Distinguishable virtual textures to understand multisensory sensation

Jenna Fradin [1], David Gueorguiev [1]

[1] Sorbonne Université, CNRS, Institut des Systèmes Intelligents et de Robotique

INTRODUCTION

When we touch a natural surface or explore an object, both **vision** and **touch** provide information about the properties of the surface or the object. The information gathered by each individual sense have been widely investigated (Bergen & Adelson (1988); Saal & Bensmaia (2014)). However, it remains unclear how the information gathered by the two modalities are fused together to enable the perception of textures.

We aim to explore how humans perceive visuo-tactile surfaces when the visual and tactile dimensions are **collocated** and exploration is performed in **active touch**.

METHODS

a. Texture recording

One of the difficulties encountered in haptic studies of real textures is to generate tactile feedback that faithfully reproduces natural surfaces. We selected five commonly used textures whose vibrotactile signature were recorded using an accelerometer and a force/torque transducer. Fig. 1.

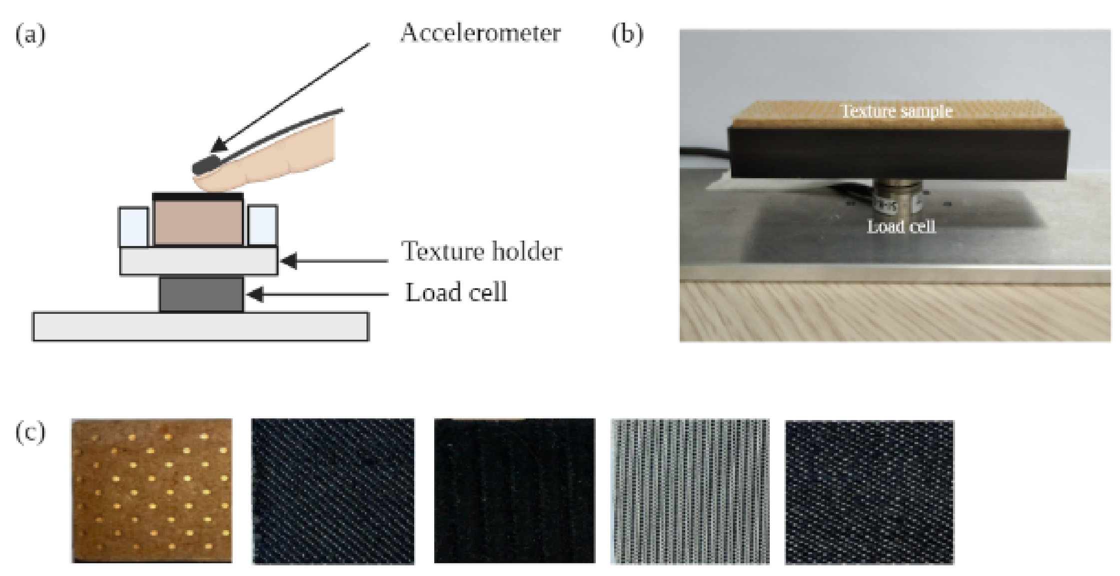

Fig.1. Apparatus. (a) Schematic representation. (b) Texture sample mounted on the recording device. (c) Selected textures.

Band-pass filter (60-500 Hz) was applied to the recorded signals to remove the imperfections caused by the recording devices and by the limitations of the MM3C haptuator.

b. Psychophysics experiments

We used the recorded tactile signals to perform two psychophysical experiments on visual-haptic interaction Fig. 2.

- **Experiment 1**: We measured the perceptual ability of five observers to become aware of the differences in the textures corresponding to different scanning speed during active sliding on a touchscreen.The same visual texture was displayed twice on the screen but the tactile feedback was different for each image.Participants were asked to tell us which of the two vibrations they thought best matched the visual feedback.
- **Experiment 2**: Ten participants were presented with a pair of tactile signals, one of them being the signal corresponding to the visual texture displayed and the other one being the signal of another texture.They were asked to pick which of the two vibrations they thought best matched the visual feedback.

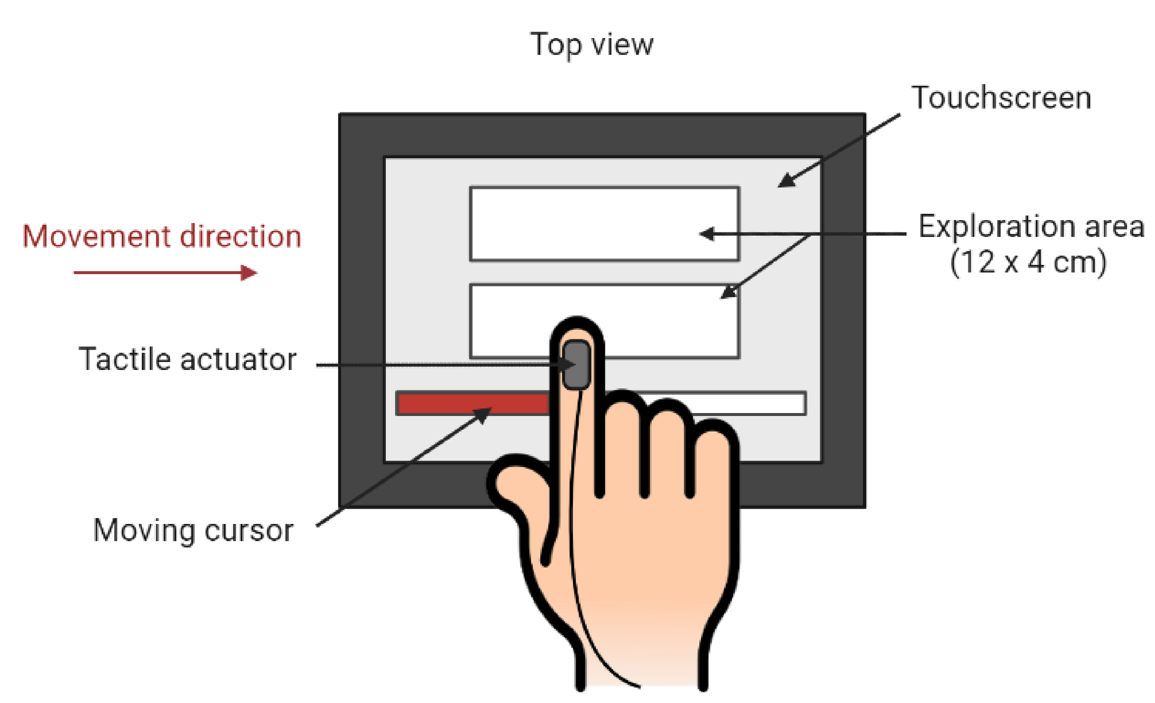

Fig.2. Illustration of the experimental setup used for our experiments.

* Supported by ANR WAVY grant

RESULTS

a. Experiment 1

- Each participant was presented with 160 trials of randomly ordered but equal combinations. The reference speed was fixed at 4cm/s.
- The performance at the task improved as the difference in speed between the reference and the comparison stimuli increased Fig. 3.
- On average, the rate of 75% of correct answers was attained for a speed difference of 3cm/s.

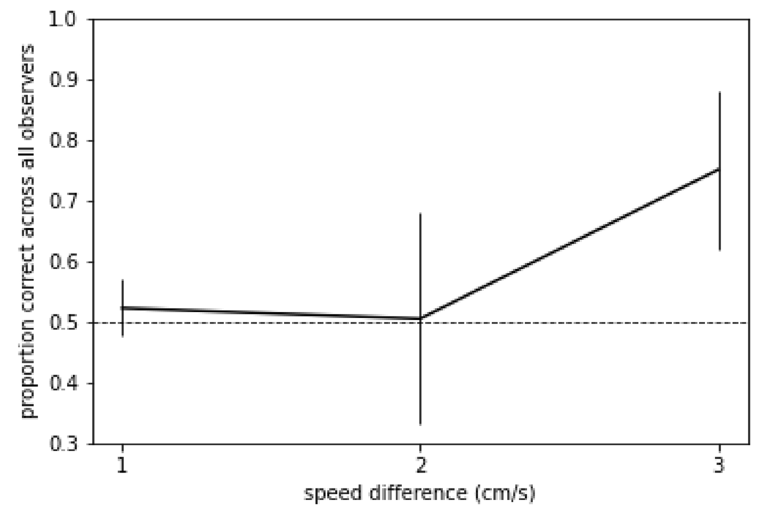

Fig.3. Fraction of correct matches across all observers (mean ± SD).

b. Experiment 2

- The experiments consisted of 200 trials presented in a random order.
- The average proportion of correct matches across all participants is 0.65 ± 0.08.
- The threshold of 70% of correct matches was reached for two textures, texture 1 and texture 3 corresponding to the plastic and the black corduroy. However, for the other three textures, participant were unable to match the haptic rendering to the texture's picture (success rate lower than 70 %) Fig. 4

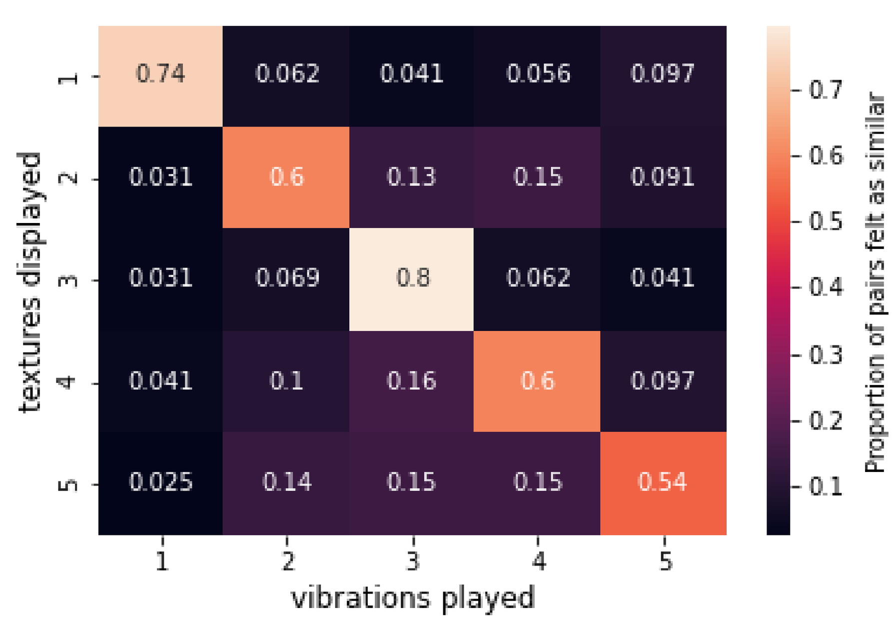

Fig.4. Fraction of correct matches across all observers.

CONCLUSIONS & DISCUSSION

In this study, we selected and recorded in active touch conditions a dataset of haptic textures. We used this dataset to conduct a series of psychophysical studies on visuo-haptic interactions.

Results of the first experiment suggest that it takes large speed differences to impact visuo-haptic matching.

Results of the second experiment showed that visuo-haptic matching of textures is confusing. In our future work, we are interested in studying whether poor matching is due to limitations of artificially generated stimuli or to human visuo-haptic perception.

REFERENCES

Bergen, J. R., & Adelson, E. H. (1988). Early vision and texture perception. *Nature*, *333*(6171), 363–364.

Saal, H. P., & Bensmaia, S. J. (2014). Touch is a team effort: interplay of submodalities in cutaneous sensibility. *Trends in neurosciences*, *37*(12), 689–697.