Presentation of a Feeling of Presence Using an Electrostatic Field

Presence-like Sensation Presentation Using an Electrostatic Field

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ABSTRACT

With the spread of infectious diseases, the importance of remote communication is increasing in people's lives. We focused on a "feeling of presence," which is considered to be an important factor in remote communication. The feeling of presence is an implicit indication of the presence of others. In this paper, we propose a system that presents a presence-like sensation using an electrostatic field. Through experiments, we showed that the system can present a presence-like sensation and investigated the distance that is most suitable for inducing a presence-like sensation.

CCS CONCEPTS

• **Human-centered computing**; • **Human computer interaction (HCI)**; • **Interaction devices**; • **Haptic devices**;

KEYWORDS

Electrostatic field, Presence, Tactile presentation

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1 INTRODUCTION

With the spread of infectious diseases, telecommunications technologies are becoming increasingly common in people's lives. Although remote communication is mainly based on visual and audio channels, research has also been conducted on tactile presentation technologies for remote communication, and systems that reproduce transmitted heartbeat signals [1], handshakes [2], touch [3], and hugs [4] [5] have been proposed. In contrast, a system that transmits a non-corporeal atmosphere [6] has been proposed using technologies that are not based on tactile presentation. The aim of this system is to realize sensory-based communication by conveying the atmosphere. Other systems that convey the atmosphere to distant families with ambient methods have been proposed [7][8]. These systems require the user to gaze at or concentrate at the device.

In this paper, we propose a system using tactile presentation technology that allows the user to obtain the atmosphere in more passive ways. We focused on the "feeling of presence" as the aspect of the atmosphere to be conveyed. The "feeling of presence" is an implicit indication of the presence of others and is considered to be an important element for expressing a "place" where others exist while reducing the cognitive load on the user. We propose a system to present a presence-like sensation using a simple method, just put the system and turn it on, that is similar to the setup method of a camera and a microphone for remote communication.

In previous studies, systems that present a presence-like sensation by generating humidity or water vapor [9] or emphasizing a part of a sound signal [10] have been proposed. The other system has been proposed that presents a presence-like sensation by making the user approach a CRT TV with a quasi-electrostatic field [11]. Experiments using this system have shown that the user can feel fluffiness when he/she obtain a presence-like sensation [11]. Therefore, we assume that generating electrostatic fields in the similar way to CRT TVs makes the user feel fluffiness, and thus the user can obtain a presence-like sensation. In previous studies using electrostatic fields, emotions related to surprise and excitement were enhanced by controlling piloerection [12]. In this paper, we use an electrostatic field to present a presence-like sensation.

2 PROPOSED SYSTEM

We used toy electrostatic generators (Fun-Fly Stick [13], 3 cm in width) as small Van de Graaff generators [14]. These toys are equipped with rotating belts to electrify the device and motors that rotate the belts. The motors were controlled by a microcontroller (Espressif, ESP32-DevKitC) via field-effect transistors (TOSHIBA, 2SK2232).

Nine electrostatic generators were arranged in rows at 5 cm intervals, and their total width was approximately 45 cm, which was about the length of the forearm [15]. The appearance of the system is shown in Figure 1

3 EXPERIMENT

3.1 Overview

The purpose of this experiment is to show that the proposed system can induce a tactile sensation on the user's body simply by being close to it. In this experiment, we also measure the maximum distance from the system at which the user feels fluffiness. Note that we did not measure the tactile sensation threshold because our purpose was to present the sensation of presence. Our preliminary

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Figure 1: Appearance of the proposed system

Figure 2: Setup of the experiment

trials revealed that people tend to describe the feeling of the electrostatic field as "fluffy." Thus, we used this term in this experiment. At the same time, we evaluated the degree of consistency with a presence-like sensation (a feeling that something is close by) at each distance to verify that our method is suitable for generating the feeling of presence.

3.2 Conditions

The setup of the experiment is shown in Figure 2. The participants were asked to place their right forearm in front of the proposed system and to wear an eye mask and earphones to block visual and auditory information. During the operation of the proposed system, pink noise was played on the earphones. After each trial, the participants were asked to verbally answer whether they felt fluffiness during the previous presentation. If they felt any sensation other than fluffiness, they were instructed not to answer. When they answered that they felt fluffiness, we also asked them to answer verbally whether the sensation was consistent with a presence-like sensation (degree of consistency). We used a 7-point Likert scale to evaluate the degree of consistency (seven being the most consistent). We also conducted interviews with the participants after the experiments to investigate the sensations other than fluffiness induced by the system.

During the experiments, all nine electrostatic field generators were operated simultaneously. The duration of each trial was 4 s.

The maximum distance from the system was determined using both the downward- and upward-series staircase method. The downward series started at a distance of 30 cm, and the upward series started at a distance of 5 cm. When the participants answered that they felt fluffiness, we moved the distance away from the system by 5 cm and conducted the next trial. When the participants answered that they did not feel fluffiness, the distance was moved 5 cm closer, and the next trial was conducted. In the downward series, the measurement was terminated when the participants answered that they felt fluffiness three times. In the upward series, the measurement was terminated when the participants answered that they did not feel fluffiness three times. In both the downward and upward series, the measurement was also terminated if the participants answered that they did not feel fluffiness at a distance of 5 cm. The maximum distance was determined by the last distance at which the participant felt fluffiness in the previous two trials. When the values obtained by the upward and downward series were different, the average of the two values was used as the final value.

All participants wore their daily clothes, and the above measurements were conducted with the sleeves rolled up (called the "without sleeves" condition) and with the sleeves down (called the "with sleeves" condition). The experiment was conducted on 14 participants (five females, nine males; one left-handed, 13 right-handed) aged between 21 and 35 years. The humidity in the room at the time of the experiment was approximately 40%.

In addition to the experiments described above, we measured the electrostatic potential at each distance using an electrostatic detector (Sunhayato, EG-1). The measurement was performed by reproducing the positional relationship between the proposed system and the center of the participant's forearm at the time of the experiment.

3.3 Results

Figure 3 shows the number of people corresponding to the threshold of the distance at which they felt fluffiness and the electrostatic potential measured at each distance.

The results indicate that without sleeves, 11 out of 14 participants (about 80%) felt fluffiness when the distance was more than 10 cm. Note again that this we did not measure the sensation threshold, but the feeling of fluffiness.

Figure 4 shows the number of participants who did not feel fluffiness according to distance. Eight of the 14 participants (57%) did not feel fluffiness even at a distance of 5 cm in the case with sleeves. In the case without sleeves, three participants did not feel fluffiness even at a distance of 5 cm.

Figures 5 and 6 show the distribution of the degree of consistency with a presence-like sensation by distance (when participants answered they felt fluffiness) without and with sleeves, respectively.

The results in Figure 5 show that the degree of consistency with a presence-like sensation tend to increase when the distance is

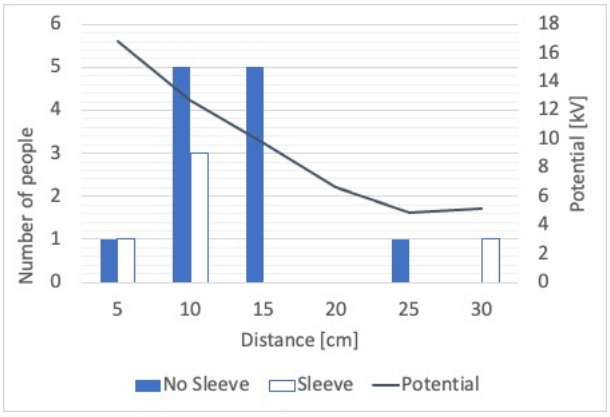

Figure 3: Number of people that felt fluffiness at each distance and the electrostatic potential measured at that distance.

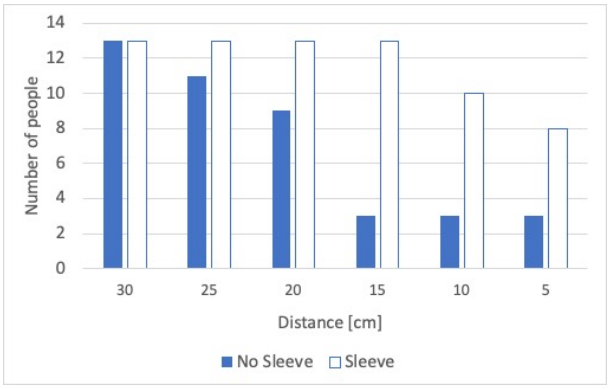

Figure 4: Number of people who did not feel fluffiness at each distance

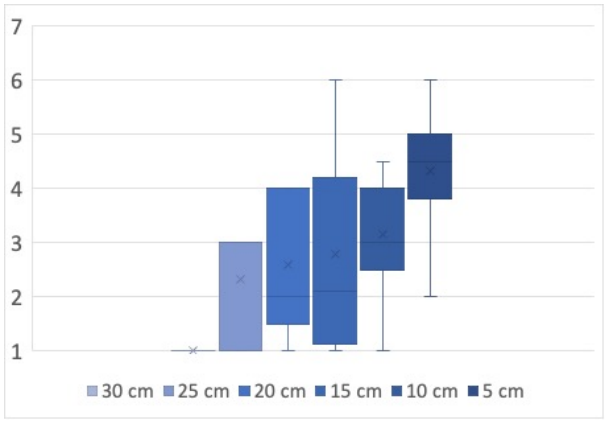

Figure 5: Consistency with a presence-like sensation at each distance: without sleeves (Note that the number of answerers varies by distance because the answers are for all cases above the threshold: 30 cm: one person, 25 cm: three people, 20 cm: five people, 15 cm: ten people, 10c m: 11 people, and 5 cm: 11 people.)

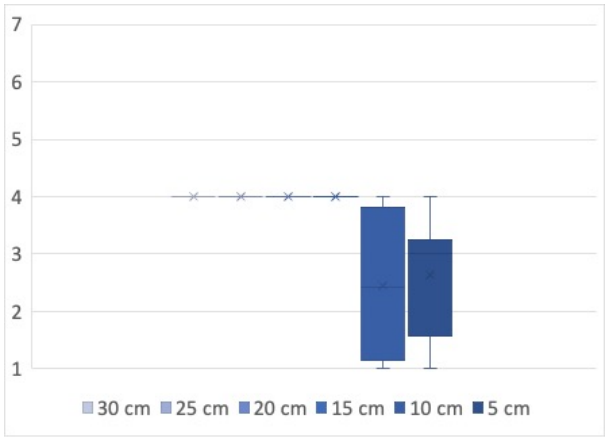

Figure 6: Consistency with a presence-like sensation at each distance: with sleeves (Note that the number of answerers varies by distance because the answers are for all cases above the threshold: 30 cm: one person, 25 cm: one person, 20 cm: one person, 15 cm: one person, 10 cm: four people, and 5 cm: six people.)

shorter, but at a distance of 15 cm, the variance of the responses increases. The results in Figure 6 show that the evaluation score with sleeves is lower than that without sleeves, even when the distance is short.

Through interviews after the experiments, the participants made comments on the sensations other than fluffiness induced by the system such as, "the sensation was like being stroked with cotton," "I felt warmth," "it was like being softly blown," "I felt piloerection," "I felt the flow," and "it was like someone was passing through rather than being there."

3.4 Discussion

The experiments demonstrated that the proposed system is capable of presenting a fluffy tactile sensation on the body when users were 5 to 10 cm away from the system and they did not wear sleeves.

Three participants did not feel the sensation at a distance of 5 cm, even when their forearms were exposed. The post-experimental interview revealed that two of them had shaved their forearms, and one of them had hair removal. Some participants who had shaved their forearms felt fluffiness at a distance of 5 cm or more, but they had shaved their forearms several days or weeks before the experiment. To clarify this effect of shaving, the author shaved and checked the sensation on the day of shaving and five days after shaving. On the day of shaving, the author did not feel the sensation at a distance of 5 cm or even as close as 1 cm. In contrast, five days after shaving, the author felt fluffiness at a distance of 10 cm. The density and thickness of body hair did not seem to affect the experimental results, but this requires further investigation. The above results reveal that body hair is necessary to present tactile sensation. It is believed that the body hair is attracted by the electrostatic field generated by the electrostatic field generators, and the hair moves, resulting in a "feeling of fluffiness."

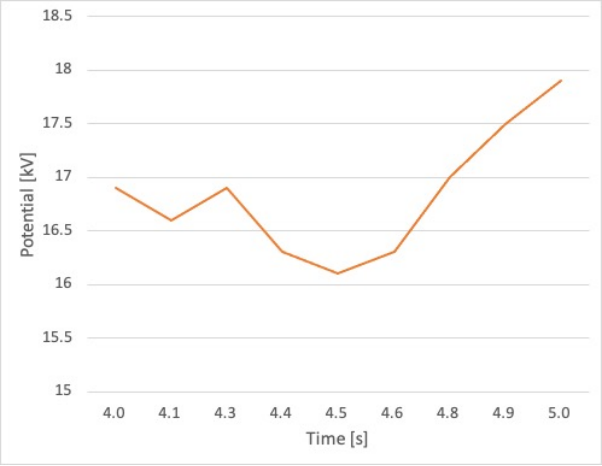

Figure 7: Change in the potential measured at 5 cm over time

As for the consistency with a presence-like sensation, there was a large variance in the responses at a distance of 15 cm without sleeves. In the post-experiment interviews, the participants who gave a high evaluation at a distance of 15 cm mentioned that they felt that a weaker sensation of fluffiness was more like a presence than a strong sensation. Therefore, there was a difference in interpretation among the participants regarding whether a stronger or weaker sensation of fluffiness resembles a presence-like sensation. This may be due to the ambiguous definition of a "sense of presence."

In the case with sleeves, some participants mentioned that they felt that their clothes were being pushed, and this was not like a feeling of presence, suggesting that the condition with exposed forearms is more suitable for a presence-like sensation.

Regarding sensations other than fluffiness, most participants answered that they felt a soft touch, but some of them also said that they felt warmth. This may be because the hairs moved by the electrostatic were perceived as wind, but it was not as cold as an actual wind; therefore, the participants felt relatively warm.

This is exemplified by the fact that some participants answered that they felt a flow or wind, even though the nine electrostatic field generators were driven simultaneously. We measured the change in the electrostatic potential using an electrostatic detector and found that it increased or decreased slightly with time. Figure 7 shows the change in the potential measured at a distance of 5 cm from 4 s after the start of the operation to 1 s.

The perception of wind was considered to be caused by this temporal variation, rather than a sense of spatial movement (because wind is generally considered to be difficult to create spatial roughness and fineness). For this reason, it is thought that the temporal changes in the electrostatic potential described above were sometimes interpreted as wind.

4 CONCLUSION

In this paper, we focused on the "feeling of presence" as an aspect of atmosphere to be conveyed along with remote communication and proposed a presence presentation system using an electrostatic field generator. Through experiments, we showed that the system can present a tactile sensation that can be felt as fluffiness on the body just by being near the system. In addition, we investigated the installation distance suitable for a presence-like sensation. As a result, we found that the degree of consistency with a presence-like sensation tends to be greater when the distance is smaller, but there are some participants who felt a presence-like sensation when the sense of fluffiness was weaker. In future work, we would like to verify the effect of using the proposed system together with sound cues, which is considered to be the main channel for the "sense of presence" in blind people [16]. We also would like to see the effect of presenting a moving electrostatic pattern and to investigate the expression of warmth using the proposed system.

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REFERENCES

[1] Christa Sommerer, and Laurent Mignonneau, "Mobile Feelings: Wireless communication of heartbeat and breath for mobile art," In The Mobile Audience, (269-276), 2011.
[2] Hideyuki Nakanishi, Kazuaki Tanaka, and Yuya Wada, "Remote handshaking: Touch enhances video-mediated social telepresence," In Proceedings of the SIGCHI conference on human factors in computing systems (pp. 2143-2152), 2014.
[3] Jongeun Cha, Mohamad Eid, Lara Rahal, and Abdulmotaleb El Saddik, "HugMe: An interpersonal haptic communication system," In 2008 (pp. 99-102) IEEE International Workshop on Haptic Audio-visual Environments and Games, 2008.
[4] Nobuhiro Takahashi, Ryuta Okazaki, Hiroyuki Okabe, Hiromi Yoshikawa, Kanako Aou, Shumpei Yamakawa, Maki Yokoyama, and Hiroyuki Kajimoto, "Sense-Roid: Emotional haptic communication with yourself," Virtual Reality International Conference, 2011.
[5] James Keng Soon Teh, Adrian David Cheok, Roshan L. Peiris, Yongsoon Choi, Vuong Thuong, and Sha Lai, "Huggy Pajama: A mobile parent and child hugging communication system," In Proceedings of the 7th international conference on Interaction design and children (IDC '08). Association for Computing Machinery, 2008.
[6] Shuzo Masaki, and Ichiro Yamada, "SHOJI: A communication terminal for sending and receiving ambient information," Emotional Engineering, 2011.
[7] Mingqian Zhao, Zhutian Chen, Ke Lu, Chaoran Li, Huamin Qu, and Xiaojuan Ma, "Blossom: Design of a Tangible Interface for Improving Intergenerational Communication for the Elderly," Proceedings of the International Symposium on Interactive Technology and Ageing Populations (ITAP '16), Association for Computing Machinery, 2016.
[8] Margot Brereton, Alessandro Soro, Kate Vaisutis, and Paul Roe, "The Messaging Kettle: Prototyping Connection over a Distance between Adult Children and Older Parents," Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems, Association for Computing Machinery, 2015
[9] Kenta Hokoyama, Yoshihiro Kuroda, Ginga Kato, Kiyoshi Kiyokawa, and Haruo Takemura, "Mugginess sensation: Exploring its Principle and Prototype Design," IEEE World Haptics, 2017, 563-568, 2017.
[10] Shuyang Zhao, Asuka Ishii, Yuki Kuniyasu, Taku Hachisu, Michi Sato, Shogo Fukushima, and Hiroyuki Kajimoto, "Augmentation of acoustic shadow for presenting a sense of existence," Proceedings International Workshop on Modern Science and Technology (IWMST2012), 2012.
[11] Kenta Suzuki, Koya Abe, and Hisashi Sato, "Proposal of perception method of existence of objects in 3D space using quasi-electrostatic field," International Conference on Human-Computer Interaction, 2020.
[12] Shogo Fukushima, and Hiroyuki Kajimoto, "Chilly chair: Facilitating an emotional feeling with artificial piloerection," ACM SIGGRAPH, 2012.
[13] "FUN-FLY-STICK magic levitation wand.", http://www.unitechtoys.com/funflystick.html, (Accessed 2020-12-09).
[14] Robert Jemison Van de Graaff, Karl Taylor Compton, and Lester Clare Van Atta, "The electrostatic production of high voltage for nuclear investigations," Physical Review, 43(3), 149-157, 1933.
[15] "Anthropometry and biomechanics." In Man-Systems Integration Standards, https://msis.jsc.nasa.gov/sections/section03.htm, (Accessed 2020-12-09).
[16] Yoshikazu Seki, Tohru Ifukube, and Yoshihiro Tanaka, "Relation between the reflected sound localization and the obstacle sense of the blind," Journal of the Acoustical Society of Japan. (J), 50, 289-295, 1994.