PlasmaTouch: Non-contact tactile technology using laser-induced plasma*

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***Abstract*—In this paper, a study was conducted to utilize the plasma generated by focusing the pulse laser as an actuator for a non-contact tactile technology. When plasma is formed in the air, a shockwave is generated from the center of creation and propagates radially. It is possible to adjust the intensity to a level that can be perceived by touch. To control the intensity of tactile sensation, the shockwave was measured using an accelerometer and a microphone. In addition, a detection threshold experiment was performed to confirm the tactile distance of from the shockwave. As a result of the experiment, the intensities were detected in all cases where plasma was created, and it was confirmed that the maximum perceptible distance was about 11 mm.**

I. Introduction

Research on presenting tactile sensation in a non-contact manner has been carried out using laser [1], magnetic field [2], and multiple ultrasonic transducers [3]. The method using ultrasonic waves has a high level of perfection and is being applied to various fields. The method using a magnetic field has the advantage of being a trans-object, but the stimulus presentation distance is short and high power must be used. The method using laser has the advantage of long presentation distance, but since it uses the thermoelastic effect, it is possible to perceive tactile sensation only when patches of complementary color of the laser are attached to the skin.

When a laser with a pulse width of several nanoseconds is focused in the air, the energy of the local area becomes high energy state instantaneously. Afterwards, as substances in the air are ionized, plasma is generated in the air. Also, during the ionization process, a shockwave accompanied by a flash of light is generated simultaneously. If a shockwave, a rapid compression wave generated in the air, is large enough, it is possible to induce physical changes in the skin [4]. In this paper, a study was conducted to induce tactile sensation with bare hands without using a patch while utilizing the advantages of a laser with the laser-induced plasma.

II. Method

Fig. 1 shows the configuration of proposed technology using laser-induced plasma. It was simply composed of a laser system and one convex lens with a focal length of 15 cm. An accelerometer and a microphone were used to measure the intensity of shockwaves. Both were positioned 10 mm away from location of plasma. In detection threshold experiment, perception was recorded while moving the subject's finger in the range of 1 mm to 12 mm from the plasma. Laser energies of 35 mJ, 50 mJ, and 65 mJ were used in all experiments.

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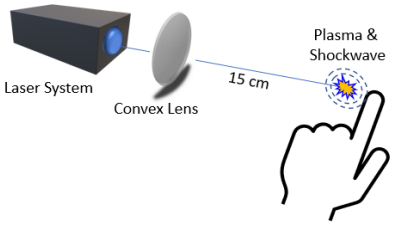

Figure 1. Overall configuration for the PlasmaTouch.

III. Result and Discussion

Fig. 2a shows the results of accelerometer and microphone measurement at 35 mJ of laser energy. The shockwave lasted for about 400 μs. Fig. 2b shows the perceptible distance of the shockwave. In the case of 35 mJ, a feel similar to that of a mechanical tap was reported up to 5 mm and when 65 mJ, up to about 10 mm from the plasma. The distance increased as the laser energy increased.

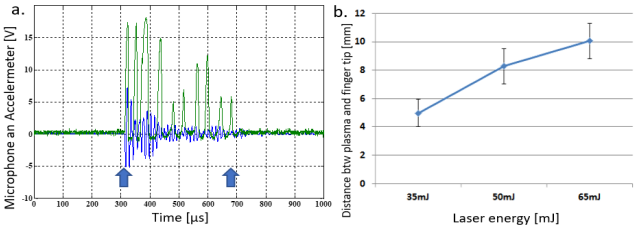

Figure 2. Results of an acceleration, intensity, and detection threshold.

In this paper, research was conducted to develop a non-contact tactile presentation technology using shockwaves generated from the laser-induced plasma phenomenon. The intensity of shockwave according to the change of laser energy were observed with an accelerometer and microphone. Through the detection threshold experiment, the perceivable distance for each laser energy was confirmed. The magnitude of laser energy and physical change and the transmission distance were proportional. This means that it is possible to adjust the presentation range to control the strength of the tactile sensation. Also, since the shockwave lasts for about 400 μs, it is enough time for humans to perceive it as a touch. Since the method using laser plasma has a long presentation distance and can feel the touch even with bare hands, it is considered that it can be used as a non-contact tactile technology through in-depth research in the future.

References

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