Interacting with Microseismic Visualizations

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Mostafa, A., Greenberg, S., Brazil, E., Sharlin, E. and Sousa, M. (2013) Interacting with Microseismic Visualizations. Research report 2013-1035-02, Department of Computer Science, University of Calgary, Calgary, Alberta, Canada, January. Paper plus video, video duration 1:53.

Figure 1. Microseismic data

Abstract

Microseismic visualization systems present complex 3D data of small seismic events within oil reservoirs to allow experts to explore and interact with that data. Yet existing systems suffer several problems: 3D spatial navigation and orientation is difficult, and selecting 3D data is challenging due to the problems of occlusion and lack of depth perception. Our work mitigates these problems by applying both proxemic interactions and a spatial input device to simplify how experts navigate through the visualization, and a painting metaphor to simplify how they select that information.

Author Keywords

3D microseismic visualizations; proxemic interactions

ACM Classification Keywords

H.5.2 [User Interfaces]: Graphical user interfaces (GUI) - Interaction styles

Introduction

Microseismic data is multi-dimensional data containing 3D spatial information representing small microseismic events (in lay terms: extremely small earthquakes). This data is normally captured by geophones and other sensors. Within the oil and gas industry, microseismic monitoring of this data is crucial for understanding oil reservoir characteristics and improving reservoir productivity [8].

Microseismic experts face various challenges while working and analyzing their data. For example, while experts consider analyzing such geological fracture geometry as essential, performing this task efficiently requires them to have an intuitive way to navigate, explore, and select subsets of the complex 3D microseismic data set. Existing microseismic visualization systems typically portray data as a 3d point cloud, as in Figure 1. Yet navigation and orienting oneself around this data is awkward using traditional interaction techniques, and selecting data in 3D is difficult due to problems such as occlusion and lack of depth perception. Our goal is to improve upon these forms of interaction and support experts with intuitive 3D interaction mechanisms. In this paper we present our initial efforts in achieving this goal, where we apply proxemic interactions [2] and a spatial input device along with a painting metaphor to ease basic navigation and selection tasks. We also highlight some of the lessons learned and likely improvements.

Related Work

Various techniques for spatial navigation have been extensively researched, where their goal is to allow users to access and manipulate 3D entities using techniques that borrow from the physical world. Virtual reality-based techniques [3], for instance, has people manipulating avatars of themselves, where the avatars simulate one's physical presence within a completely virtual and synthetic environment. Interaction is typically through conventional means (e.g., a mouse) and performed by manipulating the avatar. Caves, on the other hand, immerse a person by surrounding them with the 3d space. 3D data is seen either on large multiple displays or through stereo glasses, where people interact with that data through special input devices such as data gloves.

Our approach is only roughly similar to a Cave. Our technology uses a large low-cost readily-available display similar to consumer televisions to visualize the data, a Wiimote controller, and motion capture sensors. We use these technologies in two ways. First, we leverage the concept of proxemic interactions [2], which applies social theories of proxemics [4] to HCI by using people's natural expectation of distance to mediate interaction. Somewhat like [10], we track the proxemic dimensions of distance, location and orientation between the person and display: we use that information to let a person coarsely navigate the virtual contents of the screen by how they approach it from particular distances and perspectives, and how they then see progressively more details from those perspectives. Second, we use the Wiimote as a device to fine-tune navigation and as a device for 'painting' the data. While others have used the Wiimote for painting (e.g., [6][7][5]), we use it to let people select 3D data by 'painting' it. In essence, our approach is to simplify and enhance the 3D interaction for microseismic domain by merging different 3D interaction techniques. See the accompanying video.

Microseismic 3D and FractVis

FractVis [9] is an experimental 3D visualization system, built to support how microseismic domain experts can geometrically analyze their 3D data. We used its microseismic domain as our context to investigate 3D problems in that domain and how to improve 3D interactions within it. In particular, we identified several important tasks that involve 3D-related issues. One of these is the calculation of *stimulated reservoir volume*

(SRV), which is the volume of rock affected by the seismic stimulation [11][1]. To perform this calculation, domain experts navigate the 3D geometry of the data, where their tasks include things such as looking for and analyzing the locations of the microseismic events in relation to the well-bores in the reservoir. This includes selecting subsets of that data of particular interest, where they filter out some of these events and extract a 3D subset that will later represent the estimated oil volume.

Performing such calculations, however, requires the domain expert's ability to interact through the complex GUI of the microseismic visualization system. For example, a domain expert has to navigate the 3D space using the mouse along with many keyboard buttons and GUI combinations in order to sketch a 2D area. The sketched 2D area is then extruded with full depth, to generate a volume, in order to select subset of the data. While this approach is being used now, it is awkward and requires considerable training. Furthermore, it has many limitations regarding data selection. For instance, the experts cannot control the depth level of selected area. Our approach leverage known methods such as proxemics-based navigation to simplify interactions, ultimately to make it more natural to explore and navigate around the 3D data. Similarly, our painting metaphor attempts to ease selection of subset of the data up to a specific depth level.

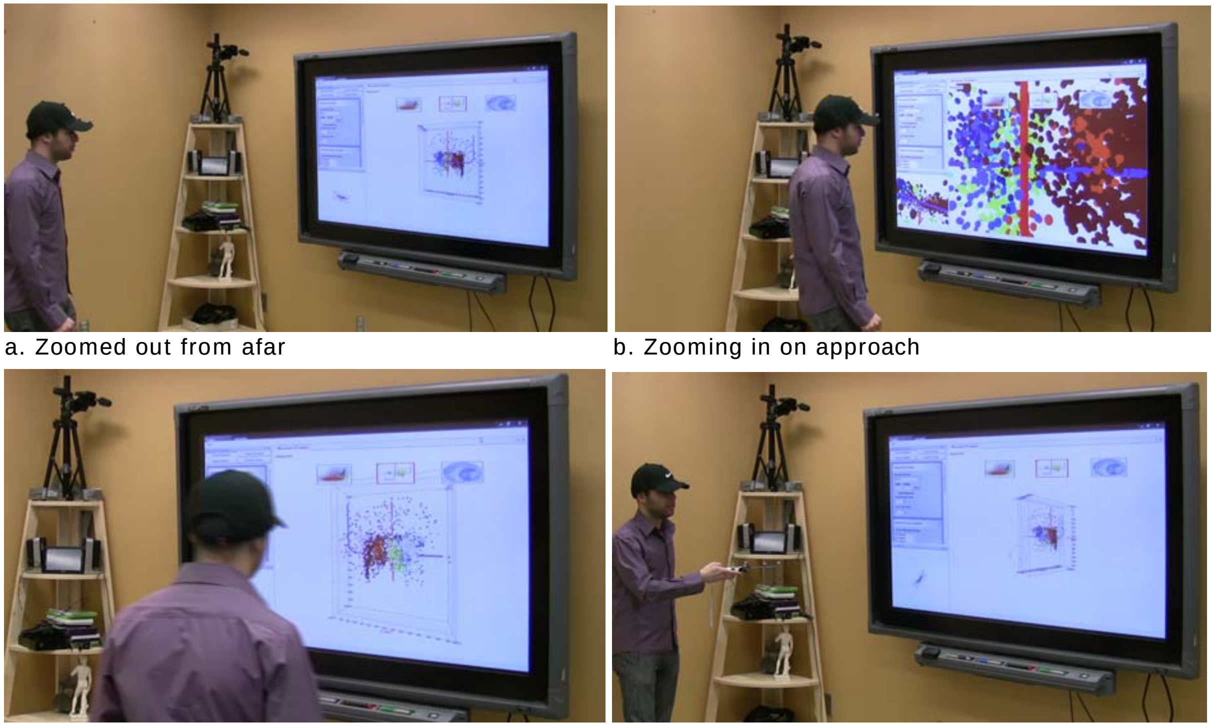
We extended FractVis [9] to showcase our new interactions as explained below. However, we believe that our approach can be generalized to other 3D visualizations that support navigation and data selection. The accompanying video illustrates our system and the primary features discussed here.

Navigation

Coarse Navigation by Proxemics. Our approach immerses the expert inside the FractVis 3D world, where the expert can navigate around the 3D data. That is, we map the 3D scene to the bounds of the room, and we transform the scene as a function of the expert's relative location and orientation to the display (i.e., their proxemic relationships with each other). The 3D visualization is continuously updated relative to the proxemic status of the expert. For instance, the proxemic distance between the expert and the vertical display is used to control the level of detail of the visualization. That means, when the user is near, the scene is zoomed-in to provide more details and when the user is far the scene is zoomed-out to provide fewer details. The orientation of the person relative to display rotates the camera of the scene to make it respond to the relative location of the expert, i.e., the camera will be rotated to be always aligned with the expert's orientation.

Figure 2 illustrates this basic navigational. In Figure 2a, the expert is approaching the data volume, where he sees it in its entirety. In Figure 2b, the expert has moves closer to the screen, and the data has smoothly zoomed in to match his approach, thus showing increasing detail. In Figure 2c, the expert moves from to the side to view the data from a different perspective; the scene transforms itself to follow this new viewing orientation.

Fine Navigation by a Device. Tracking the data with a person's body is good for course-grained navigation (e.g., for broad exploration of overview, detail, and vantage points) but not for fine-grained navigation. At any time, the expert can 'freeze' the 3D world by



a. Zoomed out from afar

b. Zooming in on approach

c. moving to change perspective

d. use the Wiimote to fine-tune the data navigation

Figure 2. 3D navigation basics

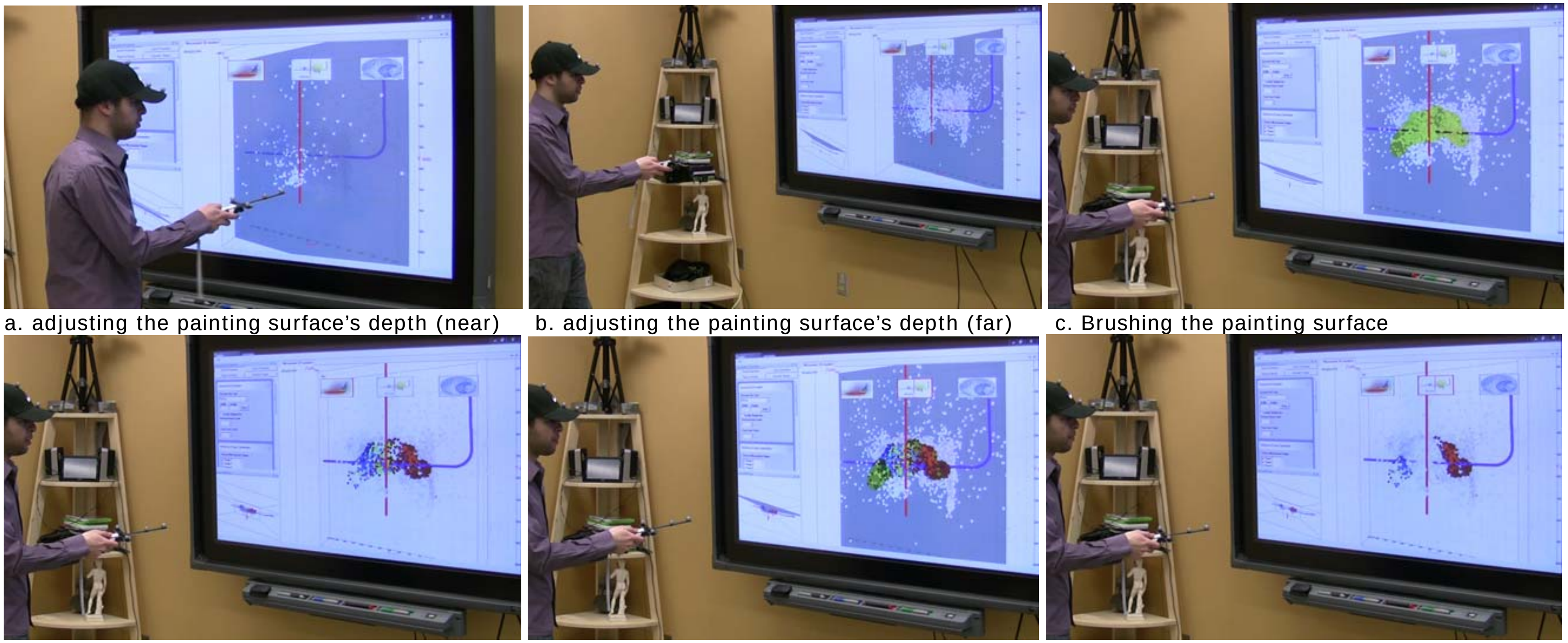
pressing a button on his hand-held spatially-tracked Wiimote. The Wiimote then acts as a 3D mouse, where (depending on the button pressed) the now-stationary expert can fine-tune their zoom level and the camera orientation of the data by moving the mouse in 3-space. For example, in Figure 2d the expert is moving Wiimote to navigate around the data and see it from different orientations while standing in a specific location. Under the covers, our motion capture system tracks the Wiimote's location and orientation relative to the display, where these other interactions (such as navigation) are then mapped to the appropriate transforms. The expert can thus continue to navigate the scene with the Wiimote. Furthermore, he can reach, access, explore and manipulate the data directly while moving his hand and pressing the appropriate Wiimote button to engage particular functions. In brief, the mental model is that the proxemics of the user's body provides coarse navigation, while the Wiimote extends one's hand to provide refined navigation as needed.

Spray Painting to Select Data

Our system also allows an expert to user to interact with the data, where he or she uses the Wiimote to point at particular data and to select it. In particular, the expert can brush the 3D data in order to select it via a spray painting metaphor.

The mental model is that the data exists inside a 3D bounding cube, where painting surface resides inside that cube at specific depth as a rectangular slice (plane). To begin, the expert navigates to the appropriate viewpoint, as described above (Figure 2). The expert then uses a different button on the Wiimote to navigate to the appropriate painting depth in the cube (Figure 3a-b). Finally, the expert selects a region of that cube by pressing a different spray painting button (Figure 3c-f), which acts upon the painting surface. Spray painting will only affect the data that exists in front of the painting surface and will ignore all data behind it.

The expert starts by adjusting the painting surface depth (Figure 3a-b). In Figure 3c, the expert has oriented himself and the painting cube, and he begins



a. adjusting the painting surface's depth (near) b. adjusting the painting surface's depth (far) c. Brushing the painting surface

d. results of painting e. modifying painted area to refine subset selection f. results of painting after refinement

Figure 3. 3D Painting to select a data subset of interest

spray painting the data to select it. Figure 3d shows the results, where the selected data is being shown in red. The expert can then continue this process to fine-tune the subset of the selected data (Figure 3e and 3f).

Discussion

Questions about user acceptance. Our system is a working proof of concept, and as such is not yet ready for a user study. Of course, we believe such a study is required to evaluate and find out more about the practicality of our approach. We expect that our new form of interactions will be resisted by experts who are trained to currently perform this task using a traditional desktop and mouse. We do not expect that our microseismic domain expert will immediately accept the need to stand and move around in order to interact with the 3D data. As usual in these cases, benefits will likely occur only after an expert has gone beyond the initial learning curve, and only when they reach a level of proficiency that pushes them past what they can do with their traditional desktop-based solutions.

Hardware. Our prototype currently uses the Vicon hardware for object tracking. While highly accurate and appropriate for prototype development, the Vicon is quite expensive and as such impractical for field deployment. We expect a more cost-effective approach for motion tracking on commodity hardware, such as Microsoft Kinect, and by leveraging other capabilities of the WiiMote, e.g. its pointing capabilities for selection.

Conclusion and Future Work

We have described our initial exploration regarding characterizing the 3D problems in the microseismic domain. Our goal was to improve interactions by domain experts when navigating and interacting with 3D microseismic data by combining proxemics and a spatially-tracked handheld pointing device (the Wiimote). In particular, we designed three interaction techniques: mapping a user's location inside the 3D world directly (proximity-based interaction), tracking a devices location relative to that world for fine-tuning the user's location (device tracking), and a painting metaphor (using the WiiMote as a pointing device).

We are continuously collaborating with the domain experts to understand their needs and processes in order to provide them with intuitive interactive visualization. While considering this work as an ongoing project, there are many improvements to follow.

Acknowledgements. ConocoPhillips provided the microseismic data set. Research supported by NSERC / AITF / Foundation CMG Industrial Research Chair Program in Scalable Reservoir Visualization, and the AITF / NSERC / SMART Industrial Research Chair in Interactive Technologies.

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