Ants in the Pants
-Ticklish Tactile Display Using Rotating Brushes-

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Abstract: We created a new entertainment called "Ants in the Pants". A user can see many ants moving around on a visual display. The user's hand is placed into a tactile display in the form of a glove that has a matrix of small motors with brushes inside it. When the user places their gloved hand on the visual display, the user can feel a sensation as if ants are crawling up their arm. We have tested the system with more than 500 participants. In response to a questionnaire, about 75% of users responded that the experience was "enjoyable" and 54% that it was "realistic". Moreover, our work was able to entertain most people regardless of their reaction to the experience. We believe our "Ants in the Pants" opened the door to a new type of "uncomfortable, creepy but enjoyable" entertainment.

Keywords: Virtual reality, Tactile display, Ticklish, Insect, Ant, Creepy, Glove, Wearable interface.

1. INTRODUCTION

Nobody likes to imagine that insects are crawling over their skin. However, this apparently repulsive situation can sometimes lead to a form of pleasure. For example, many of us have had the experience of playing with insects when we were children. We caught them, collected them and placed them on our hands and arms.

This might indicate that an apparently disagreeable sensation can sometimes also be a funny, thrilling, or even a pleasant experience. Our work aimed to highlight this fact, and to create a new entertainment that we have named "Ants in the Pants" (Fig. 1).

Fig. 1 Ants in the Pants

The system is composed of a visual display with a touch senor and a wearable tactile display. The visual display presents ants visually, and the wearable tactile display presents ants haptically. A user can see many ants living in the visual display. When the user's hand, inside the glove, is placed on the display, the ants gather around the hand. Just after an ant reaches the hand it disappears and the user begins to feel a sensation as if the ant was crawling up the arm. As ants have a habit of climbing up almost anything, once they started to move on ones hand they would soon move up to the arm. When the hand is raised, the ants crawl back onto the hand. If the user puts his/her hand back on display for a while, more ants will appear to enter the glove. If the user begins to feel bad or sick, he/she can easily shake off the ants by shaking the hand.

2. RELATED WORKS

Bugs or insects often appear in interactive art. "Delicate Boundaries" [1] gives us contact with small bugs made of light. The small bugs crawl out of the computer screen onto our bodies. "Phantasm" [2] is an interactive installation with profusion of white butterflies, which are projected on two screens, and gather to a light held by a participant. Although bugs and insects are usually disliked, the above works offer a kind of entertainment that involves playing with them.

Kume et al. [3] created a game in which a player tramples a cockroach while wearing the slippers with two vibrators attached to each sole. If you trample the cockroach, you can feel vibration under your feet. As their research purpose was to propose a type of "foot interface", the sensation of an insect crawling on the skin was not the essence of their research. Tactile displays that focus on the reality of this sensation have not been proposed before.

Tamura et al. [4] developed a wearable haptic interface that is placed on the forearm. They used a vibration motor array to generate pressure pattern. This interface aimed to display the sensation of touching something in the virtual world. Kajimoto et al. [5] developed a wearable tactile interface to convert visual 2D image to tactile pattern by electrical stimulation. Users wrap the display around their head to have an array of 512 electrodes fit their forehead.

On the other hand, the stimulus given by the legs and

antennas of an insect are actually a very soft tickle that previous tactile displays have not been able to generate. Hence, we created our original tactile display that specialized in giving a sensation of insects crawling over the skin.

3. TICKLISH TACTILE DISPLAY

Our tactile display is a glove with a matrix of motors inside (Fig. 2). Brushes made of two fishing lines with some elasticity are attached on the motors. In this way a realistic "insect's legs" feeling can be realized. The brushes touch the skin when the motor rotates. After giving the stimulus, the motor rotates backward. The glove covers and wraps the hand and forearm, with the stimulating points arranged on the back of the hand and forearm.

The distance between each motor (20mm) is set to be shorter than the two-point discrimination thresholds on the arm [6]. By using this distance, spatially continuous motion can be expressed.

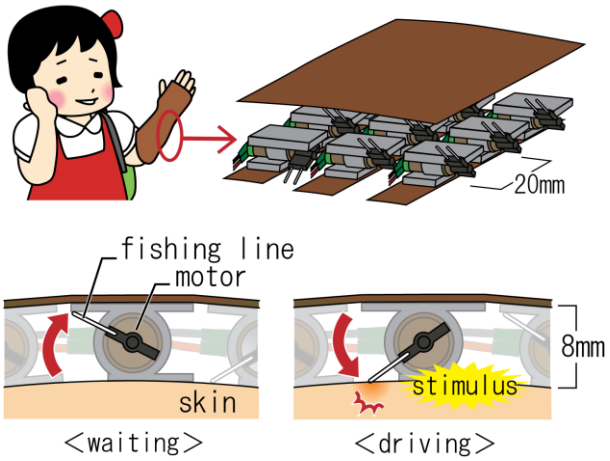

Fig. 2 Method of stimulation

4. SYSTEM OVERVIEW

Fig. 3 shows the system architecture. Our system is composed of a glove device, and position sensing and image output parts.

4.1 Implementation of glove device

Inside the glove device (Fig. 4), 34 motor cases are stitched in and motors (Matsushita, KHN4NZ1AA) which attached brushes are set in each case. An acceleration sensor (Kionix, KXM52-1050) is used to measure the tilt angle and detect shaking behavior of the glove (Fig. 5). The microprocessor (Renesas Technology, H8 3048F) controls the tactile motion of the ants by driving the matrix of motors. If "tactile" ants fall down from the glove, the microprocessor informs to the PC.

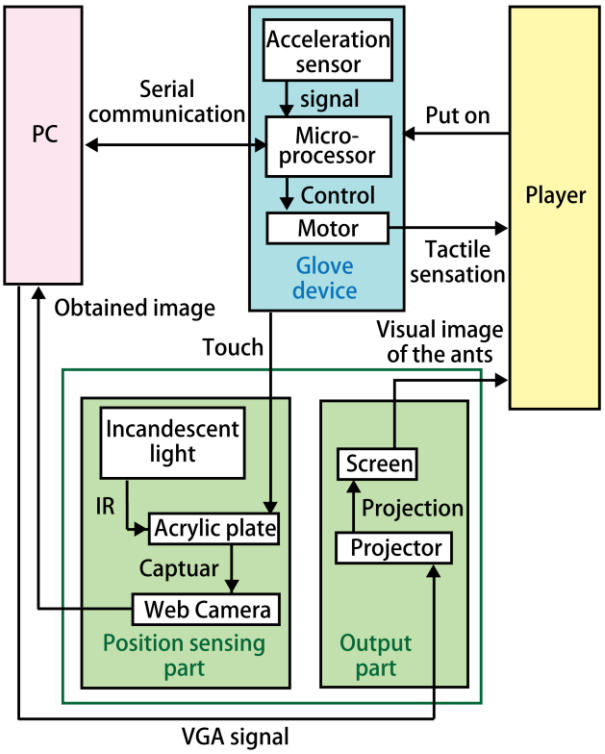

Fig. 3 System architecture

Fig. 4 Inside of glove device

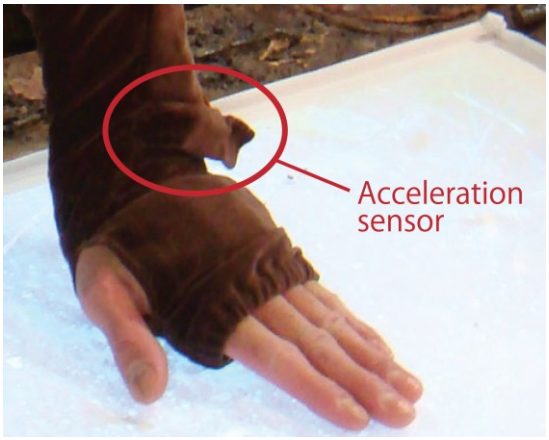

Fig. 5 The position of the acceleration sensor

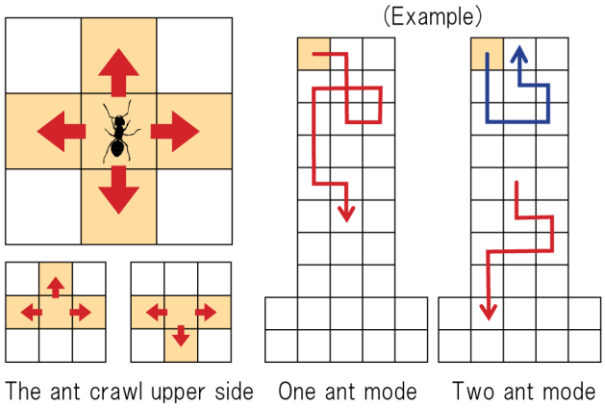

Fig. 6 One ant crawls on the upper side

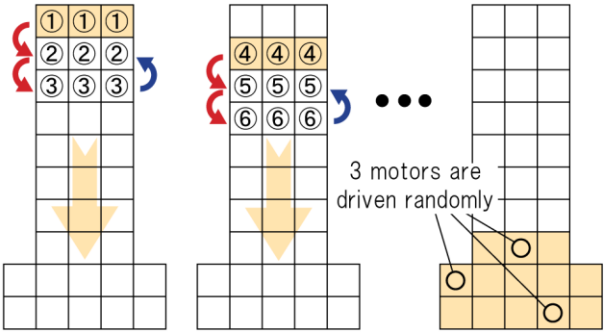

Fig. 7 Pattern of stimulus (Swarm mode)

We created three stimulus patterns.

A) One ant mode
B) Two ants mode
C) Swarm mode

When the microprocessor is informed that an ant has started to climb up on the user's arm, it starts "One ant mode". If the microprocessor is informed one more ants comes in, it starts "Two ants mode". For these modes, one ant corresponds to one motor. An ant's motion is randomly simulated to driving a left, right, front or back nearby motor for every step randomly (Fig. 6). But if the glove is tilted over plus or minus 40-degrees, the ant stops moving to the lower side (It means the ant crawls up). The more the glove is tipped the shorter the interval of the stimulus, from about 1000msec to 200msec.

When the microprocessor is informed that more than three ants are climbing up on the user's arm, it starts the "swarm mode". In the mode, the number of motors that drive every step is three regardless of the number of ants. We assume that the user does not need to know the number of ants, but the user only needs to know that "numerous ants are climbing up". Therefore, as can be seen in Fig. 7, we tried to express the feeling of many ants climbing upper gradually by driving every other row every step. The next step starts from the previous row when the microprocessor counts by three steps. If this stimulus reaches at the end of the glove, three motors chosen randomly from among upper three rows are driven. The interval of stimulus is always about 200msec).

4.2 Position sensing and image output part

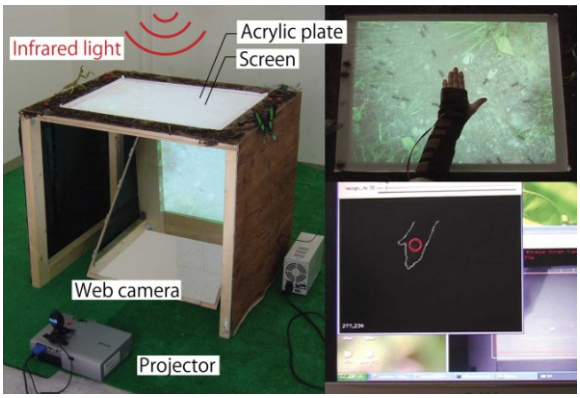

Fig. 8 Position sensing and image output

Fig. 8 shows the implementation of the position sensing and image output part. An incandescent light is radiated from the top of the display. If the acrylic plate is touched, the shade of the glove is captured by a web camera (Creative, LC-VIP-SE) with infrared passing filter (FUJIFILM, IR 80). The obtained image is sent to PC, which determines whether the hand touches the screen, and calculates the contact position. It also controls the action of the "visual" ants. A projector with an infrared cut filter (Kenko, DR655) is connected to the PC, and the visual image of the moving ants is projected on the screen. If an ant reaches the contact position, the PC informs the microprocessor and vanishes the ant image. If the microprocessor is informed that ants have fallen down to the PC, the "visual" ants appear again. If the glove has no ants or runs "one ant/two ants mode" by touching the screen, the ant nearest to the glove comes inside. If the glove runs "swarm mode", all the ants on the screen gather to the glove.

6. EXPERIMENT

Fig. 9 Exhibition of our work at Laval Virtual 2008

We exhibited at Laval Virtual 2008[1] held in France

[1] http://www.laval-virtual.org/

from 9 to 13 April 2008 (Fig. 9). We conducted a questionnaire about our work. The number of respondent to the questionnaire was 553. In each question, we asked the participants to answer by 5-point scale (1. Definitely no, 2. Sort of no, 3. Moderate, 4. Sort of yes, 5. Definitely yes), except for questions about age and gender. Question and average answers are shown in Table 1. Participants' profiles are summarized in Fig. 10.

Table 1 Questionnaire and average score

	Question	Ave.
Q1	Have you ever played with or kept ants or other insects?	2.33
Q2	Do you, by nature, like ants?	2.64
Q3	Did you enjoy playing with this work?	4.02
Q4	Do you want to play more?	3.19
Q5	Do you wish to play again when you get a chance?	3.73
Q6	Did you feel like real ants were crawling on your arm?	3.62
Q7	Did you feel that the image of ants was creepy?	1.65
Q8	Did you hesitate to touch the display?	1.53
Q9	Do you think the adjective "exciting" applies to this work?	2.88
Q10	Do you think the adjective "pleasant" applies to this work?	3.28

According to Table 1 and Fig. 11, from Q3 and Q5, many people enjoyed and wished to play again our work. The rate of respondents who respond "I enjoyed (scores 4 and 5)" was about 75%. As well, for Q6, about 54% of respondents felt like as if real ants were crawling (scores 4 and 5).

We studied the relationships among each questions. First, Fig.12 shows the relationship between Q6 and Q3. The number of respondents who responded "not enjoyable" was 25 (scores 1 and 2), under 5% of all respondents. From Fig. 12, the respondents who evaluated "enjoyable" tend to highly evaluate the "reality" except when the score for Q3 was 1. It was however not enough to analyze because there were only 6 people who chose 1.We cannot know whether respondents experienced reality because of the enjoyment or they enjoyed because of reality. But it is certain that the glove device made for this work accomplished its purpose. Fig.13 shows the relationship between Q6 and Q9, Q10. The score is not so high, but it is interesting that the respondents who evaluated "reality" high tended to evaluate "pleasant" high too.

Next, Fig. 14 and Fig. 15 show the relationship between Q3 and Q1, Q2. It seems that the preference to ants and the experience of playing with ants slightly relate to enjoyable, but the slope is quite flat. Moreover, most of the respondents who do not like ants in Q2 responded enjoyable (its average was from 3.8 to 4.0). Therefore, our work can entertain most of people regardless of their attitude to or experience of ants.

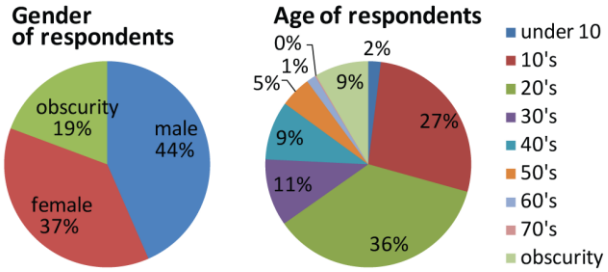

Fig. 10 Respondents' profile

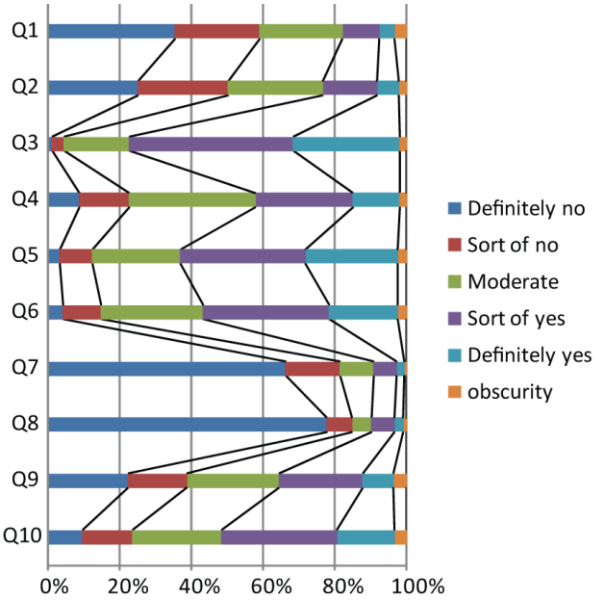

Fig. 11 Rate of respondents who chose each grade

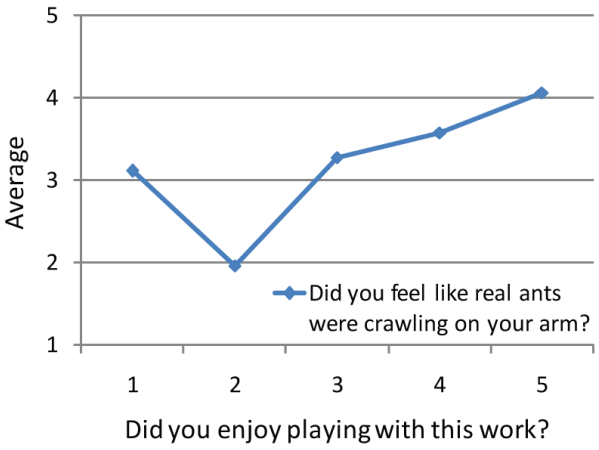

Fig. 12 Relationship of enjoying and reality

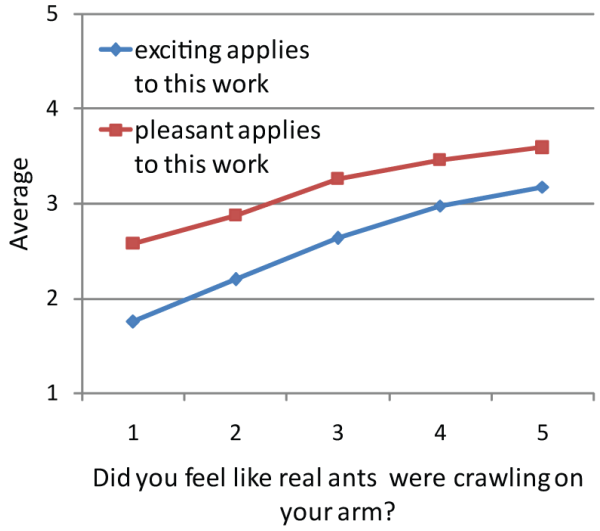

Fig. 13 Relationship of reality and "exciting" "pleasant"

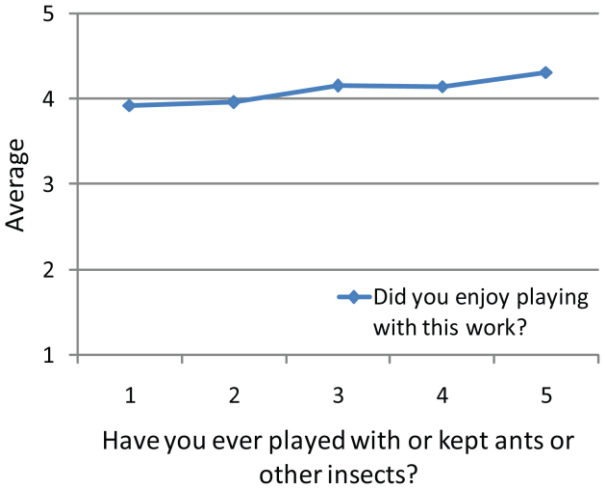

Fig. 14 Relationship of enjoying and experience

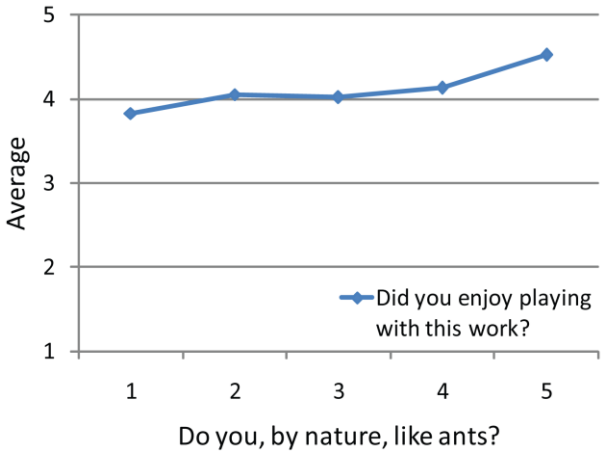

Fig. 15 Relation of enjoying and attitude to ants

7. DISCUSSION

We noticed that there are two different orders of feelings that are important for an entertainment, that is, high-order (emotional) feeling "exciting" and low-order (sensitive) feeling "pleasant". Human, by nature, have the habit of regarding some sort of danger as "exciting", especially when they know that the danger is actually not harmful. This fact is widely known, so you can see the example at haunted house in amusement park. In this work, "exciting" was appreciated as well as "reality" because we could display "danger" very well by presenting ants climb up gradually.

On the other hand, we expected that the more real the work was, the harder it would become enjoyable, because the real creepy sensation is "unpleasant". We also expected that unpleasant feeling does not necessarily impairs the feeling "exciting". If we imagine that there are "nonpoisonous tarantulas" and "slugs which don't leave sticky liquid on your arm" for example. We guess many people would want go experience them in similar ways. In this case, people maybe evaluate it as exciting but unpleasant.

However, the results suggested that the participants who evaluated "reality" high also evaluated the demonstration as "pleasant". We speculate that it is because the participants did not have difficulty playing with ants by nature, or stimulus was light rather than lacking reality. This speculation is supported by the results of our questionnaire (Q7 and Q8).

Anyway, "Ants in the pants" was able to give many people a curtain real yet pleasant experience. We can say "Ants in the Pants" become a successful form of entertainment.

8. CONCLUSION

We developed an interactive system called "Ants in the Pants" that presents a sense that ants are crawling on your arm. The result of a questionnaire we conducted about our work suggested that our original tactile display successfully rendered a stimulus that simulated ants crawling over a person's skin. Many users who evaluate the system as "enjoyable" also had "pleasant" and "exciting" sensations. Moreover, most people could enjoy our work averagely regardless of whether they liked or had experienced ants.

The ant is the insect whose weight is so light as not to cause any pressure. In addition, their antennas and legs move rapidly and only softly touch our skin. For rendering this stimulus, we designed the glove device. The method of stimulus that use a rotating stimulator with a motor has the possibility of presenting variety of tactile sensation other than just insects, by changing the material of the stimulator. For example, the gooey sensation using silicon and a smooth sensation using cloth would be possible. If we choose the material for the particular purpose, we may be able to display sensation that has never been generated before and transmit them to any parts of the body.

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