Datascape: A mobile exploration of georeferenced data

Eric Kabisch
Arts, Computation and Engineering
University of California, Irvine
Irvine, CA 92697-2775
ekabisch@uci.edu

ABSTRACT
We describe a location-aware system for the visual and auditory representation of georeferenced datasets. The portable system is designed to be deployed in vehicles but also can be used for stationary simulations. The system is composed of four major elements: a geodatabase, a data visualization engine, a sonification engine, and a periscope-like display/sensing/interface device. As users travel through space, they are presented with a moveable window into the surrounding data world. Terrain visualization provides grounding in the physical world, while other non-physical data are experienced as an overlaid environment of sonic and visual structures.

Keywords
Mobile music, sonic cartography, 3D GIS, locative installation, information visualization, data sonification.

1. INTRODUCTION
As locative, pervasive and ubiquitous computing technologies weave their way into our world it is useful to consider the resulting fabric of our enhanced surroundings. In discussions concerning ubiquitous computing many have aspired toward the "invisibility" of computing technologies [11][9]. This notion of the disappearing interface implies an increased level of technological mediation between people and their surroundings, even suggesting that computation will become "indistinguishable" from the world it augments. As our interactions with technology become more mediated and less conscious, so too does our relationship with the underlying assumptions and data which make up these technological systems [1][3][5].

Geospatial information and technologies are key components for location- and context-awareness in ubiquitous computing systems. Criticism has been levied at the methodologies and assumptions behind geographic information systems in their perception as value-neutral and in their binary and positivistic approach to defining the world [3][10]. Additionally, there are often vested interests held by institutions that produce spatial information and representations. As computational systems become invisible, so to do the methodologies and sources of data which enable the mediation between people and the world. Under these circumstances it might be easy to find ourselves in Heidegger's "Age of the World Picture" [5], where our representations are not seen as a picture of the world, but "the world (is) conceived and grasped as a picture".

This project takes a different approach to ubiquitous and mobile computing, with a fundamental goal being to make *visible* the hidden data tied to spatial locations. On one level we depart from the notion of invisibility employing ideas for a more tangible [6] and embodied [4] approach to user interface design. And on a deeper level we explore the basis of geospatial systems, by making apparent the sources of underlying data.

The first instantiation of this system will be a mobile art installation that explores the above concerns. Here we describe the system being developed, which will also enable applications such as spatial annotation, located spatial analysis and mobile GIS, and pervasive gaming.

2. DESIGN
Datascape is a mobile installation that engulfs riders in a projection of the surrounding data space. Screens inside the vehicle act as windows into a virtual world rendered from the surrounding topographical data. A periscope-like device is the command center, through which a rider scans and zooms their view into the world, enacting sounds and pinpointing areas to access for more in depth data representations.

Figure 1 shows a top view of the vehicle installation and a detail of the periscope (see Figure 1). Flat-screen displays cover the side windows and seatback displays mount onto the front seats. The periscope control panel hangs from the ceiling in the center. The pod is also equipped with a six-channel sound system.

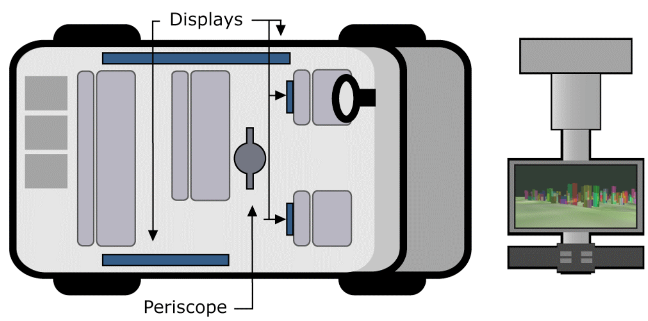

Figure 1. Vehicle installation; detail of input/display.

We've compiled a database of spatially referenced data including topography, demographic marketing segmentation, biodiversity, political affiliation, income, and others. The topography, roads, and other physical data are rendered into an immersive 3D visual environment that is projected onto the window displays. This projection is updated based upon current location and orientation of the vehicle. Overlaid on top of the topography are geometric objects, particle systems and other visualizations of non-topographical data correlated to their proper position in space. A rider can use the periscope to pan their view around the scene. In addition, the periscope acts as an input device, enacting that zoomed-in location's invisible data into sound and visualization. Additional controls (buttons, dials and on-screen menus) allow the user to select which subsets of data are being revealed (demographic, ecological, etc.).

3. RELATED WORK

There are a large number of projects exploring mobile geographies. Many seek to record movement paths and trajectories in the construction of their design or narrative, such as *The Choreography of Everyday Movement* (Teri Reub) and *The Other Path* (C5). Others allow users to annotate physical space with text or media such as *GPSter* (Locative Media Lab). While datascape does do some annotation, its primary concern is revealing existing datasets to its users.

There are also works that use movement through space as a way to explore content or works of art that have been explicitly authored. Such works include *Location 33* and *Audiomobile*. This work has similar goals to ours, however we are developing the system to employ existing datasets such that it does not require explicit authorship in each location for deployment.

Google Earth enables a similar interaction with spatial data inside a virtual 3D world. We focus on a more abstract visualization of data, especially datasets that do not have a physical instantiation in the real world. Additionally, the game engine driving our system allows for more extensibility such as the ability to add physics, artificially intelligent characters, etc.

The notion of a moveable window into the world has been explored in projects such as *Augurscope*, *Vis-à-vis Games*, and *Ambient Wood*. Other projects that have a similar vision to Datascape are *Sonic City* and *Citywide* (Equator). Also relevant is previous work by this author [7][8] concerning interactive sonic interpretation of space and landscape.

4. IMPLEMENTATION

The system is being developed in two stages. The first stage is the construction of the input/display device, development of the graphics platform, and implementation of the sound engine. The result of the first stage is a fully functional stationary installation that allows for simulation of the mobile experience. Stage two of development will be the installation of the system into a vehicle.

4.1 Data Compilation and Preparation

The system is being developed as an open infrastructure, allowing for a simplified integration of standard spatial data types. Here we describe some of the data that are being used for the current instantiation, however we emphasize that new data can and will be added. All described data has been obtained free of cost.

The terrain for our visualization is derived from digital elevation models (DEM) made available by the US Geological Survey (USGS) through the California Spatial Information Library (CaSIL) [2]. The required DEMs are stitched together and rendered as grayscale heightmaps to be used within our visualization system.

We are using US Census Bureau information to present social and demographic information. These datasets link various statistical, tabular data to Tiger shapefiles that represent population subgroups on the block, block group, tract, and county level. We supplement the Census Bureau data with other geodemographic marketing datasets, which utilize census data in addition to other privately held marketing information including purchasing and entertainment habits. These datasets are an important indicator of how marketing forces generalize certain behaviors and preferences onto aggregate geographic groups and segment people by their geographic location.

In addition to relatively static data, we are visualizing real-time dynamic data sets. We are accessing the California Department of Transportation (Caltrans) live XML traffic feed which provides access to real-time speed sensor data on major arteries, highways and interstates. The USGS provides RSS and XML feeds of up-to-date seismic activity that we are accessing to visualize recent earthquake activity. Other real-time data sources are also being pursued.

4.2 Visualization Engine

Our source data is used to create a 3-dimensional interactive representation of the user's real world surroundings. We are utilizing and extending an open source graphics engine, jMonkey Engine (jME), as the platform for our visualizations. This engine was selected for its open and extensible code base, active and supportive development community, and built-in terrain paging functionality.

The 3D terrain of our virtual world is rendered using grayscale heightmaps derived from the USGS DEMs. We drape the Landsat and DOQQ imagery on top of the terrain and superimpose road data from the TIGER shapefiles. The resulting visualization is a 3D model of the physical world void of manmade structures such as buildings, bridges, etc (see Figure 2). This gives the user a grounded representation of the physical world while leaving an open canvas for us to superimpose objects that represent non-physical data tied to the space being traversed.

Other datasets are represented more subjectively as they do not directly correspond to physical structures. We are experimenting with many ways of visualizing the data sets, and are implementing them such that they can be either customized or applied more generally to different data sources. Datasets with polygonal footprints can be extruded up from the ground, creating a skyline of data structures whose attributes are mapped to parameters such as height, color, transparency, shape and texture mapping. Procedurally generated 3D models represent point data sources, while their geometry is affected by the point attributes. Line data can be shown as 2D paths mapped to surfaces or as 3D paths through space, using shapes from simple pipe geometry to particle systems that follow the contours of the paths. Overlays and aggregate data layers can also be reflected in the form of shapes or weather patterns like mist or clouds.

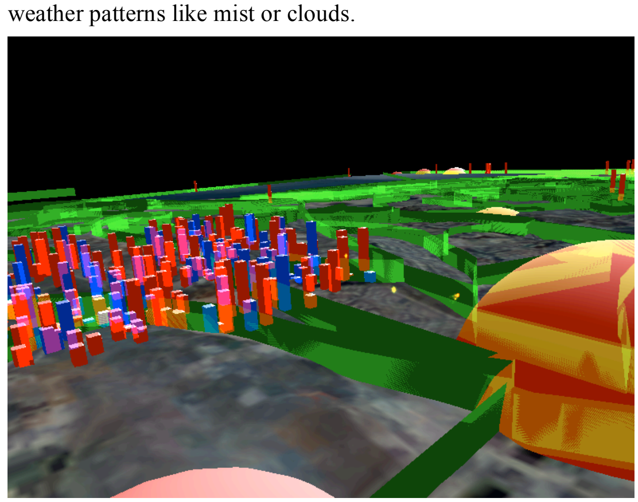

Figure 3. Experimental rendering of overlays

4.3 Sonification Engine

A musical soundtrack accompanies the users' ride through the datascape. The visualization program transfers world coordinates and other interaction data to a Max/MSP program via Open Sound Control (OSC). Based on the vehicle position and user interaction, local data is mined and mapped to various parameters of the soundtrack.

There is a continuously evolving soundtrack accompanying the ride. This "groove" is made up of drumbeats, percussion, bass, and various other instruments that form an underlying accompaniment. The types and combinations of instruments, as well as parameters affecting rhythm, are based on aggregate geodata from the spatial area around the user's current position. Our algorithmic composition technique generates rhythm, harmony and timbre from a large number of "style" parameters that we have created based on analysis of various musical styles. This allows the mapping of specific real-world datasets to stylistic control over the soundtrack.

As the user pans the periscope around the screen, they will be interacting with the data object visualizations and accessing further information on the objects. As they view and select these objects, additional layers of sound are added to the composition. These sounds are generated by the scanning of the objects' underlying data using methods from our previous work [3]. While these "selection" sounds are autonomously generated by their own data, many of their parameters also conform to a larger set of rules defined by the current stylistic groove generator as described above. This allows the overlaid sound to fit well with the accompaniment.

Sampled or generated sounds can be linked to a specific type of data or location in space. These "triggered" will be enacted a single instance when the user passes a certain threshold or comes within a given distance of the object. These sounds can also be tied into the rhythmic or stylistic parameters of the groove or they can be more abstract and ambient.

Continuous "located" sounds can also be linked to specific locations or data. These sounds will be placed into the user's 3D world and their proximity determines volume and spatialization.

4.4 User Position

As the vehicle travels, its physical location is correlated to a position in the virtual world and the displays project visuals and sound referenced to that position. The vehicle will utilize a GPS and dead reckoning system to provide location information. A digital compass determines the orientation of the vehicle to control the view frustum into the virtual world.

In the simulation stages we are using a browser-based 2D map interface to control the driving path of the vehicle. The user can enter a street address, or browse to a specific location on the map, setting a destination for the vehicle. Street routing directions are obtained from the vehicle's current position to the destination and the vehicle will drive to that location at an adjustable speed. The map interface continually refreshes to display the vehicle's updated position on the 2D map. The map gives the user context of the larger geographic area they are traversing.

4.5 Input and Display Device

The periscope input and display device (refer to Figure 1) is built from a hacked motorcycle game controller, a rotary encoder, lightweight plastics and metals, a portable 10-inch LCD display and a small computer. The device is mounted to the ceiling with the computer, sensing and power supplies mounted in a small box. A cylindrical shaft extends down out of the box, with handlebar-shaped controllers at the bottom and the LCD display mounted onto the shaft. As the user rotates the handlebars and display on the shaft, their view frustum into the virtual world is shifted to correspond to the physical rotation of the display.

In addition to rotational control, the user can change the height of the periscope view (to gain an elevated view of the surroundings), interact with menu options, and select items in the world for further visual/textual information and sound.

5. CONCLUSION

We have described the development of a system for the visualization and sonification of georeferenced data. The system is undergoing an iterative design process with informal user testing informing design revisions. User testing has already inspired several design modifications including the ability to select an elevated viewpoint and the exploration of occlusion and culling techniques for better spatial awareness and context. While we describe here a specific vehicle-based art installation, we are also designing with extensibility in mind. Future and potential uses for the system include other artworks, located spatial analysis and mobile GIS, and pervasive gaming among others.

6. ACKNOWLEDGEMENTS

Much gratitude to Elizabeth Chattin, Christopher Dobrian, Paul Dourish, Falko Kuester, Robert Nideffer, Simon Penny and Bill Tomlinson for their help and support in realizing this project.

7. CITATIONS

[1] Araya, A.A. Questioning Ubiquitous Computing. *Proc. ACM Conference on Computer Science*, ACM Press (1995).

[2] CaSIL. http://gis.ca.gov/

[3] Curry, M.R. *Digital Places: Living with Geographic Information Technologies*: Routledge (1998).

[4] Dourish, P. *Where the Action is: The Foundations of Embodied Interaction*: MIT Press (2001).

[5] Heidegger, M. The Age of the World Picture. *The Question Concerning Technology and Other Essays*, Harper & Row Publishers, New York, 1977 (1938).

[6] Ishii, H. and Ulmer, B. Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms. *Proc. CHI 1997*, ACM Press (1997).

[7] Kabisch, E., Williams, A. and Dourish, P. Symbolic Objects in a Networked Gestural Sound Interface. *Ext. Abstracts CHI 2005,* ACM Press (2005).

[8] Kabisch, E., Kuester, F. and Penny, S. Sonic Panoramas: Experiments with Interactive Landscape Image Sonification. *Proc. Int. Conference on Artificial Reality and Telexistence,* ACM Press (2005).

[9] Norman, D. *The Invisible Computer*: MIT Press (1999).

[10] Pickles, J. *Ground Truth: The Social Implications of Geographic Information Systems*: Guilford Press (1994).

[11] Weiser, M. A computer for the 21st Century. *Scientific American* (265), pp. 94-104 (1991).