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Tangible Brush: Performing 3D Selection with Portable and Position-aware Devices

Mickael Sereno*
Univ. Paris Saclay, France

Mehdi Ammi†
Limsi/CNRS, France

Tobias Isenberg‡
Inria Saclay, France

Lonni Besançon§
Univ. Paris Saclay, France
Inria Saclay, France

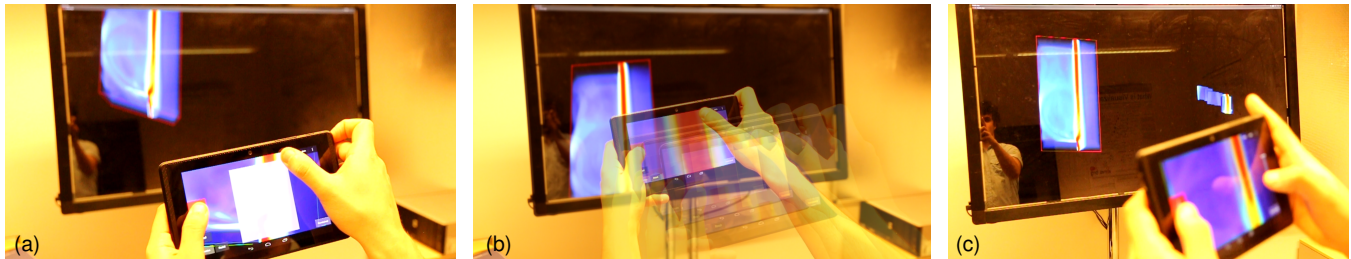


Figure 1: Tangible Brush technique: Fig. 1(a) creation of selection area with tactile input; Fig. 1(b) the area is extended to a volume with tangible input; Fig. 1(c) users can check their selection and manipulate it.

ABSTRACT

We present the design of a 6-DOF tangible controller for 3D spatial data selection. Such selection is a primary and fundamental task in scientific visualization: it is performed prior to many other interactions. Many datasets are defined in 3D space, yet selection is often performed based on 2D input. While 2D selection may be efficient for datasets with explicit shapes, it is less efficient for data without such objects. We address this issue by combining 2D tactile with 3D tangible input to perform 3D selection in volumetric datasets.

Index Terms: H.5.2 [Information Systems]: User Interfaces—Input devices and strategies

1 INTRODUCTION

Many visualization systems rely on exploratory data visualization and analysis [4] that allows domain experts to explore unknown dataset to discover specific regions of interest. An essential aspect of exploratory analysis is the selection of these specific regions of interest [6] that need to be more carefully examined to reveal their interesting patterns, properties or internal structures. While 2D selection on a 2D dataset can be easily performed with a mouse, 3D datasets require the specification of 3D volumes for selecting the intended data subset. Existing techniques are based on picking or ray-casting [1] and are effective for selecting explicit shapes. Many scientific datasets such as particle clouds or medical scans, however, lack these explicit shapes and thus require other selection approaches in which the selection is achieved by specifying a selection volume. Our goal with this work is to facilitate such 3D selection using a position-aware tablet. We make use of Google's Project Tango tablet¹ as it supports both tactile input and tangible manipulations with its position-aware mechanism. We use the tactile input to adjust parameters and draw a 2D selection shape, and the position-aware mechanism to extend the 2D area into a 3D volume selection. Our

approach thus extends existing automatic, interactive, and context-aware selection techniques with explicit adjustments of the selection volume in a tangibly spatial manner.

2 CONTEXT AND RELATED WORK

Several techniques have been developed in the past for making selections in 2D datasets. Picking—clicking on the target—is one of them and is often used for exploration of scatterplots or other 2D charts. It is a serial technique that is time-consuming when applied to multiple points—inefficient for the selection of 3D subsets within volumetric data. An alternative is the use of brushing: the user drags a pre-defined shape with the mouse to specify a region of interest in 2D. This approach facilitates the selection of multiple points in parallel with a single and efficient action [3]. A second alternative is the lasso technique—the user draws a shape or indicates its endpoints to perform a selection—which has been extensively used in operating systems. These two techniques have proven their efficiency for 2D datasets due to the match between input and data space dimensionality. 3D selection, however, requires the user to provide an additional depth information to create a selection volume and, in contrast to 2D environments, the 3D space is not fully visible (i. e., occlusion) and accessible for interaction. The lasso technique is the foundation on which we build our prototype implementation.

Ulinski et al. [5] proposed to use two hands to manipulate a cuboidal selection volume. However, cuboidal selection might include undesired parts of the dataset due to the shape of the selection. Other approaches rely on the context or the inherent structure or properties of the data have also been investigated. For instance, Yu et al. [7, 8] propose to base their selection on a 2D lasso which is then refined and extended into a 3D selection by taking into account the density of particles in 3D point cloud dataset as well as the drawn shape. While Yu et al. rely on an automatic approach for the 3D extension, our approach emphasizes an interactive and tangible user control. Lucas and Bowman [3] use a physically tracked tablet on which a lasso is drawn, which is then extended into a 3D selection shape automatically. We build on the latter: we extend the selection area manually—with user input—instead of automatically creating it. We achieve this through the manipulation of a position-aware device, inspired by, e. g., Konieczny et al.'s [2] work.

*e-mail: mickael-francisco.serenio@u-psud.fr

†e-mail: mehdi.ammi@u-psud.fr

‡e-mail: tobias.isenberg@inria.fr

§e-mail: lonni.besancon@gmail.com

¹<https://www.google.com/atap/project-tango/>

3 SELECTION TECHNIQUE AND INTERFACE

The main idea of our approach is to show the data on the tablet, selecting a good view, and making a selection by creating a selection shape with tactile input and extending it to 3D with tangible interaction. Thus a user can start by making view adjustments to the data projection on the tablet—either by tangible or tactile interaction. After a good view is found, the user can initiate the Tangible Brush. It works similar to 2D brushing, only that a tangible interaction is used to move the brush shape in 3D space. We thus start by creating a selection shape using tactile input (see Fig. 1(a)).²

Next, the tangible motion of the tablet is used to move the 2D selection shape in 3D space to specify the selection volume. For this tangible interaction we can either make use of only the motion perpendicular to the tablet's orientation or its full 6 DOF motion. In contrast to 2D brushing, however, we not only actively select data items touched by the brush but use its motion to derive a 3D selection volume as shown in Fig. 1(b) and (c). This approach has the advantage that we can support both particle-based and volumetric data. Moreover, we can also make selections in large datasets for which only a well-chosen sample can be shown on the tablet.

This overall approach can be repeated several times to extend or adjust the selection volume, potentially with a re-adjustment of the view in-between the selection interactions. This iterative selection process can be achieved by a user by simply creating a new selection brush using tactile input, and then using the tangible interaction to complete the selection volume. For example, one may start with a larger brush to select the main part of a dense region in the data, and then create a smaller brush to add fine details (see Fig. 1(c)).

Our setup that combines the mobile tablet with a larger but static display supports this iterative creation of the selection (Fig. 2): The vertical display does not only show a second (potentially more detailed) copy of the data (on the left) but also a representation of the selection volume (on the right) which may be otherwise difficult to see in, for example, volumetric datasets. Together with the tablet, this setup thus combines the flexibility of tactile and tangible input for navigation and selection with the larger screen real estate and more computational power of the separate vertical display/workstation.

To facilitate and demonstrate the use of both input modalities, we implemented the prototypical interface shown in Fig. 2. Menus on top allow users to load different datasets and change general visualization settings. User-controlled mode switching between selection and data manipulation is achieved through an explicit button. To provide a better control over the tangible interaction, clutching is achieved by the pressing or releasing of this button—which is located right under the left thumb of users. We provide users with an additional toggle button that constrains the tangible interaction to motions perpendicular to the tablet or enables full 6 DOF motions. Finally, we provide users with a slider to adjust the control gain of tangible manipulations.

4 REALIZATION

A crucial point of our approach was to use position-aware devices to avoid expensive and tracking systems that are difficult to maintain and often dismissed by users. We thus decided to use the Tango device: a 7" tablet with a touch-sensitive screen, augmented with tracking capabilities and built-in sensors. We combine it with a vertical display (55", 3840 × 2160 pixels) to provide multiple synchronized views as shown in Fig. 2.

Communication between the devices uses the UDP protocol and we send absolute transformation matrices to ensure that packet loss does not negatively impact the display/tablet synchronization.

²The current implementation uses rectangular shapes, but we are working on extending these to support arbitrary lasso-like input.



Figure 2: The overall data exploration setup including the interface on the position-aware tablet.

We process datasets with the VTK library.³ We render them with OpenGL ES 2.0 on the tablet and OpenGL 3.0 on the large display.

5 CONCLUSION AND FUTURE WORK

Our 3D selection technique relies on both tactile and tangible modalities, facilitated by Google's position-aware Tango tablet. It allows researchers to explore their 3D datasets using both tangible and tactile interaction paradigms, and combine the exploration with a hybrid selection technique. The advantages of this selection technique are that selections can now be made and adjusted through physical motions in 3D space, reinforcing the 3D spatial character of the data.

Future work includes adding the possibility to draw different selection shapes. We wish to implement additional Boolean operations to support intersections and subtractions as well. Furthermore, we would like to compare Tangible Brush against other selection techniques used in scientific visualization as well as explore how it can be combined with such existing techniques. Ultimately, we wish to integrate Tangible Brush into our already existing platform for the visualization of fluid dynamic datasets and explore how it can be integrated with existing tactile, tangible, and hybrid interaction paradigms for 3D data exploration. After this integration we are also planning to observe experts using our Tangible Brush selection to understand how it can support their data analysis workflow.

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