Pseudo-attraction Force Display Using Vibrating Motors
- Design of asymmetric oscillation for generating an illusion of being pulled -

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Abstract—We developed a new pseudo-attraction force display using four vibrating motors. The advantage of this device is that it uses phase difference control to alter the time width of pulses to generate asymmetric oscillation. It does not require altering the frequency of the vibrating motors. In this study, we investigated the influence of the pulse width generated in the device using vibrating motors on the perceptive intensity of pseudo-attraction force. From the result, the oscillation having shorter pulse widths within the range of 10-20 ms induced the “being-pulled” sensation more strongly.

Keywords- Pseudo-Haptics, Asymmetric oscillation, Pulse width

I. INTRODUCTION

Recently, many kinds of force feedback devices have been developed. However, most of them use either a mechanical linkage to establish a fulcrum relative to the ground [1], or use huge air compressors [2]. Physical constraints mean that none of them can be used freely outside the laboratory.

We have developed a novel mobile force display that can generate a translational force sensation, which uses asymmetric oscillations of a moving mass, where brief intense pulses of acceleration alternate with longer periods of low-amplitude recovery (The examples of such wave patterns are shown in Fig. 2.) [3]. The advantage of the display is a capability to induce a translational force sensation despite the fact that the device is not grounded anywhere. The device exploits the characteristics of human perception to induce a pseudo-force sensation. Our haptic sensors cannot detect the weaker force, so the original position of the mass is not perceived. The device generates a strong force for a very short time in a specific direction and a weaker force over a longer period in the opposite direction. Consequently, the user perceives a unidirectional force.

II. PSEUDO-ATTRACTION FORCE DISPLAY

A slider-crank mechanism was used in a previous study to generate the asymmetric back-and-forth motion of a constrained mass [3]. However, it is hard to realize the desired waveforms of asymmetric oscillation in the slider-crank mechanism since the asymmetric oscillation depends on the link length when the device is driven at a constant frequency.

Therefore, we developed a new pseudo-attraction force display using four eccentric vibrating motors (Fig.1). It has the advantage that the waveform of the asymmetric oscillation can be easily realized by phase difference control. Therefore, we expect that our device will be able to display many variations of pseudo-attraction force sensation if the relationship between the waveform, especially the pulse width, and perceptive intensity of being-pulled sensation is clarified.

III. EXPERIMENT

We investigated the relationship between the pulse width and the perceptive intensity of pseudo-attraction force with our developed force display. In the experiment, it was measured how correctly subjects perceived the force direction that was intended by the designed waveforms.

A. Method

1) Stimulus: Four vibrations be used in the experiment. The fundamental frequency of asymmetric vibration was set to 10 Hz, because it is known that it is easy to perceive pseudo-attraction force in this frequency [3]. The impulsive value taken within one cycle was controlled at 0.0015 kgm/s. Under these conditions, four patterns of oscillations, whose pulse widths were 10ms, 15ms, 25ms, and 50ms (Fig. 2), were displayed to subjects.

2) Procedure: The subjects pinched the device using the thumb and index finger of right hand as shown in Fig.3. One of the four patterns of asymmetric oscillations was selected randomly and was presented in either the right or left direction. The presented duration was 3s in a single trial. After presentation of oscillation, the subjects answered with the direction of perceived force (left or right). Each participant was given the four oscillations × 20 trials (10 right direction and 10 left direction), for a total of 80 trials.
Five volunteers aged between 20 and 25 years participated in this experiment.

B. Result

The rate of correct answers according to the pulse width is shown in Fig.4. When the pulse width is set to 10 ms, the rate of correct answers became highest, at about 90% on average. We also found that shorter pulse widths between 10 and 20 ms can induce the being-pulled sensation more strongly.

IV. DISCUSSION

The previous study performed the same experiment using the slider-crank mechanism with similar pulse width ranging from 11.5 ms to 23 ms. The results showed that short pulse (11.5 ms) oscillations induced higher perceptive intensity than long pulse (23 ms) oscillations [4], as was found in our experiment. The previous study and our results are consistent despite the fact that there is a difference in the impulsive value.

The impulsive value taken within one cycle is 0.14 kg·m/s in the case of the slider-crank mechanism. This is about 100 times as much as the value of our device used in this experiment. However, when the pulse width is about 10 ms, both mechanisms obtained a high rate of correct answers (about 90%). From this result, it is clear that the pulse width is an important factor in inducing a stronger perception of pseudo-attraction force using asymmetric oscillations.

V. CONCLUSION

We investigated the influence of the pulse width to the intensity of pseudo-attraction force induced by our device using vibrating motors. We found that shorter pulse width between 10 and 20 ms can induce the being-pulled sensation more strongly. In the experiment, limitation in the performance of our device prevented oscillations of less than 10 ms of pulse width from being displayed. In the future, we will improve the device to investigate perceptive intensity of pseudo-attraction force with shorter pulse widths.

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REFERENCES