Interacting with Microseismic Visualizations

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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 (VR) is one such technique [3]. In one form of VR, people manipulating avatars of themselves, where the avatars simulate one's physical presence within a completely virtual and synthetic environment. Other VRs use projective technologies such as Caves to surround and immerse a person within the 3d space. 3D data is seen either on large multiple displays or Stereo glasses, directional sound, and input devices such as data gloves can enrich the 3D experience even further.

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 (Vicon). 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.

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.

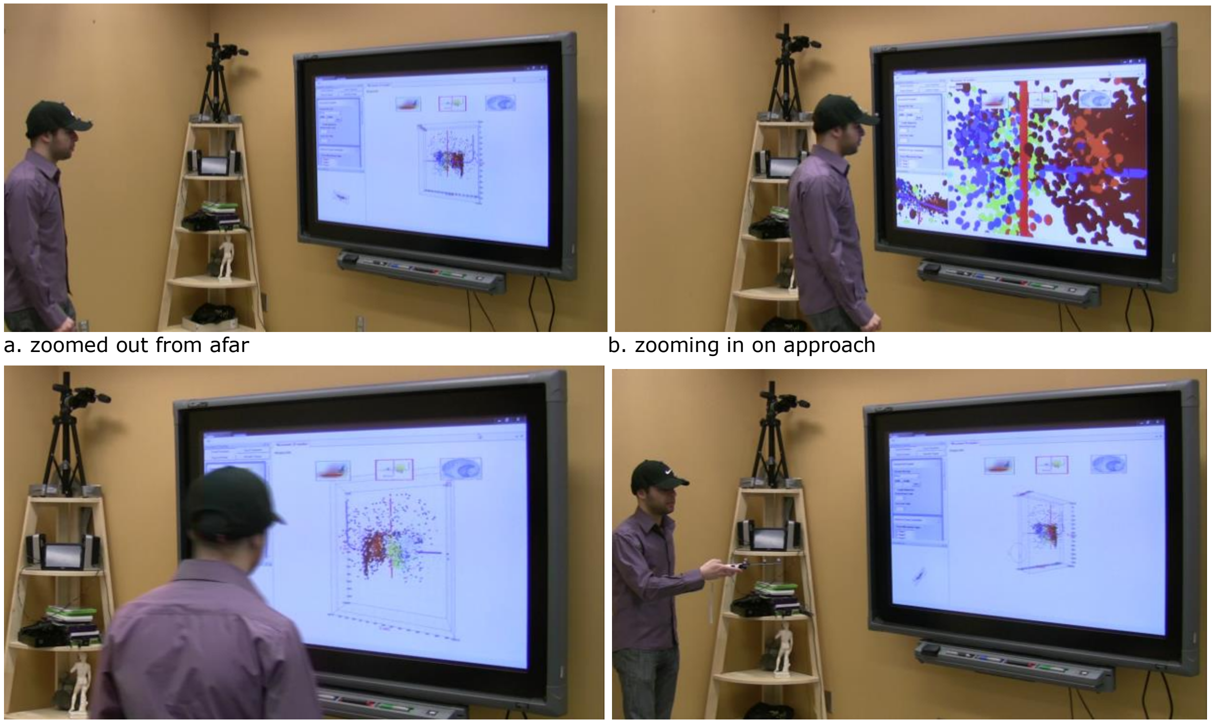
Performing such calculations, however, requires the domain expert's ability to interact through the complex GUI of the microseismic visualization system. For example, a domain expert has to navigate the 3D space using the mouse along with many keyboard buttons and GUI combinations in order to sketch 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.

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 proxemics, i.e., the expert's *distance, location* and *orientation* relative to the display. The 3D visualization is continuously updated relative to its proxemics relation to the expert. For instance, the *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 camera responds to the *location* and *orientation* of the person relative to display by rotating the scene so that its 3D content always align with the expert's view of it.

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 moved 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



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

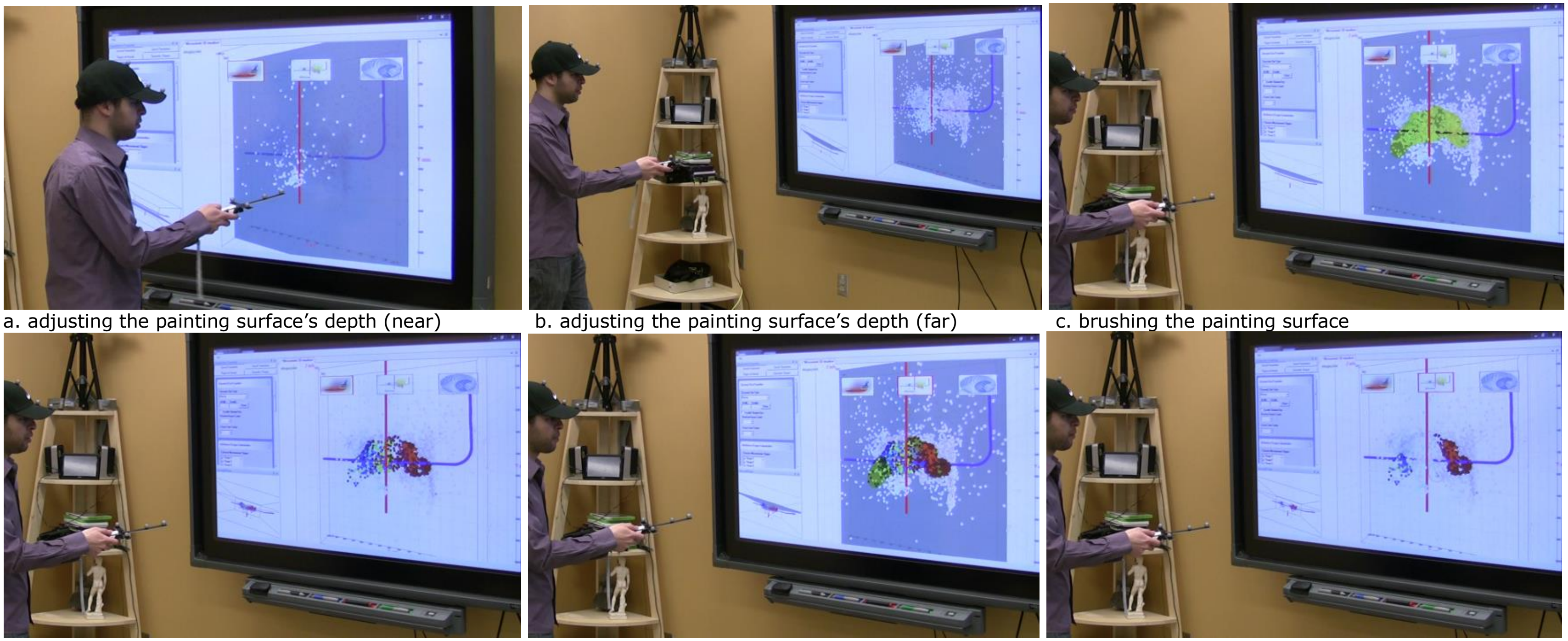
perspective; the scene transforms itself to follow this new viewing orientation.

Fine Navigation by a Device. Tracking the data with a person's body is good for coarse-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 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. The expert can thus continue to navigate the scene with the Wiimote. 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 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 desired painting depth, by progressively moving through slices within the cube (Figure 3a-b). In Figure 3c, the expert has oriented himself within the cube, and he begins spray painting (using a different button) to select the desired data. 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).



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

Although spray painting is happening over the fixed 2D slice, we use a projection technique to affect the data that exists in front of the painting surface and ignore all data behind it.

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. Clearly, some form of participatory design will be required, both to elicit the design nuances that domain experts would like, and to develop champions within the community.

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. This remains to be implemented and tested.

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.

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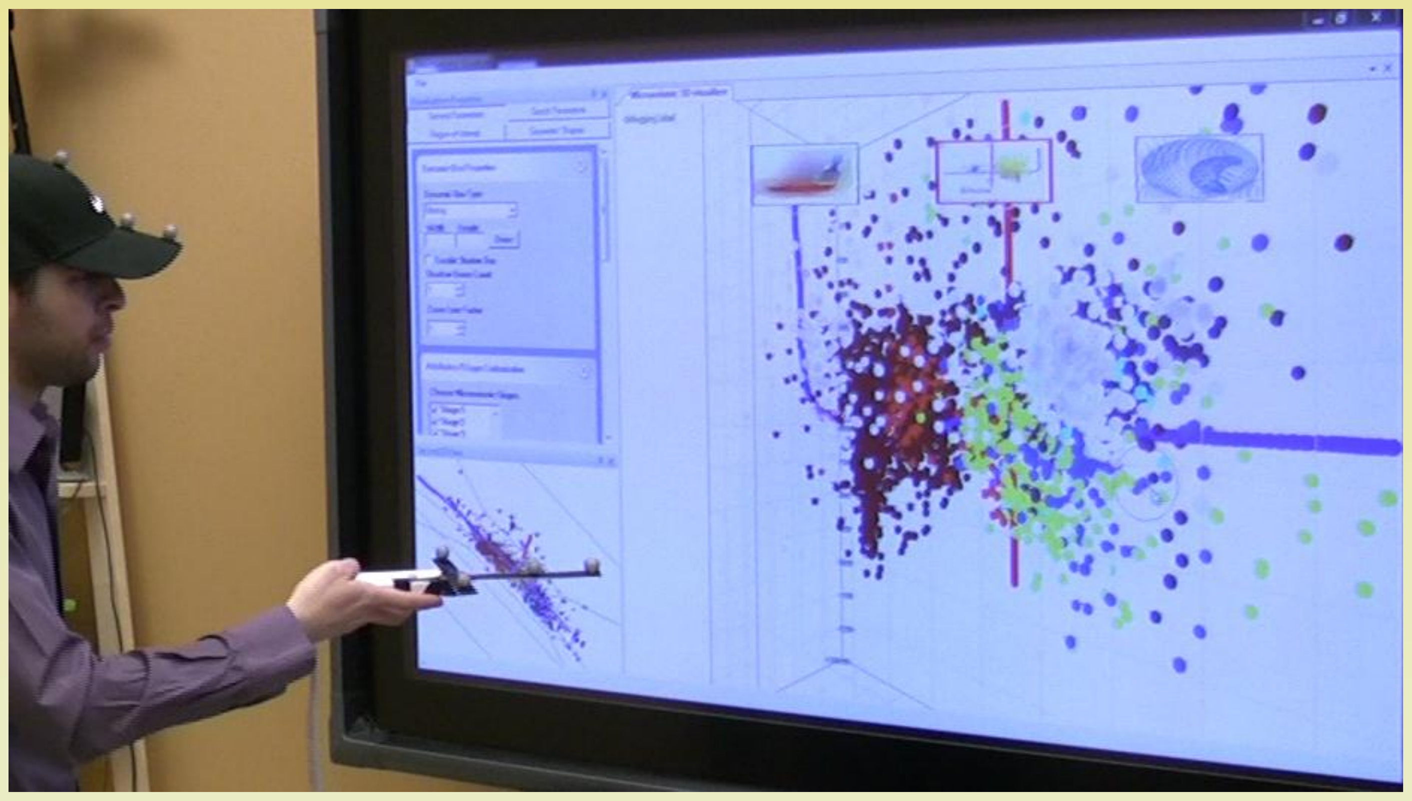
Overview

Problems in microseismic visualizations

- 3D spatial navigation and orientation
- 3D data selection
- Solving these problems:
  - proxemic interactions to simplify navigation
  - a painting metaphor to simplify data selection

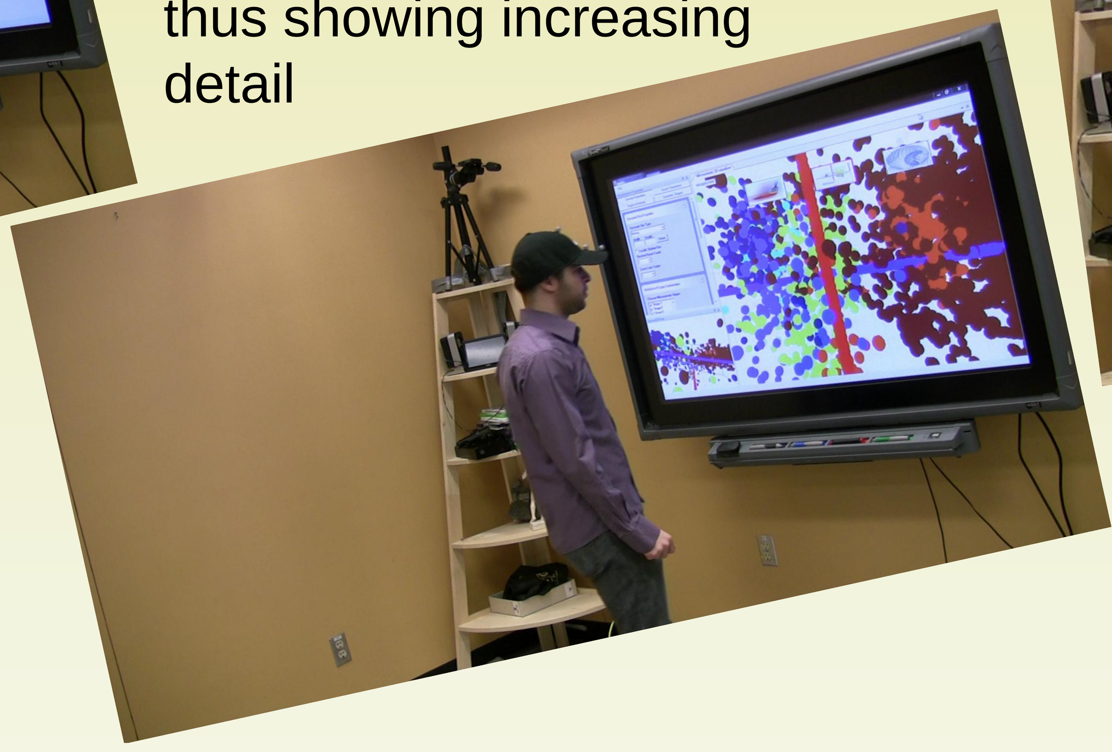


Proxemic Navigation

The 3D visualization is continuously updated relative to the proxemic status of the user

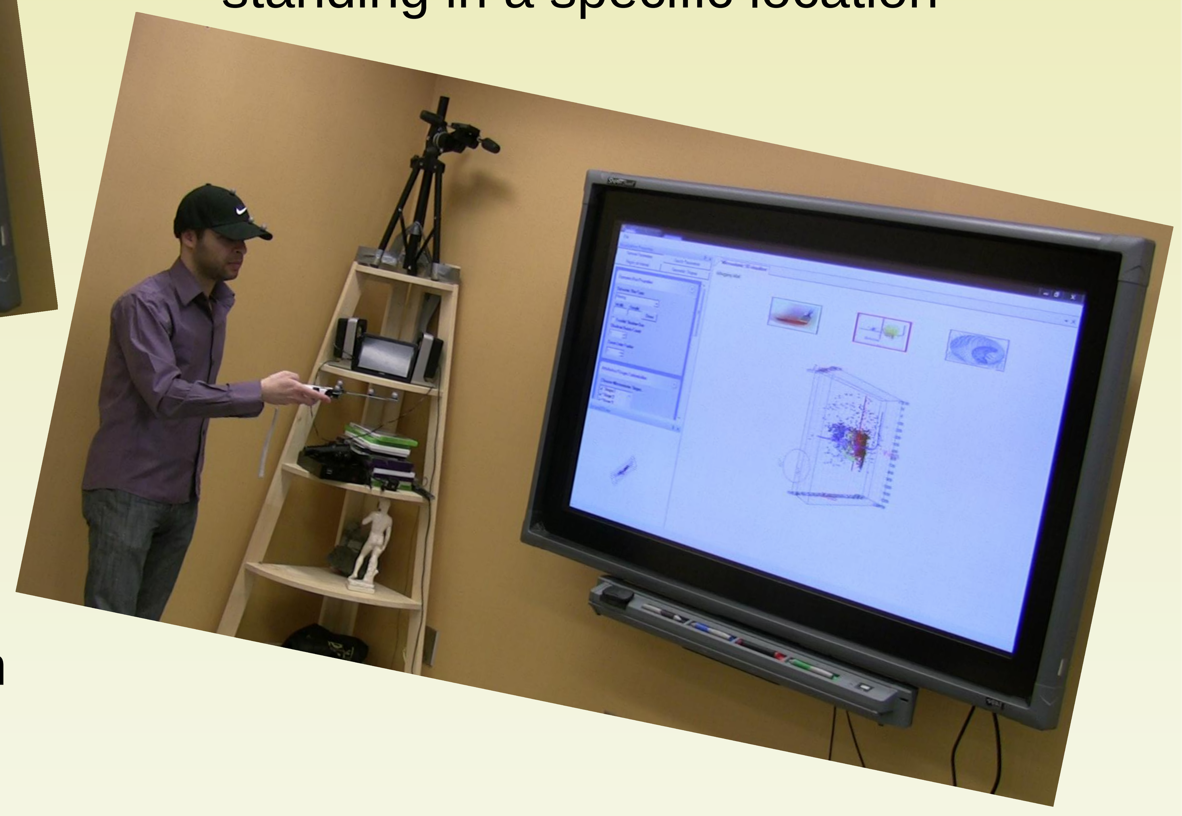
Approaching the display to overview the 3D data and see it in its entirety

Moving closer; the data has smoothly zoomed in relatively, thus showing increasing detail



Moving to the side to view the data from a different perspective; the scene transforms itself to follow this new viewing orientation

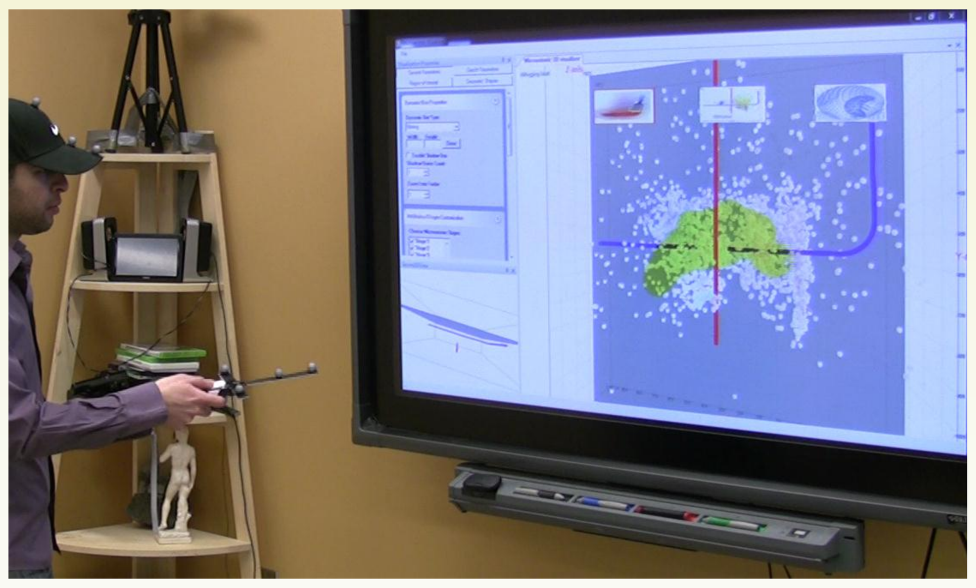
Moving WiiMote (as a 3D mouse) to navigate around the data and see it from different orientations while standing in a specific location



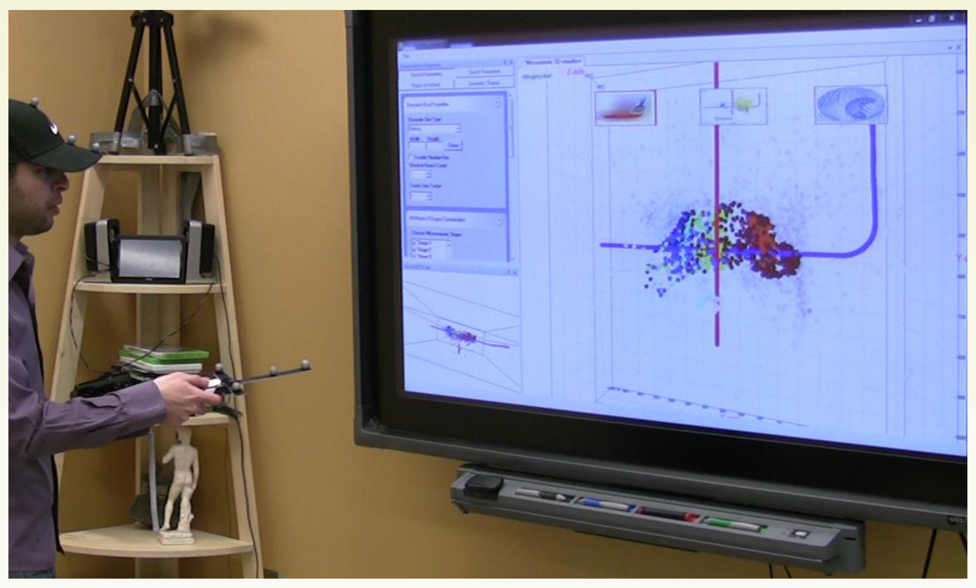
Painting Metaphor

The user can brush the 3D data in order to select it via a spray painting metaphor

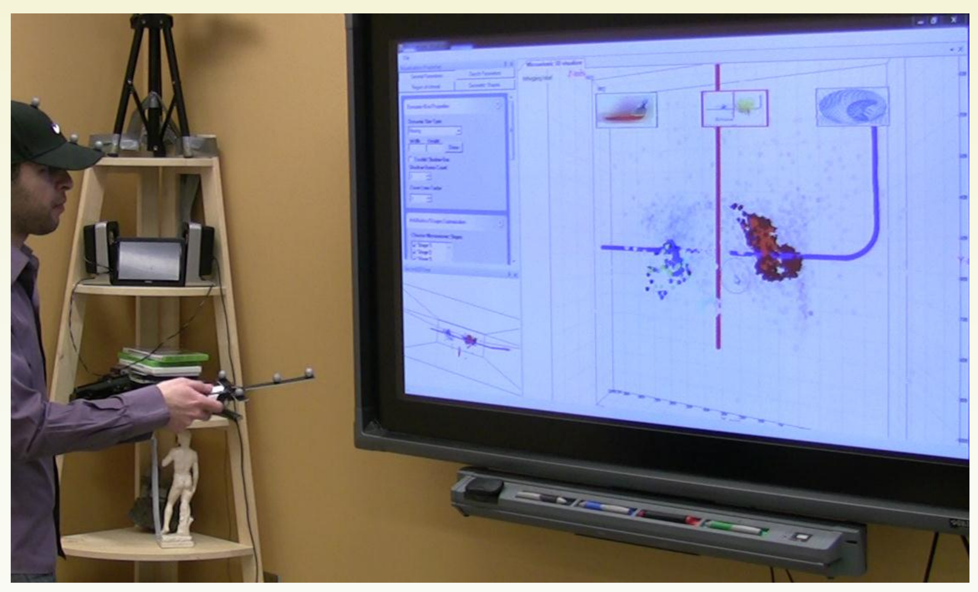
Spray painting to select the data, after moving to appropriate viewpoint



The results of the painting showing the selected data in different color



Modifying the painting to fine-tune the subset of the selected data



Conclusions & Future Work

- Characterizing and exploring 3D problems in the microseismic domain.
- Designing three interaction techniques:
  - mapping a user's location inside the 3D world (proximity-based interaction)
  - tracking a device's location relative to the world for fine-tuning the user's location
  - a painting metaphor (using the Wiimote as a pointing device) to select 3D data.
- User study evaluating our current prototype.
- Kinect-based implementation as more practical commodity device for tracking.

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