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Iris-based Particle Jamming Haptic Display for Lump Simulation in Palpation Training

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***Abstract*—This demo presents a compact, pump-free palpation training device using an iris-based particle jamming mechanism to simulate lumps with adjustable stiffness and size. The device generates stiffness values from 0.3 to 2.0 N/mm and sizes from 8 to 27 mm, with high repeatability (2.54% stiffness, 1.31% size variation across 50 trials).**

***Index Terms*—Haptic Display, Particle Jamming Mechanism**

I. Introduction

This work addresses the need for realistic palpation training tools, as existing models lack variability and tactile realism [1]. Prior approaches often restricted hand posture or introduced excessive system complexity [2]. To overcome these issues, we propose a compact, pump-free device that simulates clinical lumps with adjustable stiffness and size via an iris-based particle jamming mechanism.

II. Method

A. Iris-based Particle Jamming for Lump Simulation

The main principle for lump generation with iris-based particle jamming and the overall device structure are shown in Fig.1. A pouch filled with tiny particles is constricted by an iris module, allowing stiffness and size modulation via compression force and iris position. The iris was designed for uniform constriction with high structural stability, and both constriction and positioning were controlled by servo motors.

B. Simulated Lump Characterization

To assess lump generation capability, stiffness and size were quantitatively measured. Stiffness was evaluated by applying a force gauge to the lump's apex, whereas size was determined via edge detection from captured images. The device can generate stiffness values from 0.3 to 2.0 N/mm and sizes (i.e. diameters) from 8 to 27 mm. Repeatability was tested across 50 trials for 12 representative conditions, yielding average inconsistencies of 2.54% in stiffness and 1.31% in size.

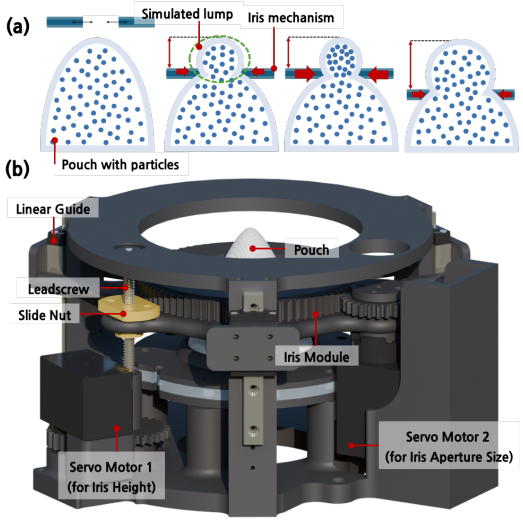

Fig. 1. (a) Working principle of the iris-based particle jamming for lump generation, (b) Overall structure of palpation training device.

III. Conclusion

This demo presents a palpation training device that can generate lumps with various stiffness and size using an iris-based particle jamming mechanism. Characterization of the lumps showed the device can generate a range of lumps with high repeatability. Further work will focus on recruiting a number of clinicians to evaluate the clinical efficacy of the device in palpation training.

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References

[1] K. Ahmed et al., "Effectiveness of procedural simulation in urology: a systematic review," The Journal of urology, vol. 186, no. 1, pp. 26–34, 2011.

[2] N. Takizawa et al., "Encountered-type haptic interface for representation of shape and rigidity of 3d virtual objects," IEEE transactions on haptics, vol. 10, no. 4, pp. 500–510, 2017.