An Assembly of Soft Actuators for an Organic User Interface

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ABSTRACT

An organic user interface (OUI) is a kind of interface that is based on natural human-human and human-physical object interaction models. In such situations, hair and fur play important roles in establishing smooth and natural communication. Animals and birds use their hair, fur and feathers to express their emotions, and groom each other when forming closer relationships. Therefore, hair and fur are potential materials for development of the ideal OUI. In this research, we propose the hairlytop interface, which is a collection of hair-like units composed of shape memory alloys, for use as an OUI. The proposed interface is capable of improving its spatial resolution and can be used to develop a hair surface on any electrical device shape.

Author Keywords: Hair-like interface; organic user interface; shape memory alloy; flexible actuator; haptic; surface display.

ACM Classification Keywords: H5.2 [Information interfaces and presentation]: User Interfaces. Haptic I/O.

INTRODUCTION

Developments in display technologies allow us to explore display designs that are not just planar but can be curved or flexible. With flexible displays, the display deformation can also be used for user interaction. Vertegaal et al. proposed the organic user interface (OUI) [8], which is capable of changing its shape actively or passively by deformation of its body. The 'organic' term originates from the use of organic electronics or inspirations from organic life forms found in nature, e.g., the skin and fur of a living creature. Rekimoto proposed adaptation of this OUI concept to the design of object surfaces and suggested that an OUI is capable of forming an intimate relationship with a user [6].

The fur and feathers of animals and birds are among the most important media in their communication processes. They form a layer that covers the animal, and thus are the material that a human contacts when touching animals. Animals with fur or feathers also use them to express their emotions by changing the state of their body surface, such as the use of bristle hairs. In contrast, current animal robots do not generally have such media. Those robots are often expected to operate alongside human users, and thus an emotionally intimate relationship should be achieved between the human user and these robots. If we introduce hairs to the exterior interface, the object surfaces can change state actively according to human user contact, just like living animals with fur. To realize a dynamic hair surface, high-density and large area mounting methods will have a very important role in preserving the fur texture. In this case, it is desirable that the size of each unit that acts as a hair-like unit is small, has simple wiring, and can be controlled individually in real time. This would provide a building block for a scalable surface.

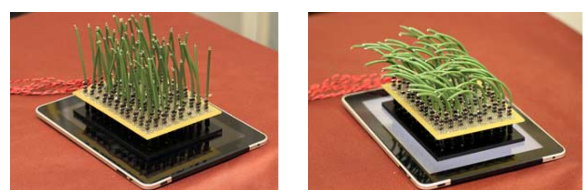

Figure 1. Overview of "large area type" prototype.

By focusing on these points, we aim to realize a hair surface that can be used for OUI operation and feedback. In this study, we first reduce the size of the hair-like unit by using a shape memory alloy (SMA) [4]. Bending control of each hair-like unit is achieved via an optical signal from a liquid crystal display (LCD). Also, contact detection is implemented through the functionality of a capacitive liquid-crystal touch panel. Then, based on these methods, we propose the hairlytop interface as a hair surface and make initial hair surface prototypes (Figure 1). The proposed interface is capable of improving its spatial resolution and can be used to develop hair surfaces on any electrical device shape.

RELATED WORKS

While we focus on the characteristics of hairs and furs, some haptic interface studies have aimed to realize the interaction through the hair surface [1, 3]. However, those researchers have not taken note of the communication aspects of hair surface active deformation. Furukawa et al.

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[2] developed a hair surface with reproducible piloerection using natural fur and vibration motors. This system has realized piloerection within a certain definite hair range, but needs particular animal hair to control it, and it is not possible to control each hair. Other researchers intended to control the posture of each flexible unit [5]. However, to implement the hair surface with a large area and high density levels, the massive amount of control wiring, the size of the contact detection and actuation mechanism cause serious problems. We thus developed hair surfaces that are capable of deformation by controlling each hair-like unit with minimal wiring.

SYSTEM CONFIGURATION

Figure 2 shows a conceptual view of the hairlytop interface, which consists of a collection of flexible hair-like units. Each unit consists of a flexible tube with SMA actuator and a drive circuit with a light sensor facing the bottom of the unit. All units are controlled by light patterns, which is known as Display Based Computing [7]. Also, our previous study shows that the system can be touch detectable by using a capacitive touch screen [4].

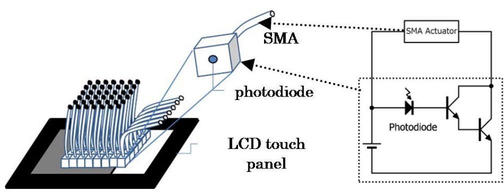

Figure 2. Conceptual view of hairlytop interface and its drive circuits.

PROTOTYPING

To control the hair surface, it is necessary to implement hair-like units extensively and at high density. It is also desirable that each unit can be controlled in any direction. We produced two prototypes.

Large area prototype

An overview of the first prototype is shown in Figure 1. We manufactured 88 hair-like units, placed in a rectangle, which is 90 mm long in the vertical direction and 130 mm long in the horizontal direction. This prototype has a 70 mm long SMA actuator and a drive circuit with a photodiode and two transistors (Figure 1 right). The hair-like unit photodiode measures the brightness immediately below the actuator to control the current supplied to the SMA actuator. Each unit can bend in one direction individually according to the LCD panel brightness. The hair surface density can be increased by introducing smaller parts for each unit.

Multi direction prototype

The second prototype is shown in Figure 3. This prototype consists of 9 hair-like units placed in a 35 mm square, which can bend in any direction. Each unit has SMA actuators in three locations around the circumference of the inner silicon tube and three driving circuits (Figure 3 lower) that control the power to the SMA actuator. Spatially separated light is used to control the bending direction of each unit.

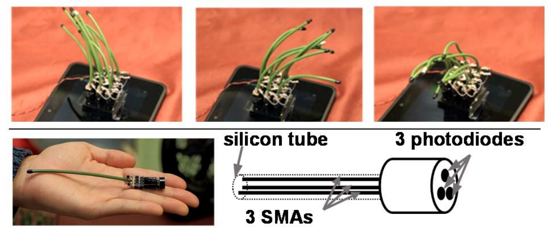

Figure 3.“Multi direction type” prototype.

CONCLUSION & FUTURE WORK

We have developed hair surfaces for use as OUIs. By controlling all hair-like units through the LCD light pattern, the proposed interface simplified high-density and large-area implementation. To approach the texture of real hair, the hairlytop interface must achieve greater density by further reducing the circuit size. We must also increase the flexural behavior reproducibility and examine application of the interface when combined with hand contact.

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