Interaction hybride tactile/tangible pour l'exploration de données 3D

Interactive 3D Data Exploration Using Hybrid Tactile/Tangible Input

Lonni Besançon, Paul Issartel, Mehdi Ammi and Tobias Isenberg

English Abstract—We present the design and evaluation of an interface that combines tactile and tangible paradigms for 3D visualization. While studies have demonstrated that both tactile and tangible input can be efficient for a subset of 3D manipulation tasks, we reflect on combinations of the two complementary input types. Based on a field study and follow-up interviews, we present a prototypical application of hybrid tactile/tangible interaction techniques for fluid dynamics data visualization using a portable, position-aware device. We briefly report on the evaluation of our approach with qualitative feedback.

1 Introduction

Interactive data exploration has long been an essential aspect of the visualization of 3D datasets. Traditionally, researchers have been investigating both dedicated interactive visualization platforms such as immersive VR settings and traditional workstations. While the former rely on dedicated 3D input devices such as wands, gloves, or 3D tracking, the latter make use of either desktop-based 3D input devices such as 3D mice or the traditional mouse+keyboard setup. Both of these interaction settings have a long tradition and continue to be important. Nonetheless, people have increasingly easy access to novel display and computation environments such as tablet computers and large displays providing tactile input, or physical props facilitating tangible interaction.

Research has shown that these tactile and tangible input paradigms have many benefits for effective and efficient interaction, in particular for 3D data exploration (e. g., [1], [5], [7], [13]). Yet, they are quite different from each other: tactile input benefits from its directness and a resulting perception of control and precision of interaction [12], [13], while tangible input offers an integrated, multi-sensory, and intuitive 6 DOF control due to its similarity to day-to-day interaction with real objects [3], [6], [8]. The development of portable position-aware devices offers opportunities to use a tablet for tangible input in addition to the usual tactile input on the screen. Yet, it is still unclear how this transition between the different input modalities could and should be realized in practice, in particular due to the different characteristics of tactile and tangible inputs. Based on the thorough description of how these input paradigms can be combined to benefit 3D data exploration [2] we propose a design of hybrid mappings to achieve common 3D visualization tasks for fluid dynamic visualization.

- *Lonni Besançon: Université Paris Sud, Inria, Université Paris Saclay E-mail: lonni.besancon@gmail.com*
- *Paul Issartel: Université Paris Sud, Limsi CNRS E-mail: paul.issartel@u-psud.fr*
- *Mehdi Ammi: Limsi CNRS E-mail: mehdi.ammi@limsi.fr*
- *Tobias Isenberg: Inria, Université Paris Saclay E-mail: tobias.isenberg@inria.fr*

2 Field Study and Prototype

In this work we focus on supporting data exploration for fluid dynamics researchers [2]. In order to better understand their needs, we carried out a field study with five experts (2 females; ages 22–44; mean of 13.6 years of professional experience). When analyzing new datasets, experts first want to obtain a general understanding of the dataset [11]—particularly through cutting planes—and then focus on understanding how the flows evolve spatially and temporally. The latter can be evaluated thanks to a technique called particle seeding. It consists in placing particles at a given point and seeing how the different forces in the dataset make them move around in the dataset.

In order to facilitate, first, regular 3D exploration, we proposed four different mappings. In the first mapping both modalities controlled the data volume, and in the second mapping both controlled the cutting plane (Fig. 1, Fig. 2) . This way a temporal multiplexing made it possible to switch between the two input modalities for a given interaction, allowing us to investigate which mappings would be preferred by participants. For the other two mappings, tactile input was mapped to view manipulation and tangible input mapped to the cutting plane manipulation, or the other way around.

We also wanted to investigate at least one mapping that requires the specification of a 3D point. We thus explored 3D seed point placement (Fig. 3). From the different alternatives we implemented tactile input for specifying a seeding point because the act of touching is a good metaphor for the placement of objects.

To evaluate our hybrid interaction paradigm, we recruited 7 researchers (all male; ages 23–61 years, mean: 35.7, median: 32, and SD: 13.1) from a fluid dynamics lab whose work focuses on volumetric flow data. Our unpaid volunteers had 1–38 years (mean: 12.9, median: 9, and SD: 12.9) of post-Master's professional experience. Our setup included the 7 inch Google Tango tablet (370 g, 1920 × 1200 pixel resolution) and a 55 inch (139.7 cm diagonal) vertical screen with a 3840 × 2160 pixel resolution. We asked our participants to stand in front of the large display throughout the experiment. The external screen showed synchronized larger views of the data as well as additional visualization elements in order to address the occlusion issue of tactile interaction [4], [10]. The devices communicate via UDP and we sent absolute transformation matrices to ensure that packet loss would not be critical for the display/tablet synchronization. Elaborate computations and visualizations were restricted to the vertical display for performance and battery issues.

The study consisted in an initial learning and training phase, followed by a free exploration task to try and understand as much of the FTLE dataset as possible. Participants could freely switch between tactile-only, tangible-only, and hybrid interaction.

3 Result discussion and conclusion

We recorded the ratio of time each participant spent using each possible modality (i. e., tactile, tangible, or hybrid). It is clear from Fig. 4 that, after the training, participants predominantly used the hybrid mapping (86% of the time on average). This is reinforced by the fact that overall the hybrid interaction was preferred by most participants, and only one stated it was his second favorite. It was reported as "easier to use" and a reproduction of what "users can do with a PC but with more flexible interaction techniques." In particular, the particle seeding was the favorite feature of our system. Participants compared particle seeding to the PC/workstation-based exploration tools, where they place particle sources by editing a script that is then executed. To be able to adjust the particle source they need to edit the script and re-run it. In contrast to this rather crude form of data exploration, our approach allowed them to interactively adjust the placement based on the location and orientation of the tablet (when using tangible control) or the cutting plane (for tactile input). All experts reported that this technique was "engaging" and "easy to use."

We can thus conclude with our observation that our participants appreciated our prototype and that they found it better suited for primary 3D visualization tasks than a traditional mouse-and-keyboard setup. Our participants especially appreciated that a complex seed point placement task could easily be achieved by combining a tangible manipulation of the cutting plane and a ray-casting with the tactile input, thus demonstrating the potential of hybrid tactile-tangible interactions. The flexible seed point placement enabled them to use an exploratory data analysis style of vector fields. Most importantly, however, we demonstrated that current hardware allows us to realize hybrid tactile/tangible interaction environments that support flexible 3D data exploration, without relying on external 3D tracking. Without the need for constant maintenance, calibration, and support that such hybrid interaction would normally require, it is thus now possible to make the proposed interactive data exploration techniques available to researchers in various domains.

This initial exploration leaves several question open such as a possible integration in a VR or AR setup. Still combining both input paradigms was deemed beneficial to 3D data exploration. As follow-up work, we also proposed to focus on 3D selection of region of interest [9], which is often the primary step before proceeding to further 3D manipulation tasks. We thus combined tactile and tangible input, the tactile input being used to specify a 2D-free form stroke that is then extruded in 3D by the tangible tablet's movements.

References

[1] L. Besançon, P. Issartel, M. Ammi, and T. Isenberg. Mouse, tactile, and tangible input for 3D manipulation. In *Proc. CHI*. ACM, New York, 2017. To appear. doi: 10.1145/3025453.3025863

[2] L. Besançon, P. Issartel, M. Ammi, and T. Isenberg. Hybrid tactile/tangible interaction for 3D data exploration. *IEEE Transactions on Visualization and Computer Graphics*, 23(1):881–890, Jan. 2017. doi: 10.1109/TVCG.2016.2599217

[3] G. W. Fitzmaurice. *Graspable User Interfaces*. PhD thesis, University of Toronto, Canada, 1996.

[4] M. S. Hancock and K. S. Booth. Improving menu placement strategies for pen input. In *Proc. GI*, pp. 221–230. CHCCS, Toronto, 2004.

[5] K. Hinckley, R. Pausch, J. C. Goble, and N. F. Kassell. Passive real-world interface props for neurosurgical visualization. In *Proc. CHI*, pp. 452–458. ACM, New York, 1994. doi: 10.1145/191666.191821

[6] H. Ishii and B. Ullmer. Tangible bits: Towards seamless interfaces between people, bits and atoms. In *Proc. CHI*, pp. 234–241. ACM, New York, 1997. doi: 10.1145/258549.258715

[7] P. Issartel, F. Guéniat, and M. Ammi. Slicing techniques for handheld augmented reality. In *Proc. 3DUI*, pp. 39–42. IEEE Computer Society, Los Alamitos, 2014. doi: 10.1109/3DUI.2014.6798839

[8] D. López, L. Oehlberg, C. Doger, and T. Isenberg. Towards an understanding of mobile touch navigation in a stereoscopic viewing environment for 3D data exploration. *IEEE Transactions on Visualization and Computer Graphics*, 22(5):1616–1629, May 2016. doi: 10.1109/TVCG.2015.2440233

[9] M. Sereno, M. Ammi, T. Isenberg, and L. Besançon. Tangible brush: Performing 3D selection with portable and position-aware devices. In *IEEE VIS Poster Compendium*, October 2016.

[10] B. Shneiderman. Touchscreens now offer compelling uses. *IEEE Software*, 8(2):93–94, 107, Mar. 1991. doi: 10.1109/52.73754

[11] B. Shneiderman. The eyes have it: A task by data type taxonomy for information visualizations. In *Proc. VL*, pp. 336–343. IEEE Computer Society, Los Alamitos, 1996. doi: 10.1109/VL.1996.545307

[12] D. Watson, M. Hancock, R. L. Mandryk, and M. Birk. Deconstructing the touch experience. In *Proc. ITS*, pp. 199–208. ACM, New York, 2013. doi: 10.1145/2512349.2512819

[13] L. Yu, P. Svetachov, P. Isenberg, M. H. Everts, and T. Isenberg. FI3D: Direct-touch interaction for the exploration of 3D scientific visualization spaces. *IEEE Transactions on Visualization and Computer Graphics*, 16(6):1613–1622, Nov./Dec. 2010. doi: 10.1109/TVCG.2010.157

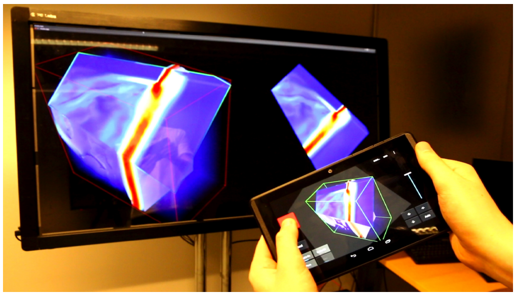

Fig. 1. Tangible manipulation of a cutting plane in the visualization.

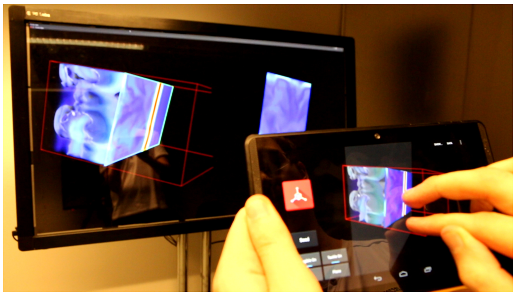

Fig. 2. Tactile manipulation of a cutting plane in the visualization.

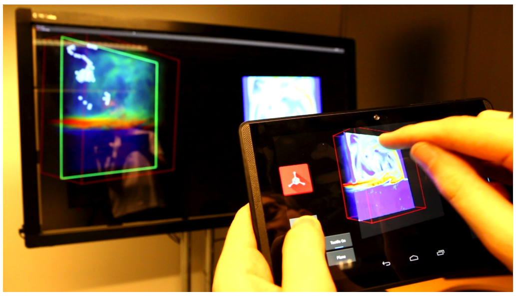

Fig. 3. Seed point placement for particle seeding.

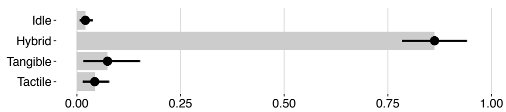

Fig. 4. Ratio of time spent interacting in the different conditions. Error bars are 95% confidence intervals.