Laser HaPouch: A Haptic Display Utilizing Selective Activation of Laser-powered Liquid-to-gas Phase Change Actuator Arrays

Kazuki Yamaura[1] and Takefumi Hiraki[1,2]

I. Introduction

Pneumatic actuators in haptic displays have gained attention due to their small size, lightweight, large force output, and flexible shape that doesn't harm the human body. However, there is a challenge that the system tends to become bulky due to the need for a cumbersome compressor and tubes required to drive the pneumatic actuators. Liquid-to-gas phase change actuators [1], which drive by heating and vaporizing the low-boiling-point liquid sealed in a plastic pouch, can solve this problem because they can be constructed with only electrical wiring to the pouch and heater. Thus, a haptic display combining this actuator and a Peltier element has been realized [2]. However, only a single-point haptic presentation has been achieved, and the challenge of connecting a vast amount of wiring to construct a multi-point presentation haptic display remained unresolved.

In this paper, we propose a multi-point haptic display by selectively heating and expanding the liquid-to-gas phase change actuator arrays using a laser. It is known that the low-boiling-point liquid inside the liquid-to-gas phase change actuators can be heated using the wavelength selectivity by employing a CO_2 laser [3], and we also use a CO_2 laser to heat the actuators in our proposed method. By utilizing the proposed method, we can realize a haptic display system capable of multi-point presentation without the need for wiring in the presentation part.

II. Method

In this study, we propose a display system that enables users to experience multi-point haptic presentation by selectively heating and expanding liquid-to-gas phase change actuator arrays using a laser (Fig. 1). We fabricated the liquid-to-gas phase change actuator array by dividing a plastic film (Nylon Poly B type, Fukusuke Industries) into sections using heat sealing, injecting a low-boiling-point liquid (Novec 7000, 3M Company) with a syringe, and sealing it again with heat sealing. We used a 10-W CO_2 laser (48-1, SYNRAD) as the laser source and employed a galvanometer scanner (JD2808, Sino-Galvo Technology) for laser scanning. Additionally, we placed a web camera (C310n, Logicool) at the bottom of the housing and performed calibration of the galvanometer scanner using homography transformation.

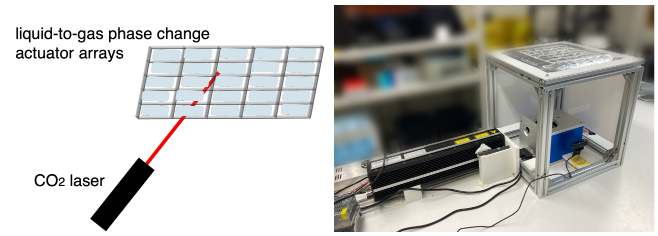

Fig. 1. Concept (left) and appearance (right) of the proposed haptic display. We selectively heat and drive liquid-to-gas phase change actuators by scanning the laser with a galvanometer scanner.

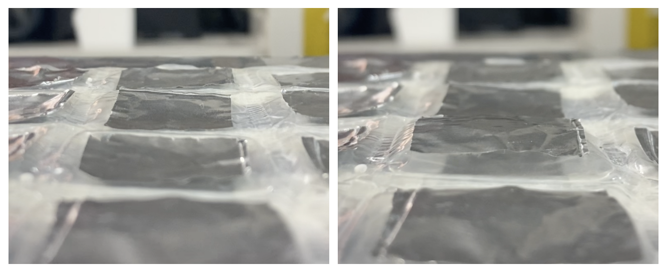

Fig. 2. Actual selective actuation of the liquid-to-gas phase change actuator array (left: before actuation, right: after actuation).

Figure 2 shows the actual operation of the haptic display. To prevent the laser light from accidentally shining on the user's hand, we attached a thin aluminum tape to the surface of the liquid-to-gas phase change actuator array. It can be observed that the central liquid-to-gas phase change actuator is driven by selective heating due to laser irradiation. Furthermore, preliminary experiments with multiple participants experiencing the proposed haptic display revealed that the pressure perceived was sufficient for human perception.

III. Conclusion

In this paper, we proposed a haptic display capable of multi-point haptic presentation by selectively heating liquid-to-gas phase change actuator arrays using a laser. In future work, we would like to conduct evaluations such as measuring the distribution of presented pressure.

References

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[1]K. Yamaura and T. Hiraki are with University of Tsukuba, Tsukuba, 305-8550 Japan. e-mail: yamaura@pml.slis.tsukuba.ac.jp

[2]T. Hiraki is with Metaverse Lab, Cluster, Inc., Tokyo, Japan. e-mail: t.hiraki@cluster.mu