Physical and behavioral comparison of haptic touchscreens

Corentin Bernard[1,2], Nicolas Huloux[2], Michaël Wiertlewski[3] and Jocelyn Monnoyer[4]

I. Introduction

Touchscreens equipped with friction modulation can provide rich tactile feedback to their users. To date, there are no standard metrics to properly quantify the benefit brought by haptic feedback on touchscreen usability. The definition of such metrics is not straightforward since friction modulation technologies can be achieved by either ultrasonic waves or with electroadhesion. In addition, the output depends strongly on the user, both because of the mechanical behavior of the fingertip and personal tactile somatosensory capabilities. We investigate here a method to evaluate and compare the performance of haptic tablets on an objective scale. The method first defines some metrics using physical measurements of friction and latency. The comparison is completed with metrics based on pointing tasks performed by users. We evaluated the comparison method with two haptic devices, one based on ultrasonic friction modulation (Tpad) and the other based on electroadhesion (Tanvas).

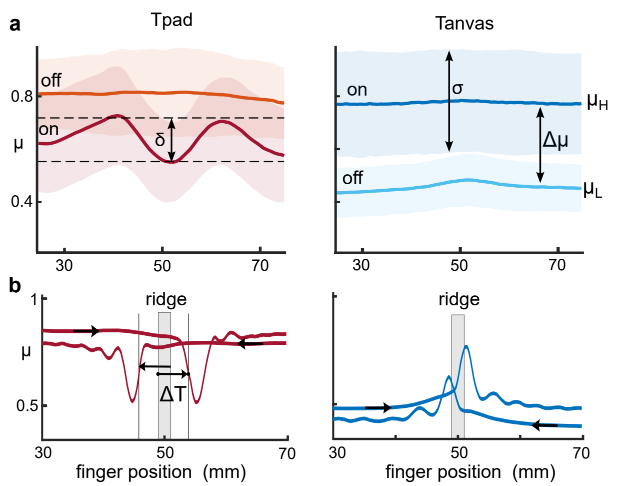

Fig. 1. **a.** Evaluation of the constant friction levels μ_H and μ_L, when the actuation is on or off, the friction range Δ_μ, the inter-subject standard deviation σ and the mean intra-trial standard deviation δ. **b.** Evaluation of the end-to-end latency ΔT trough the rendering of a haptic ridge (actuation on the grey area). Friction is presented for left-to-right swipes and for right-to-left swipes to exhibit the impact of the delay on the actuation.

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[1]Corentin Bernard is with Aix Marseille Univ, CNRS, PRISM, Marseille, France. bernard@prism.cnrs.fr

[2]Corentin Bernard and Nicolas Huloux are with MIRA, Aflokkat, Ajaccio, France.

[3]Michaël Wiertlewski is with TU Delft, Delft, The Netherlands.

[4]Jocelyn Monnoyer is with Stellantis, Paris, France and Aix Marseille Univ, CNRS, ISM, Marseille, France.

II. Physical measurements

First, physical measurements of friction, are required to evaluate the haptic surface capability. As presented in Fig. 1.a, the friction range metric is measured as the difference between the highest and lowest constant friction levels. It reflects the maximal possible intensity of the haptic feedback. The perception of elementary stimuli such as edges is indeed directly linked to friction change amplitude.This measurement also provides the intra-trial and inter-subject variability metrics that shows the robustness of the device.

In addition, we measured the end-to-end latency, that corresponds to the delay between a user's action and the haptic actuation, as shown in Fig. 1.b. A low end-to-end latency is crucial for touch based HCI to render trustful haptic feedback [1].

III. Behavioral measurements

However, since these interfaces are intended to be used by humans, the evaluation must be complemented by behavioral measurements. In the same way that [2] evaluated force-feedback haptic devices, we propose here to evaluate the performances of the haptic tablets through the performances of users in a one-dimensional pointing task, as shown in Fig. 2. We hypothesize that user rapidity and accuracy are metrics that can assess the haptic touchscreen's usability.

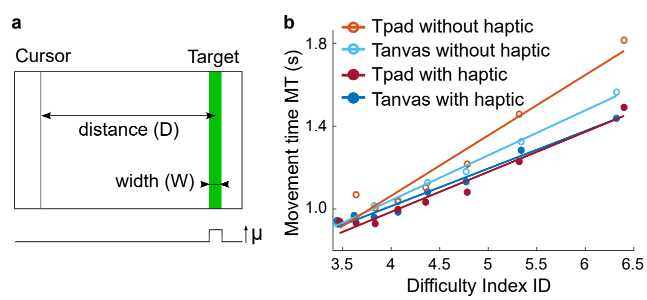

Fig. 2. **a.** Interface of the pointing task. **b.** Results of the pointing experiment. Mean movement time is plotted with respect to the difficulty index for the 4 conditions. Linear regressions $MT = a + b \times ID$ are calculated to exhibit Fitts' law to compare the interfaces.

This work paves the way toward the definitions of standard specifications for haptic tablets, to establish benchmarks and guidelines for improving surface haptic devices.

References

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[2] E. Samur, *Performance metrics for haptic interfaces*. Springer Science & Business Media, 2012.