SeismoSpin: A Physical Instrument for Digital Data

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ABSTRACT
SeismoSpin is a novel interactive instrument designed around a "Disc-Jockey/mixer" metaphor that gives seismologists a quick and powerful way to explore earthquake data. The custom-built interface and display maps earthquake data to responsive, user-selected windows of time and space. Seismologists who tested SeismoSpin found that the interface provided a greater level of control and dataset understanding than their current tools.

Keywords
Tangible media, information visualization, data mining, data analysis, interactive visualization, interaction design.

INTRODUCTION
Consider the way a music disc jockey (DJ) uses a mixer's sliders and turntable controls to move through a music collection, sampling and matching selected pieces. In SeismoSpin, we explored how this interaction metaphor could be applied to seismology. With SeismoSpin, the seismologist becomes a DJ – moving through earthquake data, identifying patterns over time, and piecing together the rhythms of the earth. Just as the ease of playing records allows the DJ to concentrate on the aesthetic value of the music instead of the mechanisms of pushing keys or playing strings, the physical affordances of SeismoSpin allow a seismologist to "play" the seismological data.

Prior work in this area includes a number of software solutions for visualizing earthquake data. For example, Seismic/Eruption and Seismic Waves [1] visualize earthquakes and volcanic activity, show seismic activity under the earth in three-dimensional and cross-sectional views, and illustrate how waves propagate from an earthquake's hypocenter to seismic stations around the world. Several other online seismological tools are listed by Hall-Wallace [2]; these use standard GUI techniques and target educational users seeking information about individual events.

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DESIGN
The design goal of SeismoSpin is to facilitate the discovery of temporal and spatial patterns in a catalog of seismic events by enabling real-time physical interaction with the data. Seismic patterns relate to both location and time, and have different qualities over varying time scales. On a large time scale (e.g. decades), earthquakes align in patterns along fault lines. On a short time scale (e.g. minutes), more detailed patterns appear in the distribution of before-shocks and after-shocks near a major earthquake.

The SeismoSpin system consists of a PC running our specialized visualization software, a custom-built control box, and a rear-projected display screen.

Physical Interface Design
Since we envisioned SeismoSpin as an expert's tool for exploration and discussion of the data, it made sense to provide a large display so that multiple users could interact with and discuss the data together. Thus, for visual output, we chose to construct a 4-foot-by-3-foot projection screen, and positioned it at a height such that the entire screen is within arm's reach of a standing person. For user input, we designed a specialized control box, shown in Figure 1.

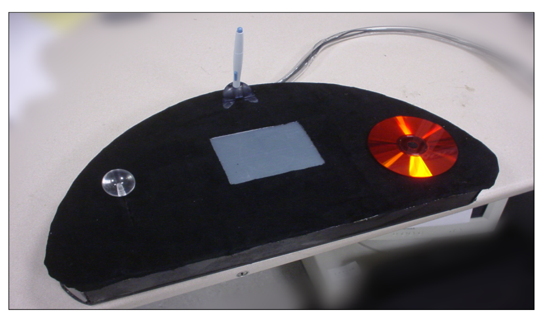

Figure 1. Control box (from left): slider, tablet, and disc.

The control box integrates three controls: a slider, a graphics tablet, and a free-spinning disc. At all times, the display shows data points within a selected time interval; the slider and disc navigate in time by manipulating this interval. The *slider* is moved up and down to set the size of the time interval, which corresponds exponentially to the position of the slider. The interval expands to about 10 years when the slider is at the top and contracts to about 30 seconds when it is at the bottom. The *disc* is spun with the fingers to move the time interval forward and backward through time. It offers a very wide dynamic range, as the user can nudge the disc gently or flick it quickly, and can vary the rate of control by touching the disc near its center or at its edge. The disc is weighted so that it tends to continue spinning at a constant rate, and carries enough momentum that the user can feel how fast it is moving. The user can start the disc moving and let it spin to get a continuous playback of events at any desired rate, or choose a short time interval and move second by second with fine precision. The *graphics tablet and stylus* let the user specify spatial selections and draw cross-section lines.

Software Visualization Design

The software application downloads data from the Northern California Earthquake Catalog [3] and plots it on a map. The catalog gives the locations, dates, times, magnitudes, and depths of about 361,000 events with magnitude one or greater from 1967 to the present.

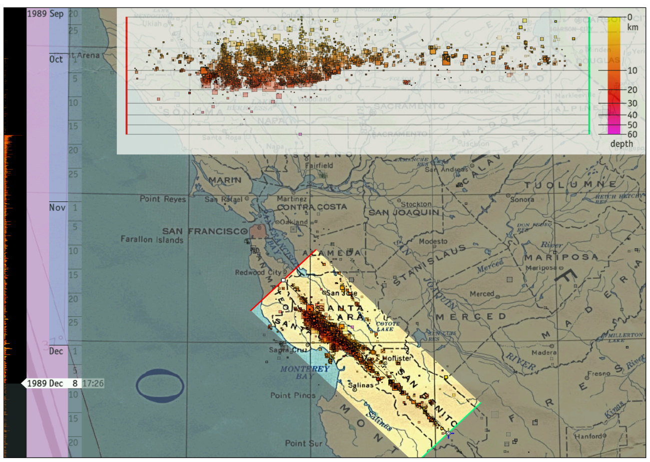

Figure 2. The main display, showing the bar chart and time ruler along the left, and a cross-section selection on the map with the corresponding depth plot at the top.

Map Plot. Events are plotted as squares on the map, where the size of the square represents the magnitude and the color of the square represents the depth of the hypocenter.

Time Ruler. Along the left edge of the screen, a semi-transparent time ruler indicates the selected time interval. The ruler is composed of six columns (year, month, day, hour, minute, second) that fade in and out to provide a level of detail appropriate to the current interval size.

Bar Chart. At the far left next to the time ruler is a bar chart that reveals temporal seismic patterns. Events are plotted as horizontal bars, with length representing magnitude and color representing depth.

Selection. Drawing a loop around a geographical region with the graphics tablet selects and focuses on the region. When a selection is active, the bar chart shows only events in the selection. Thus, the slider and disc help the user find spatial patterns over selected intervals of time, while the stylus and bar chart help the user find temporal patterns over selected regions of space.

Cross-Section Plot. Seismologists study cross-section plots to see how the hypocenters of earthquake events align on planes in the earth's crust. With SeismoSpin, the user can specify a cross section by drawing a line on the graphics tablet. This selects a rectangle of events within a constant distance of the line and brings up a semitransparent depth plot overlaid onto the map. The depth plot, main map, bar chart, and time ruler are all kept synchronized with the selected time as the slider and disc are manipulated.

USER TESTING AND DESIGN ITERATION

We conducted a small, informal user study, inviting two members of the Berkeley Seismology Lab to try out our instrument. They were given a brief introduction, and then used the instrument for about 45 minutes. This led to in-depth design discussions yielding recommendations that we applied to subsequent iterations of our instrument.

Observations. During the test session, the seismologists had no trouble understanding and using the instrument. They spontaneously started using it to talk about the data with each other. Though they were already very familiar with earthquake data, the instrument gave them some new insights: "Oh, I didn't realize that these events were so close in time."

Feedback. The seismologists were very positive about SeismoSpin, describing it as an excellent communication tool for public and educational uses as well as for experts. The seismologists noted that SeismoSpin differed from many other tools, including those they currently use to visualize seismic activities, by adding levels of physical control that were more engaging and interactive. They suggested the region-selection and cross-sectioning features, which we added in our latest design iteration.

CONCLUSION

SeismoSpin provides intuitive hands-on control crucial to allowing the user to identify patterns quickly. The instrument enables fluid and intuitive movement through time, allowing the user to concentrate on the data patterns and not the mechanics of interaction. We believe the metaphor of a DJ mixer yields a new dimension of exploration for earthquake data, and plan to explore it further.

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