Electrotactile Patterns for Single Finger Interactions in VR

Sebastian Vizcay, Panagiotis Kourtesis, Ferran Argelaguet Sanz, Claudio Pacchierotti, Maud Marchal

Electrotactile Patterns for Single Finger Interactions in VR*

Sebastian Vizcay[1], Panagiotis Kourtesis[1], Ferran Argelaguet[1], Claudio Pacchierotti[2], and Maud Marchal[3]

[1] Inria, Univ Rennes, IRISA, CNRS – 35042 Rennes, France
[2] CNRS, Univ Rennes, IRISA, Inria – 35042 Rennes, France
[3] Univ Rennes, INSA Rennes, CNRS, Inria, IRISA – France and IUF – France
name.surname@inria.fr ; name.surname@irisa.fr

Abstract. Electrotactile feedback has been proven effective in improving mid-air interactions in Virtual Reality (VR) scenarios. However, the elicited sensation is often described as unnatural. We explore standard stimulation patterns or effects (FXs) found in the literature and how they can get coupled with common VR interactions. We propose 6 implementations of these patterns and, based on our expectation that some couplings work better than others, we evaluated their coherence in an experiment (N=8).

1 Introduction

Matching user's expectations while interacting in VR is an important factor of presence [2] and agency [1]. Tactile feedback needs to ensure a coherence between the user's interaction and the elicited sensations. While electrotactile feedback has been proven effective in rendering contact information when interacting with virtual objects [3], one of its disadvantages is that it elicits sensations that are often described as unnatural, due to the fact that it directly stimulates the skin nerves endings. Electrotactile feedback is still capable of rendering rich sensations thanks to the high density of actuators, their high wearability, and the wide number of parameters that can be customized. This paper investigates and present preliminary results of how different set of electrotactile actuation parameters can be used to render different tactile sensations and how these are perceived while performing single finger interactions in VR.

2 Methodology

We propose the study of three common single finger interactions: tapping an object, sliding the finger along a surface, and pressing down objects (see Fig. 1-left). From the literature, we collected six common tactile effects rendered using electrotactile feedback.

* This work was supported by the European Union's Horizon 2020 research and innovation program under grant agreement No. 856718 (TACTILITY).

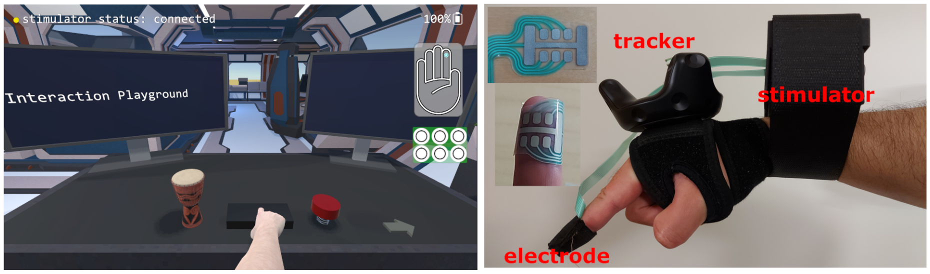

Fig. 1. VR scenario with 3 interactable objects (left) and equipment used (right), with electrode layout in the inset.

We use a custom electrical stimulator (see Fig 1 right) that has up to 32 channels which can be configured as cathode or anode. The stimulator produces biphasic cathodic square pulses with a pulse frequency in the range [1-200] Hz and with pulse widths between [30-500] μs. Amplitude of the pulses can be set between the range of [0.1-9.0] mA. For this particular experiment, we connected a 7-channels electrode (6 cathodes and 1 anode) with the cathodes laid out in a 2×3 matrix.

We designed 6 electrotactile patterns (FXs) which can be easily distinguished. The feedback design was done for a 2×3 pads electrode (see Fig 1 right). The six patterns (or FX) are described in detail in this accompanying technical report [4].

Eight subjects are asked to use their index finger, equipped as shown in Fig. 1, to interact with a virtual environment in three different ways – tapping an object, sliding the finger along a surface, and pressing down objects. We tested the performance of each of these interactions when rendered in the six different ways mentioned above, in order to understand the best way to render such interactions through electrotactile feedback. Each interaction is repeated 6 times per each pattern, leading to 108 interactions in total.

At the end of the task, participants answer a post-experience questionnaire providing us additional feedback regarding the perception of the tactile patterns during the considered interactions.

3 Results and discussion

The ranking and the distribution of the scores for all interactions are reported in Fig. 2.

For the tapping interaction, the best patterns are the direction, the intensity, and the binary ones. This is also corroborated with the ranking data. We emphasize here that the directional pattern behaves similarly to the intensity one, having as only difference the activation of 2 central active pads rather than only one [4].

For the press interaction, we found similar results, but these are more pronounced given that the interaction span is longer. The directional and intensity patterns are still the best but this time the intensity pattern takes the first place most often in the ranking data.

Finally, for the slide interaction, we see clearly the preference for the directional pattern which is a richer pattern compared to the others, thanks to the additional interaction input data. It is interesting to notice in the ranking data that 2nd and 3rd best are the clockwise and random patterns, indicating that one of the most important factors for rendering a coherent sensation for this particular interaction is having a stimulus that changes location over time.

As next step, we will recruit more participants in order to perform a statistical analysis and verify that the differences are significant. We will also analyze the interaction data that we have collected such as time spent per interaction, object interpenetration, button compression and sliding speed to see if the tactile FXs have an incidence in the way participants interact with the virtual objects.

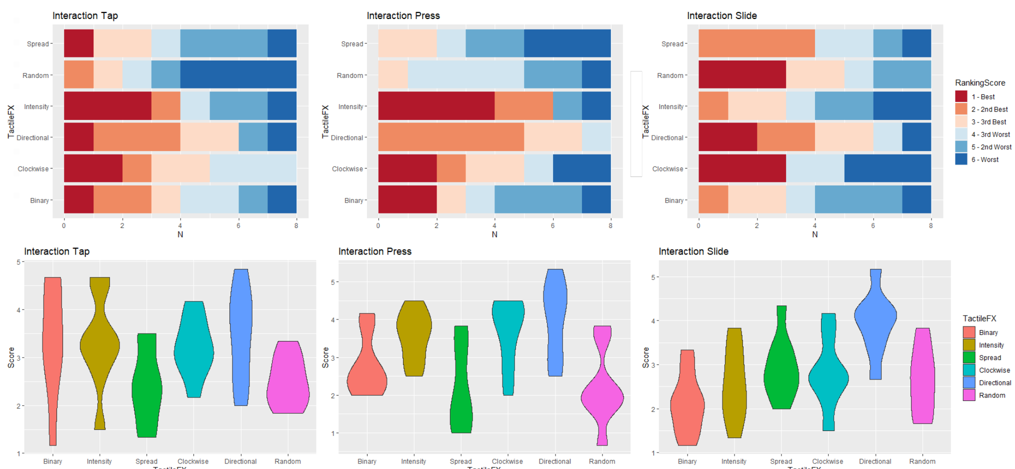

Fig. 2. Ranking order (top) and distribution of the scores (bottom) of the tactile patterns (FXs) per each interaction: tapping an object, sliding the finger along a surface, and pressing down objects. The six considered patterns are detailed in [4].

References

1. Jeunet, C., Albert, L., Argelaguet, F., Lécuyer, A.: "do you feel in control?": towards novel approaches to characterise, manipulate and measure the sense of agency in virtual environments. IEEE Trans. Vis. Comp. Graphics **24**(4), 1486–1495 (2018)
2. Skarbez, R., Brooks, Jr, F.P., Whitton, M.C.: A survey of presence and related concepts. ACM Computing Surveys (CSUR) **50**(6), 1–39 (2017)
3. Vizcay, S., Kourtesis, P., Argelaguet, F., Pacchierotti, C., Marchal, M.: Electrotactile Feedback For Enhancing Contact Information in Virtual Reality. In: Orlosky, J., Reiners, D., Weyers, B. (eds.) ICAT-EGVE (2021)
4. Vizcay, S., Kourtesis, P., Argelaguet, F., Pacchierotti, C., Marchal, M.: Tactile patterns for electrotactile simulation. Tech. rep. (2022), `https://team.inria.fr/rainbow/files/2022/03/Vizcayelectrotactilepatterns.pdf`