Shape-Changing Touch Pad based on Particle Jamming and Vibration

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Abstract— **This extended abstract describes the design of a haptic interface based on particle jamming and a pair of vibration actuators for simultaneous rendering of vibration, shape and softness/hardness sensations.**

Particle jamming is a rapidly emerging technology that uses controlled air pressure to affect the physical hardness of a granular fluid, such as seeds or coffee grounds and has been used in several haptic devices to enable control over hardness/softness and shape [1], [2], [3], [4].

Previous work has extended this particle jamming technology with the addition of an ERM style vibrating motor suspended in the granular fluid, which demonstrated that it is possible to use particle jamming to modulate the vibration frequencies felt by a user at the touch pad [5]. Particle jamming combined with vibration has significant application potential in tactile interfaces, as the vibrotactile sensation adds another dimension of haptic feedback.

This concept is now extended further with the intention of creating a novel, 1 dimensional touch based human-input device able to offer all of the haptic sensations afforded by the existing vibrotactile particle jamming system.

The new interface (Fig. 1) has three key developments. The single ERM motor has been replaced with a pair of linear resonant actuators (LRAs) which offer more precise control over the vibrotactile response, as well as allowing localisation of the vibrations on the left or right of the device. The interface has been placed on a force sensing platform (load cells) to allow detection of a single fingertip's position and movement. The touch surface is also larger, giving the user space to draw simple gestures.

The operating principle of the interface is feedback control of two LRAs and both positive and negative pressure control of the air inside the device to render tactile vibrations and change the touch pad shape and softness. These control signals can be based on the user's finger's location and applied contact force, or use external information channels such as the state of a remote mobile robot. The interface requires a microcontroller, LRA drivers and a pressure regulator with an air compressor and vacuum pump (pressure range ±50KPa).

Initial testing of the interface has demonstrated that it is able to generate a wide variety of haptic sensations: change of shape and softness by modulating pressure; tactile stimulation with vibration; sliding and apparent motion effects by modulating two LRA actuators. Combination of the above are also possible. For example, vibrotactile feedback could potentially be used to create the illusion that the touch pad is moving under the users finger while its softness changes.

This effect is created by pulsing each actuator, one after the other, for 300 ms each and simultaneous control of the granular fluid pressure. In an exploratory trial, three participants were asked to use the interface in this mode and describe the action of the interface upon pressing the button. All three participants described the touch pad sliding under their finger in some way, even though it was fixed in place. Such haptic effects are useful for telerobotics and virtual reality applications where both movement and terrain information are useful to the operator [6].

Further studies will investigate the effect of using positive air pressure to inflate the interface and generate convex shapes and force feedback against the finger, as well as controlling the softness of the particle media. It is hoped that this will increase or reduce the resistance to fingertip movement and give a harder or softer texture under the finger to, for example represent a hard or soft virtual object or surface.

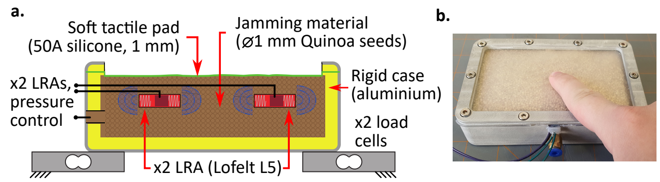

Fig. 1. **a:** Schematic view of the interface. **b:** Working prototype interface

This work was funded by the EPSRC studentship 2111330, the IEEE RAS TC Haptics under the "Innovation in haptics" research programme, the UK EPSRC grant NCNR EP/R02572X/1 and the RS Grassroots Student Project Fund.

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