Experimental evaluation of two haptic techniques for 3D interaction: the constriction polyhedron technique vs magnetic attraction.

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Despite numerous successful applications, in the field of medical training and simulation for example, effective haptic assistances for 3D designation tasks still need to be developed. Nowadays, haptic enhancement of graphical interfaces sometimes leads to situations where the user is disorientated and less efficient than within the same framework without haptic assistance. While designed to increase speed and accuracy, and reduce error rates [1] in the realisation of manipulation tasks, haptic enhancement sometimes reduces performances if the chosen assistance is not adapted to the task at hand [2], [3], [4]. Tornil, for example, underlines that for designation tasks, apart from very simple and not very realistic situations, the effects of a magnetic haptic assistance often prove to reduce performances, and should be considered as harmful for the interaction.

However, 3D interaction still remains difficult for users if they are not provided with specific and adapted techniques to help them complete their objectives. We propose a technique that, we think, might improve users' performances and satisfaction for designation tasks in 3D environments and could be applied in manipulation tasks such as item selection in a menu. This technique is inspired from Yamada et al. study on selection tasks on a magnetic grid. Their objective was to propose a haptic assistance to make selection in a magnetic grid of points regularly distributed in a 3D space. They compare a method where each plan or edge behave as a haptic guide, with the traditional method of a magnetic grid where only the vertices are provided with haptic [5].
In this technique the pointer is haptically constrained to the 3D magnetic grid. Our technique, rather than attracting and maintaining the user on the edges of the grid, allow them to take support on the edges and slide along them towards a vertex. This technique can be generalized to all configuration of target forming a convex polyhedron, assuming the haptic guidance is determined by the collisions of the pointer with the hedges of the polyhedron. In others terms, the targets are accessible while slipping along the interior faces and edges which connect them.

We realised a preliminary experimental study. 6 participants had to realize selection tasks of randomly highlighted items on a 2D octagonal menu. We compared 3 conditions: selection without haptic help, magnetic attraction and our hardborders technique. Each task was repeated 30 times. After the experimental setup, subjects were asked to fill a questionnaire (a shorter version of the NASA Task Load Index [6]) to rate each technique regarding difficulty and performances.

We realized a statistical comparison of each technique regarding task completion times and precision. An ANOVA showed a significant effect of the type of haptics feedback ($F(2, 537) = 62.051$, $p < .0001$). A post-hoc multivariate analysis showed that our technique leads to shorter completion times (gain of 22%, $p < .0001$) and increased precision (gain of 29%, $p < .0001$).

	Mean Task completion times (in seconds)	Precision (in cm)
No haptics	2.361	0.321
Constriction polyhedron	1.559	0.228
Magnetic attraction	2.003	0.322

Table 1: Task completion times and precision with each technique

Concerning subjective evaluations, there was a significant effect of the type of haptics feedback ($F(2, 537) = 3.34$, $p < .013$). A post-hoc multivariate analysis showed a perceived performance significantly higher with the hardborder technique ($p = .006$) but no statistically significant difference appeared concerning the difficulty ($p = .051$, see table 2).

	Difficulty	Performance
No haptics	8.2	9.8
Constriction polyhedron	3.917	15.73
Magnetic attraction	5.517	13.71

Table 2: mean evaluations for Difficulty and Performance with each technique

We are actually realising further analysis, in particular concerning the effects of each technique on multiple selections and we are planning to work on the generalisation of this technique for selection tasks in a random set of targets.

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