiber. The resistance decreases as the fingers bend because the surface of the glove short circuits, as shown in Figure 2a. The short circuit is caused by the deformation of the cloth at the joint of the finger when the finger is bent. The resistance reaches its minimum value when the tip of the finger touches the base of the finger.

Finger contact estimation

Grov can also detect contact between fingers. To detect such contact, Grov applies ACs with different frequencies to each finger and detects the signal propagation between the fingers, as shown in Figure 2b. It calculates the frequency spectrum of the signal propagation using a fast Fourier transform (FFT) and estimates the contact position based on the power of the frequency at each finger. The power of the AC signal of the specific frequency for a given finger becomes strongest when the thumb touches the tip of the finger and becomes weakest when it touches the base of the finger.

Grabbing tag differentiation

Grov can differentiate a grabbing tag by measuring ACs with different frequencies from each tag and analyzing the signal propagation, as in the case of finger contact estimation. This mechanism is shown in Figure 3. There are two electrodes on the surface of each tag; one is a signal output, and the other is a ground (GND). When a user grabs a tag, one finger is used as a signal input, and the other is used as a GND connection between the circuit and a tag.

PROTOTYPE AND DEMONSTRATION

We developed a prototype data glove, as shown in Figure 1. The circuit of the data glove can be connected to a personal computer (PC) via Bluetooth. It can estimate finger bend, contact between fingers, and detect a grabbing tag in real time. The weight of the system is 70 g including the measurement circuit and battery; the glove part weights 20 g. The production cost is approximately $50 per glove. We washed the glove three times in a washing machine and verified that it still worked.

In our demonstration, a visitor can try our data glove and see the hand-shape visualizer, as shown in Figure 4. This visualizer shows hand shapes (Figure 2) and indicates which tag is grabbed (Figure 3). Furthermore, the visitor can try our data glove in 3-dimensional (3D) space using a head-mounted

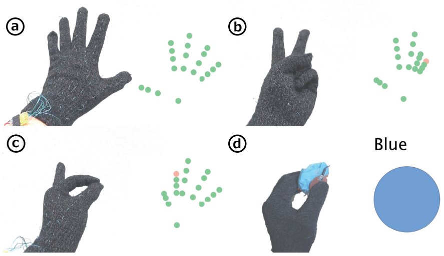

Figure 4: Hand-shape visualizer. (a) Normal, (b) finger bend, (c) contact, (d) grabbing tag differentiation.

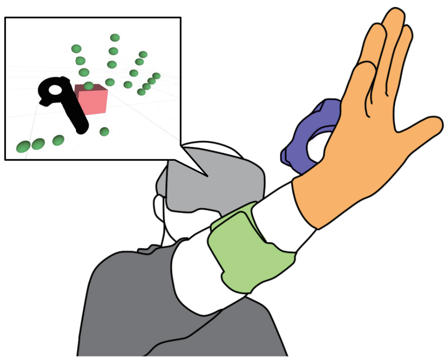

Figure 5: 3-dimensional visualization application for Grov.

display (HTC VIVE), as shown in Figure 5. In this demonstration, the hand position is tracked using the VIVE Tracker. The visitor can move a 3D cube by grasping it with their hand. The visitor can try out this prototype without calibration because the glove stretches to fit their hand.

CONCLUSION

In this work, we showed Grov, a wearable hand shape estimation and grabbing tag differentiation system that uses a conductive fiber knitted glove as a sensor. Grov uses the electrical characteristics of conductive fiber to estimate hand shape. Grov can also differentiate a grabbing tag by measuring ACs with different frequencies from each tag and analyzing the signal propagation. We developed a prototype data glove. In future, we plan to improve Grov's performance and investigate its characteristics.

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