A Soft, Vibrotactile, Shape-Changing Joystick for Telerobotics

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Abstract— **This extended abstract describes the design of a haptic interface based on a joystick to provide vibrotactile, shape-changing and hardness/softness based feedback to the operators of remote mobile robots.**

Particle jamming refers to the principle of using controlled air pressure to affect the viscosity of a granular fluid inside a soft, sealed container. This can be used to create shape-changing, shape-memory and hardness changing haptic interfaces which have already been shown to be useful to relay environmental information to users of remote robots [1], [2].

Previous work has added rendering of vibrotactile sensations to a haptic surface based on particle jamming [3]. This design is now extended and expanded with the intention of creating a haptic system that can be retrofitted to a computer joystick to render a wide variety of haptic sensations whilst controlling a remote mobile robot.

The new interface (Fig. 1) builds on the previous vibrotactile jamming system by replacing the ERM style vibrating motor with a LRA (Linear Resonant Actuator) to give more precise control over the vibration effects. The partially rigid container is replaced with a completely soft silicone pouch designed to fit to the rigid shaft of a joystick. Finally, and most significantly, the new design is half-cylindrical (20mm radius, 66mm length), allowing two identical segments to be used simultaneously but controlled independently, giving a spatial component to the haptic feedback.

The operating principle of the interface is independent control of the LRAs and air pressure (fluid hardness/softness) in each segment of the device. This means that the front and back (or left and right, or in future more than two) sides of the joystick can render different haptic effects. To ensure that the interface is sufficiently compact to be held in a fist, the LRAs are housed below the hand grips and mechanical antennae are used to transfer vibrations up to the handle.

The control system will consist of a microcontroller which interfaces with ROS to control and take feedback from a variety of aquatic and off-road robots and sensor systems. The pneumatic system requires independent air pressure regulation and LRA driver electronics. The LRAs can be synchronised should the same vibration be required in both segments of the interface. The control system and joystick interface are portable and can be easily set up on site should the operator need to accompany the robot to a site, as is common some emergency response scenarios.

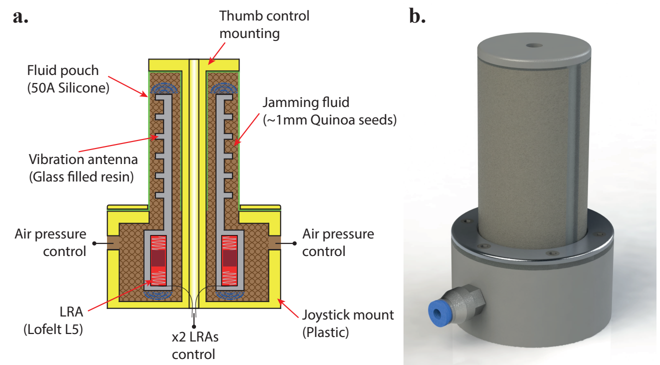

Fig. 1. **a:** Schematic showing the construction and main components of the joystick. **b:** 3D CAD render of the prototype interface.

Future exploration of haptic effects that are particularly relevant to telerobotics will focus on the sensation of movement imparted through haptic vibrations [4] as a sliding sensation on the side of the joystick. Localised to the front-back or left-right of the user's closed palm, it is hoped that this sensation will provide a haptic of roll and pitch information from a remote robot. This is known to improve vehicle safety, but has so far not been integrated into a robot's control device [5]. The control of hardness and softness can also be used to indicate soft or loose terrain, and tactile force feedback afforded by the interface's shape changing functionality can indicate obstacles in visual bind spots or air or water currents affecting an aquatic or aerial robot.

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References

[1] A. A. Stanley, D. Mayhew, R. Irwin, and A. M. Okamura, "Integration of a Particle Jamming Tactile Display with a Cable-Driven Parallel Robot," in *Haptics: Neuroscience, Devices, Modeling, and Applications*, M. Auvray and C. Duriez, Eds. Springer Berlin Heidelberg, 2014, pp. 258–265.

[2] M. Li, T. Ranzani, S. Sareh, L. D. Seneviratne, P. Dasgupta, H. A. Wurdemann, and K. Althoefer, "Multi-Fingered Haptic Palpation utilizing Granular Jamming Stiffness Feedback Actuators Smart Mater," *Struct*, vol. 23, p. 95007, 2014.

[3] J. P. Brown and I. Farkhatdinov, "Soft Haptic Interface based on Vibration and Particle Jamming," in *IEEE Haptics Symposium, HAPTICS*, vol. 2020-March. Washington DC: IEEE, 3 2020, pp. 1–6.

[4] I. Farkhatdinov, N. Ouarti, and V. Hayward, "Vibrotactile inputs to the feet can modulate vection," *2013 World Haptics Conference, WHC 2013*, pp. 677–681, 2013.

[5] J. Corujeira, J. L. Silva, and R. Ventura, "Attitude Perception of an Unmanned Ground Vehicle Using an Attitude Haptic Feedback Device," in *2018 27th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 8 2018, pp. 356–363.