

Design proposal of space clothes that supports lives in the future space tourism era

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Abstract. In a near future, many people will be able to visit and stay in the space hotels easier than now days. In this situation, a novel clothes that fit to the special environment will be required. In this paper, we describe the detail of a prototype of “space clothes”, a new clothes design that could solve the appearance and functionality conditions shown below.

- Conventional clothes especially skirts and loosely designed shirts are often difficult to be worn in space because it restricts wearer’s motion. On the other hand, such clothes are often preferred by women because of their elegance. The both elegance and functionality must be achieved for the clothes of the future space tourists.
- All the future space tourists should suffer from space sickness and sunburns by ultraviolet rays. Those issues will worsen the experience in the space. Future clothes for space tourists should be able to solve or be able to mitigate them.

Based on these conditions, we developed a prototype of clothes for future space tourists(Figure 1(a)). This clothes is carefully designed to achieve both functionality and elegance. In addition, it embedded with bio-informatics display system to share wearer’s health status among other tourists to enable early initial treatment(Figure 1(b)). We believe that this paper could be a good opportunity to initiate the discussion to clear new market of clothes in space.



Figure 1 proposed space clothes in the future space tourism era
(a) a conceptual image (b) optic/kinetic display part around the neck

Introduction

Space tourism, is no more a science fiction. Hotels will be placed at orbits. And many people will visit and stay at those hotels in the future. As represented by the Virgin Galactic Co. Ltd., commercial space flights have already been started[12][14][15][16]. Furthermore, the commercial space station is supposed to welcome guests in coming year[13]. There are few companies and facilities sending general people into space, currently. However, the increasing number of successful flights and space tourists could forward more people to take the space tour.

When considering the situation that the increasing of usual people among space tourists, various kinds of supportive system will be required to maintain their comfortable stay. The current mission specialists are highly trained, to overcome any kinds of problems that often arise within the space station. However, it is likely that future space tourists are less trained comparing to the current mission specialists, because their aim of the tour is leisure, for fun. The current training menu will be simplified that fit to such general people for their easier space travel. To achieve decreasing the training load, a certain kinds of system will be required to support their comfort and safe space tour.

In this research, we especially focus on space sickness and sunburn issues to be solved. The space sickness is most common diseases that almost all the space travelers suffer from. Unfortunately, precise mechanisms of space sickness are still unclear and methods of treatment are limited. Under such situation, “taking care of each other” becomes relatively important method to relieve the people who suffer from space sickness. On the other hand, the mechanisms of sunburn are clear and easy to avoid; decreasing the chance to exposure to ultraviolet rays. The problem is that human nature does not capable of perceiving ultraviolet ray through vision. In addition, the ultraviolet rays in space is extremely strong comparing to that of on the earth. Although the size of window is small and protected from ultraviolet rays, people in the space ship will easily suffer from sunburn. Thus, a certain kinds of information display to indicate the amount of exposure to ultraviolet will be preferable.

To comply with these issues, we propose using clothes as information display to share the wearer’s bio status and indicate the wearer’s amount of exposure to ultraviolet rays. The basic and natural method to “taking care of each other” is to look at other person’s face. This method substantially includes looking at face and clothes especially around upper body. When considering this, clothes have a good potential to be a kind of information display that could support but not harm such natural behavior. To achieve this, we developed a prototype of sensor-display integrated clothes named “space clothes”. This clothes equipped with a heart-rate sensor and kinetic displays to indicate the wearer’s bio-status. The heart-rate is considered to be one of the essential information to diagnose the space sickness [4][17]. The wearer’s bio-status is displayed ambiently through developed garment around neck by using its color and motion, to encourage awareness to the wearer’s bio-status. In addition, by using ultraviolet sensitive material, the color of clothes can be used as an indicator of the amount of exposure to ultraviolet rays.

As mentioned above, not only the function but beauty and elegance will also be important to clothes for the future space tourists. Those sensors and display systems must be integrated into clothes naturally and beautifully. The Figure 1 shows our prototype of the “space clothes” that cope with both functionality and elegance. In this paper, we describe its system and material interface that could support quality of lives in space from its functional aspects and appearance aspects.

Related Works

Current clothes that are used in space is mainly developed for mission specialists, for their scientific/engineering activity in space. One of the typical example is spacesuit that enables mission specialists to survive outside of the space station[1] [11]. That is highly sophisticated techno-clothes which is essential for them to complete task outside of the station. The daily clothes used within the station are also well considered. For example, their daily clothes have special function that reduce wearer’s body odor to keep comfortable small, enclosed space station. Unfortunately, current mission

specialists have limited options of appearance of clothes. This is clearly because they give priority to completing their missions.

On the other hand, space tourists in the future will focus on their enjoyment during their stay in space. Changing clothes according to their situation will be one of the important aspect to enjoy their special experience. Currently, ESA and the science museum in London is working the project to design clothes for the space age[3]. According to their work, special clothes which has fluffy garment and its movement would be expected for their special experience in space. Unfortunately, they have less argument about practical role of the clothes in space environment. Especially for the importance of sharing one's bio-status, which is considered to contribute their comfortable stay in space.

As mentioned above, space sickness and sunburn will be big issues for space tourists. One of the important way to deal with them is monitoring one's health status and applying adequate care to that person as early as possible. To achieve this, appropriate sensors and display systems will be required. The sensor aspect, various kinds of sensors to monitor one's biological status are developed[5]. Although the precise mechanisms of space sickness is still unclear, respiration and heart rate variety(HRV) are considered to be one of the index to diagnose space sickness[17]. Those sensors have enough potential to be used to monitor a person's bio-status especially related to space sickness.

The display aspect, clothes are considered to be an adequate media to notify a person's bio-status. The person we focus on this project is future space tourists. They visit space just for leisure. This means, a display method that could harm their precious experience will not be preferred. If they are in early stage of such bad condition, far from severe condition, ambient notification will be preferable. In other words, display methods are also naturally integrated into their environment and just encourage awareness of each other's bio-status. To cope with this condition, clothes could be preferable ambient media. On the ground condition, which is our usual situation, checking one's complexion is simple and effective method to know a person is in the bad condition or not. When considering this fact, the clothes, especially around the neck have enough potential to display additional bio-related information in ambient way. In the decades, the clothes which express wearer's bio-status have been developed[2] [9] [10] [18]. Unfortunately, those clothes are not intended to be used in space, although they can display a certain kinds of bio-related information.

Prototype design of Space Clothes

In this chapter, we describe the detail about our prototype of space clothes. The key features of space clothes are as follows: (a) elegance of its appearance, (b) capability of displaying wearer's bio-status. Taste in clothes differs between male and female. In the field of clothes for women, there are various kinds of design that are rarely be seen in that of men's, such as a skirt and a loosely designed shirts. However, such kind of clothes is often difficult to be worn in space because it restricts wearer's motion. In addition, the appearance of such clothes in microgravity environment will differ from that of on the earth. That affects beautifulness, or elegance of the design of such clothes. Based

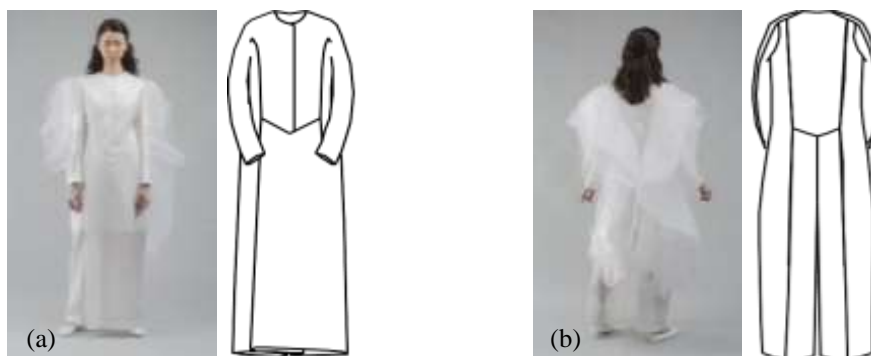


Figure 2 Appearance design
(a) Front, (b) Back

on this discussion, we propose a new design of clothes for space tourists. In addition, as discussed above, it is preferable to be able to show wearer's bio-related information to encourage awareness of wearer's health status. This will contribute comfortability staying in space both for the wearer and for fellow travelers. This function is considered to be an ambient warning for the wearer that he/she is in bad condition and encourage them to get early treatment, which will finally lead to early recover.

Appearance design

Figure 2 shows our first prototype of space clothes. By considering elegance of its appearance, the bottom part is designed similar to a skirt like shape. However, its basic structure and function is similar to pants to preserve wearer's ease of motion. The upper part, the tightened shaped sleeves contribute elegance, which is achieved by draping not to restrict the wearer's upper body motion.

Functional design

The proposed space clothes have two functions as bio-status display. The first is to show wearer's heart-rate, the second is to show the amount of exposure to ultraviolet rays. The heart-rate is one of the essential information to diagnose space-sickness. However, the precise mechanisms of space sickness are still unclear, and single information about heart-rate is insufficient for precise diagnose. Thus, this prototype is regarded as a first step toward future space clothes. To indicate wearer's heart-rate, we made use of our previous achievement named Bio-collar[7], which is shown in Figure 3. The Bio-collar is an attachment of collar-shaped garment that could indicate wearer's heart-rate through its color and kinetic motion. The basic material of the collar is mesh fabric, which contributes improving elegance of the collar. The color of the Bio-Collar can be changed according to the wearer's heart-rate. If it is regarded as high rate, it turns to red. On the other hand, if it is regarded as low rate, it turns to blue. The intensity of color also changes according to the heart-rate. The kinetic display part is composed of Smart Hair[6] [8], which is fine, light weighted and soft actuator. These characteristics are preferable when considering such electrical parts into clothes. In this prototype, the actuators move frequently in the same rhythm of wear's heart-rate, which is sensed by the heart-rate sensor, SEN-11574 (SparkFun Electronics, CO, USA).

To indicate the amount of the exposure to ultraviolet rays, it is planned to use ultraviolet sensitive textile as a basic material of the space clothes. As shown in Figure 4, this textile is capable of indicating the amount of exposure to ultraviolet rays by changing its color(Figure 4). In the space station, it is difficult to completely cut off ultraviolet rays from sun. Although the tourists away from the window, they are inevitably suffering from ultraviolet rays. This textile will contribute notify how much he/she have been exposed to ultraviolet rays, to avoid unwanted sunburn, and skin cancer.

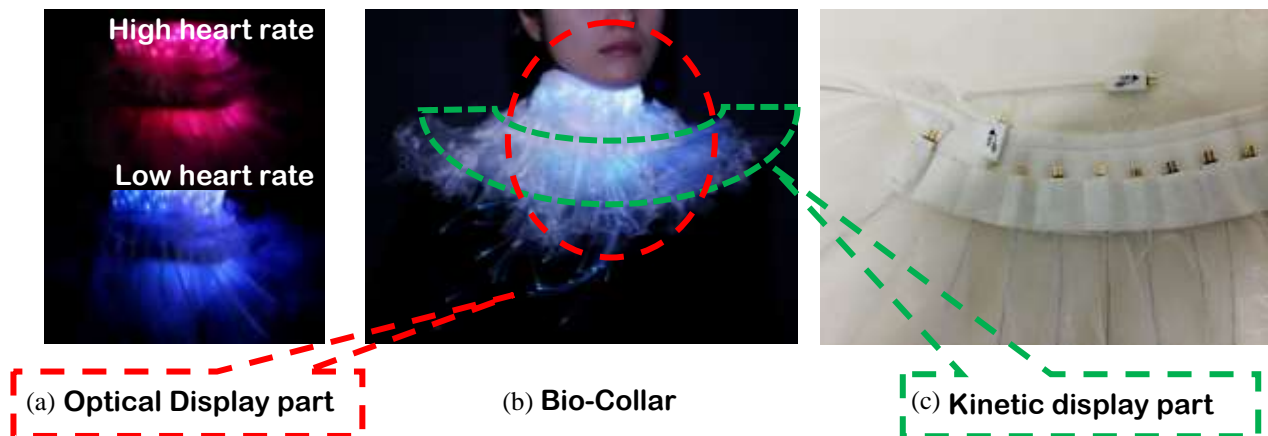


Figure 3 Functional design of heart-rate display system



Figure 4 Indication function of exposure to ultraviolet rays

Conclusions

In this paper, we propose clothes especially designed for the usual people who visit and stay in space in the future. Such clothes are required to support tourists' comfortable lives in space. To support it, both appearance and functional aspect must be considered. The elegance of clothes contribute joy of wearing especially for women, which is common on the earth. In addition, showing wearer's bio-related information will lead to sharing their health status, which enables tourists to encourage early treatment. This prototype is designed to fulfill both requirement, especially focusing on space sickness and exposure to ultraviolet rays. In future work, we will integrate additional sensors such as breathing sensors and skin conductance sensors for precise bio-status indication.

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