Improving the Haptic Perception of Virtual Walls Using a Vibrating, Hardness Changing Haptic Joystick

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***Abstract*—This work-in-progress project investigates how tactile feedback can be used to enhance the haptic sensation of force when feeling a virtual wall. An experiment is described which tests how a soft haptic handle for a torque feedback robot can use different tactile effects to render strong virtual walls for users. Preliminary results are presented and early conclusions drawn.**

Virtual haptic walls are typically rendered by multi-DoF haptic robots which exert forces to stop users moving past a specified boundary. This is an open challenge in haptics due to the force required to stop a person's movement and the speed at which it must be switched on and off to maintain the sensation of a rigid wall at a fixed boundary in space. Existing force feedback robots require large and powerful motors to generate the wall resistance and expensive high-speed controllers [1], [2] to resist movement effectively without exerting too much force and becoming dangerously unstable [3], [4].

This **project aims** to investigate whether using tactile feedback as well as torque feedback at the wall boundary can enhance the perception of a solid wall.

The experiment consisted of participants being asked to compare pairs of virtual walls - one rendered solely with torque feedback provided by a robotic wrist interface, the other with torque feedback and a tactile effect. These effects were vibration, hardness change and the combination of the two, provided by a soft haptic joystick [5]. An adaptive staircase protocol was used to adjust the stiffness of the torque feedback for one wall in each pair, converging on a JND (just noticeable difference) - the torque gain (Nm/deg) for which a wall with tactile augmentation was indistinguishable from one rendered using only torque. The other wall (augmented or otherwise) maintained a constant stiffness throughout the study. The augmented wall always started the study less stiff than the non-augmented wall.

Preliminary results showed that every form of tactile feedback enhanced the sensation of feeling a strong wall (non-zero and non-negative JNDs as shown in Fig. 1). The average JND was highest for the two effects combined, followed by vibration and hardness change, which proved to be similar. Psychometric functions were computed for the three tactile effects. These again showed that combining hardness and vibration had a beneficial effect on the sensation of wall strength compared to presenting either effect on its own.

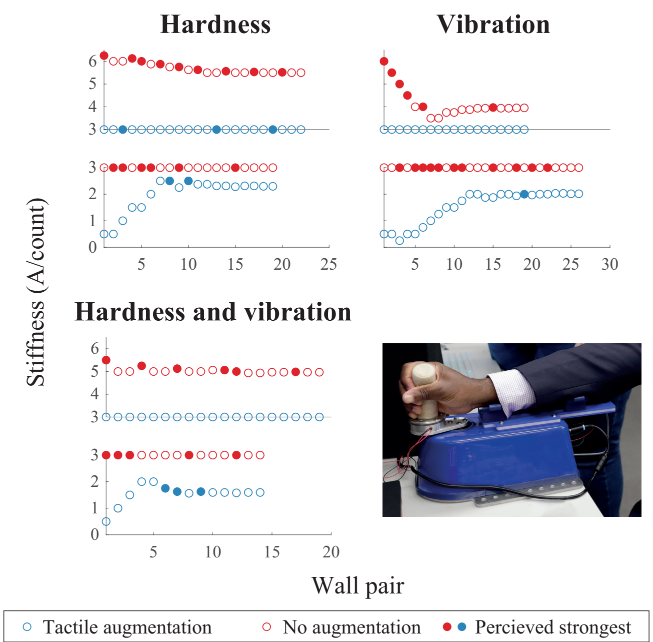

Fig. 1. Representative results obtained from one participant showing the stiffness difference produced by different tactile effects. Lower right: A participant using the robot and soft haptic joystick.

In conclusion, this study demonstrates that using tactile feedback in the handle of a kinaesthetic haptic interface can improve the perceived strength of the force feedback provided. This has applications in virtual reality games and simulations, where significant research effort is being spent rendering physical objects and environments through haptics. These results are in the process of being submitted to the Journal of Soft Robotics for peer review and publication.

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