Fashion and Textile for Augmenting Human in Space

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Advances in space transportation technology, usual people will be able to visit space more easily in the future. However, space is quite different environment from that of the earth. Future space tourists, who should not be trained enough comparing to current mission specialists, will suffer various problems. Thus, a novel textile will be required for augmenting human in space to support their lives to become more comfortable. The basic component of such clothes will be, sensors to monitor wearer's biophysical status, a certain kinds of intuitive display method that could be easily used casually. In addition, the appearance of such clothes should be considered to be worn by usual people. This paper proposes the Bio-Collar, a sensor integrated kinetic-optic wearable system. This is a novel collar-shaped wearable bio-status display. The Bio-Collar indicates the wearer's bio-status through its color and kinetic motion.

Key Words: Augmented human, Kinetic clothes, Space tourism, Wearable interface, Biological data visualization

1. Introduction

Space will become an easily accessible place for every person on the earth in the near future. Environment of space is very different from that of on the earth. Thus, the redesign will be required to fashion and textile for such usual people to be able to spend a comfortable time in space. At present, very limited, highly trained people could go and stay in space to conduct scientific experiments. They are called mission specialists. Clothes for those mission specialists is well designed in its functional aspects. For example, most clothes that are used in the ISS are made from cotton to avoid static electricity. A specially designed cooling underwear is used during the launch phase and EVA (Extravehicular Activity). However, in the space tourism era, space will become a social place, not merely an experimental chamber. It is the same as on the earth, people will meet and communicate each other. Therefore, functions that are required to clothes for such people should be different from those for specialists in space these days. In addition, the visual aspect of clothes is also important. Good looking, stylish dress is preferable for people to stay in space as a tourist.

In space, people have to stay within an artificial environment. The micro gravity and such artificial environment greatly affect human body and their mental aspects. Therefore, people in such environment should become careful of their physical and mental status each other. Unfortunately, the human being does not have a suitable display for expressing such information by nature. Then, to begin with this research, we focus on the visualization of human property in space for their physical and mental health. Such specially designed fashion and textile could be a new expression media for human. Which means, they could be a system to augment human in space.

More specifically, we focus on space sickness. Space sickness is common among astronauts. The basic countermeasure is taking care of their own status and if it became worse, taking actions to feel comfortable. In daily life, we are often aware of a person's bio-status on the basis of their complexion and demeanor. In this project, wearable technologies will be pursued to be able to help such people to become aware of their own and other person's status intuitively.

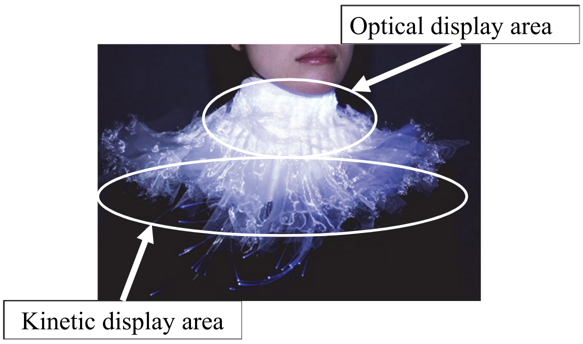

Fig. 1 Overview of the first prototype of Bio-Collar

In this paper, a novel collar-shaped wearable bio-status display named Bio-Collar is proposed (Fig. 1). The Bio-Collar is capable of showing the wearer's bio-status through its color and kinetic motion. Conventionally, visual monitors are often used to show the detail information from wearable systems. However, visual displays often draw too much attention to the monitors and is thus not suitable for face-to-face communication. Taking care of one another is a basic feature of interpersonal interaction. In this respect, a bio-status wearable display is needed that allows us to note a person's bio-status in a casual way. Opening such data for a certain close group will lead to better communication and appropriate care among members of the group. By displaying and sharing biophysical information among a certain group, members of the group could notice each other's bio-status, allowing the members to provide immediate and appropriate care.

2. Related Works

Wearable technology is one of the methods to augment human. Thus much research has been conducted on wearable technology area, especially sensor related topics. One major application of the wearable sensors is health monitoring [7]. The Major purpose of using such sensor is to collect biophysical data to monitor wearer's status. In this situation, detail evaluation of such data is necessary, then visual monitors are often used to show such data. However, visual monitors tend to pull too much attention of the viewers. That is unwanted situation for daily casual communication. It will be preferable for future space tourists being able to share their biophysical status in a casual way.

Some researchers focus on the same issues and propose some textile embedded with optical display elements [1,3] and with kinetic elements [2,6]. Such technology should have the potential to provide a casual display that shares the bio-status among people.

3. Prototype System

3.1. Overview of the Bio-Collar

Fig. 1 shows the overview of the prototype system. As the figure shows, the upper part of the Bio-Collar is optical display part and the lower part is a kinetic display part. This is the first prototype of clothes that could augment human in space. Thus a removable collar based system is developed. The basic material of the collar is mesh fabric, which contributes improving elegance of the collar. The color of the optical display part of the Bio-Collar is changed to show the wearer's bio status. Meanwhile, the kinetic display part, the bottom of the Bio-Collar, moves according to the same information. In the following sections, the basic structures of the each part of the Bio-Collar, a sensory part, a kinetic display part, and an optical display part, is described.

3.2. Sensor

In this study, we focus on motion sickness as a status that could be displayed and shared among space tourists. Previous works on motion sickness and simulator sickness [4] suggest that the heart rate and heart period, hypergastric response and skin conductance are sensitive parameters that can be used to detect motion sickness and simulator sickness. As a first step, we construct a Bio-Collar that indicates the heart rate optically and kinetically.

The system uses a pulse sensor (SEN-11574, SparkFun Electronics, CO, USA) to detect the wearer's heart rate. The sensor is attached to wearer's ear by using clip as shown in Fig. 2. The measured data are transmitted to a personal computer via Arduino Duemilanove hardware through a serial interface.

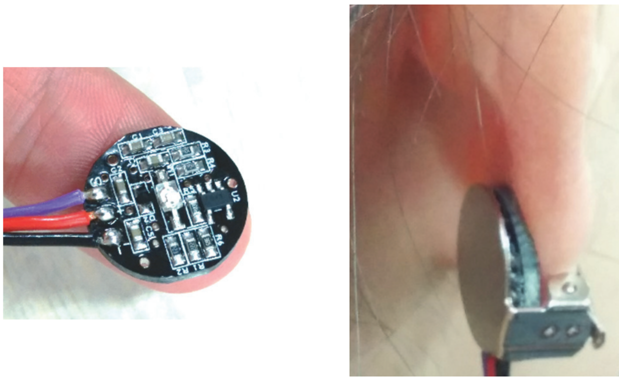

Fig. 2 SEN-11574 heart rate sensor

3.3. Optical display part

The color of the Bio-Collar can be changed using full-color LEDs and side-emitting optical fibers (PF-1.0S, ϕ1.0 mm, Saiden Corp.). The optical fibers are integrated into the base part of the Bio-Collar as shown in Fig. 3. Then, kinetic display part (Fig. 9) is overlaid to it. The color of the LEDs is controlled from blue to red according to the wearer's heart rate by using Arduino UNO, Maxuino and Max/MSP6 as shown in Fig. 4.

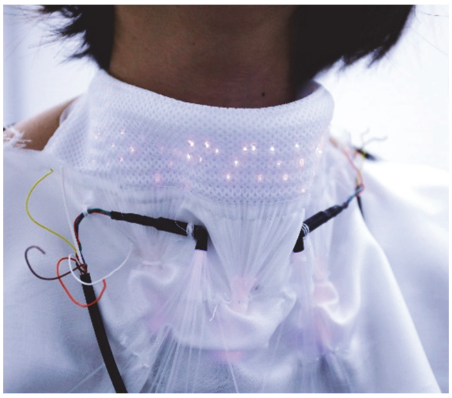

Fig. 3 The structure of the optical display part of the Bio-Collar

Fig. 4 The color that indicates wearer's heart rate

3.4. Kinetic display part

To compose a kinetic display integrated clothes, soft and light weighted actuators are preferable. If the actuators of the kinetic display are composed of hard material, the clothes should be uncomfortable to wear. In addition, heavy material also makes the clothes uncomfortable. Thus we use smart hair as actuators of the kinetic display part. The smart hair is fine and flexible soft actuators as shown in Fig. 5.The smart hair, which is the basic component of the Hairlytop Interface [5], originally composed of silicone tube integrated with fine Shape Memory Alloy(SMA), driving circuit and a sensor. The size and weight of the soft actuator is less than 6 mm and 1 g respectively. This soft actuator bends when heating the SMA. The Fig. 6 shows the typical circuit design of the smart hair integrated with drive circuits and a sensor. The amount of the bending is simply controlled through the amount of supplied current to the SMA, which generates Joule heat. In the configuration shown in the Fig. 6, the electric current is controlled through the sensory information of light intensity. This means, the amount of the bending is controlled through the light intensity as shown in Fig. 7. Owing to its soft and simple structure, the smart hair has high flexibility in configuration. In addition, the bending motion of the smart hair is so unique that reminds us a certain kinds of creature. Thus, the smart hair could be an appropriate component to be integrated into textile. In this project, the smart hair is used as an actuator to activate the specially designed collar, to indicate the wearer's biophysical status, heart rate in this case, through its bending motion.

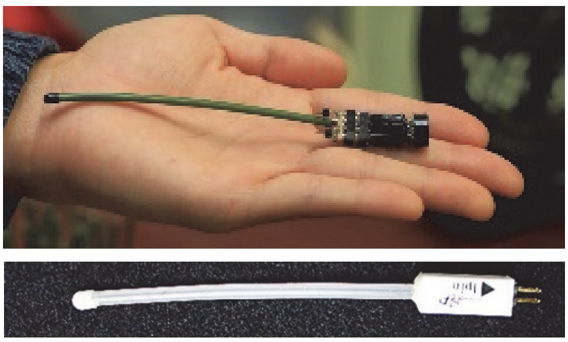

Fig. 5 Smart Hairs (Top: initial prototype including driving circuit and light sensor, Bottom: commercial model without driving circuit and sensor)

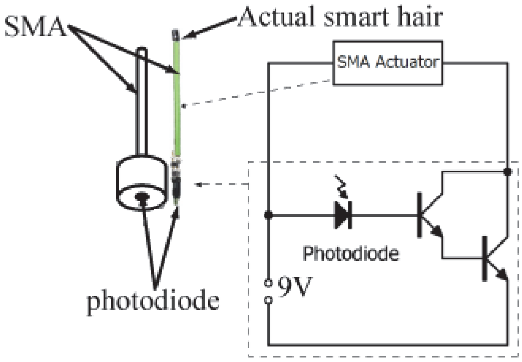

Fig. 6 Typical circuit design for the smart hair

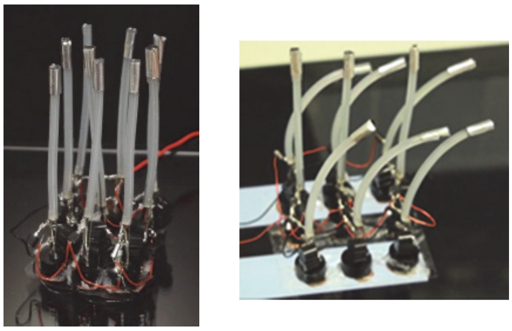

Fig. 7 Light sensitive configuration of the smart hairs: the amount of bending is controlled through the light intensity of the display

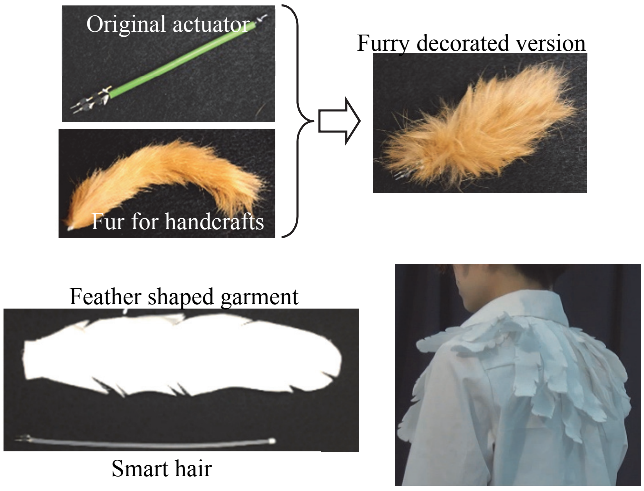

Fig. 8 Variations of design of the smart hair (Top: furry decorated version to enable tail-like component. Bottom: feather shaped component to be equipped with a shirt [6].

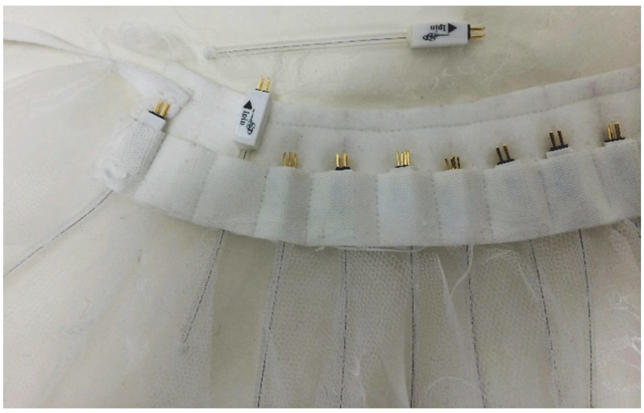

Fig. 9 Detail integration method of the smart hair

Fig. 9 shows the detail of the integration method of the smart hair. As shown in the figure, smart hairs are inserted between the layers of mesh fabric. The root of the smart hair is fixed to the base component by using elastic fabric. The electrical system to activate smart hairs is shown in Fig. 10. Considering the future extension of such clothes, it is assumed that the number of actuator increase and the hardware should be simple and small as possible. In order to the requirement, we use TLC5940 of Texas Instruments which has 16 PWM outputs. By adopting this IC, this system can move each actuators independently corresponding to sensory information. At the same time modularization to expand the amount of actuators is available. 19 Smart Hairs are used to move the bottom of the collar in the Bio-Collar as shown in the Fig. 11. All Smart Hairs move simultaneously with a certain period, according to the measured heart rate. In this prototype, we assume the range of the heart rate from 60 bpm (beat per minute) to 140 bpm. Then, the interval period changes from 2056 milliseconds to 904 milliseconds respectively. Those parameters are designed based on the time constant of the heat conduction of the smart hair.

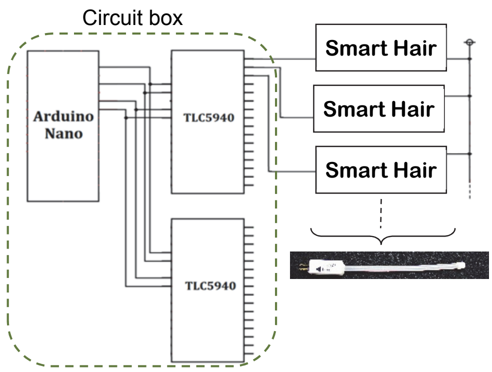

Fig. 10 Electrical system design

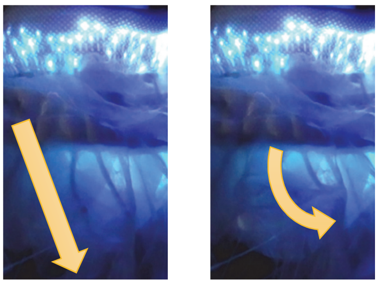

Fig. 11 Left: straight shaped condition, Right: curved shaped condition

4. Conclusion and future work

This paper proposed the Bio-Collar, which is a removable collar unit that could display the wearer's biological information optically and kinetically. The Bio-Collar is not only a wearable display system, but also carefully designed textile that could be worn by people who concern their elegance. Both functional aspect and elegance aspect must be carefully considered equally to design clothes for the future space travel era to support space tourists' live in space. That is because the majority of the space tourists will be usual people, different from current highly trained mission specialists.

In future work, we will integrate additional sensors such as breathing sensors and skin conductance sensors to detect the wearer's status related to motion and simulator sickness [4]. This integration is also aimed to detect the wearer's status in specific relation to space sickness. Space travel will be common in the future. Wearing such sensor systems should help many numbers of future space travelers who suffers from space sickness. In addition, to improve the degree of the freedom of the display method, multi-directional bending smart hair will be used. The current version of the smart hair is equipped with single SMA. Thus, it could bend one direction. However, if it is integrated with three SMAs (Fig. 12), it could bend every direction as shown in Fig. 13.

The current Bio-Collar system is a simple removable collar. Now we are working on novel full-body clothes to augment human in space, which is integrated with the Bio-Collar (Fig. 14). We will continue improving functionality of clothes that could improve lives in space in the future.

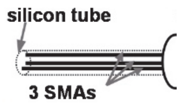

Fig. 12 The configuration for the multi-directional type of the smart hair

Fig. 13 The movement of the multi-directional type of the smart hair

Fig. 14 Full body clothes to augment human in space using the Bio-Collar technology hair

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