Map Sonification for Accessibility

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Introduction

Students commonly learn spatial reasoning skills by studying maps. For students who are blind or have a visual impairment, however, tools to learn these skills are limited. The Minimal Geographic Information System (mGIS) interface enhances accessibility by providing an audio interface to GIS software with new techniques for data sonification.

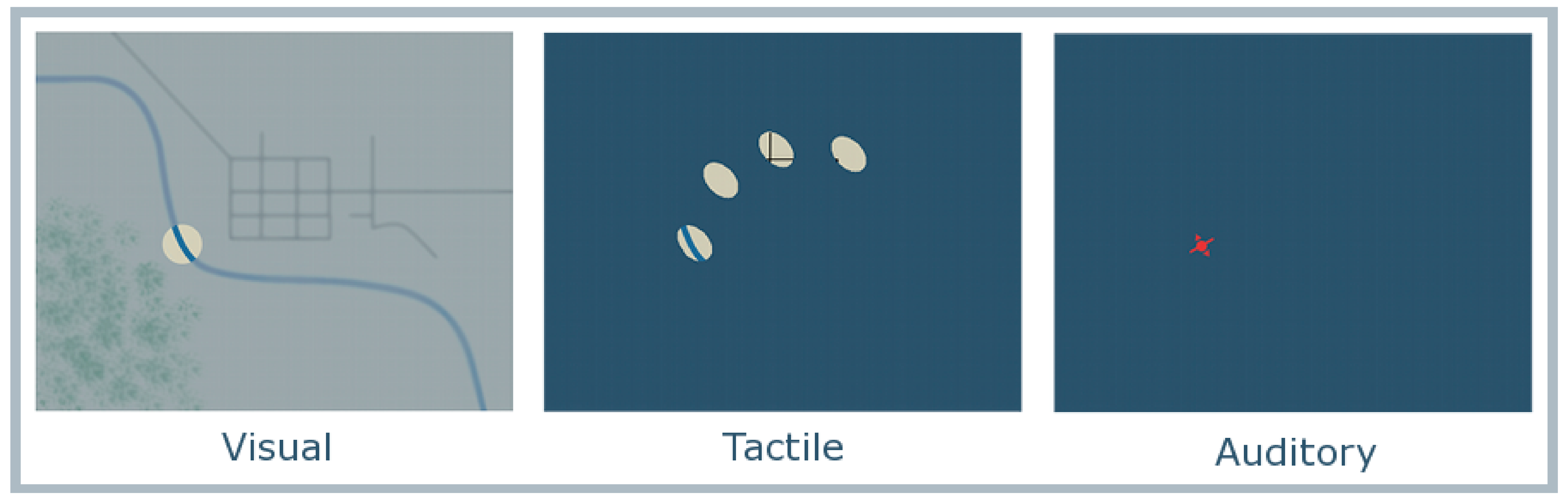

Figure 1: Three modes of human perception

This project identifies the aspects of visual and tactile perception that facilitate map use and explores ways to convey details of the map through sound. The diverse human perceptual systems provide varying types and amounts of information (Figure 1). Vision uses combined foveal and parafoveal vision to perceive a broad two dimensional space. Tactile maps with raised lines and symbols are one alternative to visual displays, but perception is limited to the area under the fingertips and flexibility is limited by the static medium on which the maps are printed. Simple sonification communicates information about only a single point, but a more complex sound can convey both position and attributes.

Interface

The mGIS interface was built using the ArcGIS Java Developer Kit and the JAWS (Job access with speech; Freedom Scientific) screen reader. A touch screen monitor accepts input from the user and provides a large area for map exploration. Two corner menus provide access to the file control options and audio output functions with the assistance of JAWS. All menu options are also bound to keyboard shortcuts for efficient access.

The current tools include:

Explore with Sound

Automated audio feedback in response to cursor motion

Where I Am

On demand text-to-speech for object identification

Overview

Text-to-speech script that provides an overview of the full screen.

Three levels of attribute data (Figure 2) were mapped to audio parameters. Real time synthesized audio or natural sound output is produced based on finger position.

Figure 2: Population density in Arizona counties

Methods

Line features are buffered, or given width, so that they can be represented in the display. A two-dimensional shape, orthogonal to the plane of the map describes the audio feedback (Figure 3). A line drawn through the cursor position and perpendicular to the line feature becomes the horizontal axis of the sound shape. The parameter under consideration (e.g. frequency) is then plotted on the vertical axis (Figure 4). These shapes describe the parameters of complex sounds that convey layered information.

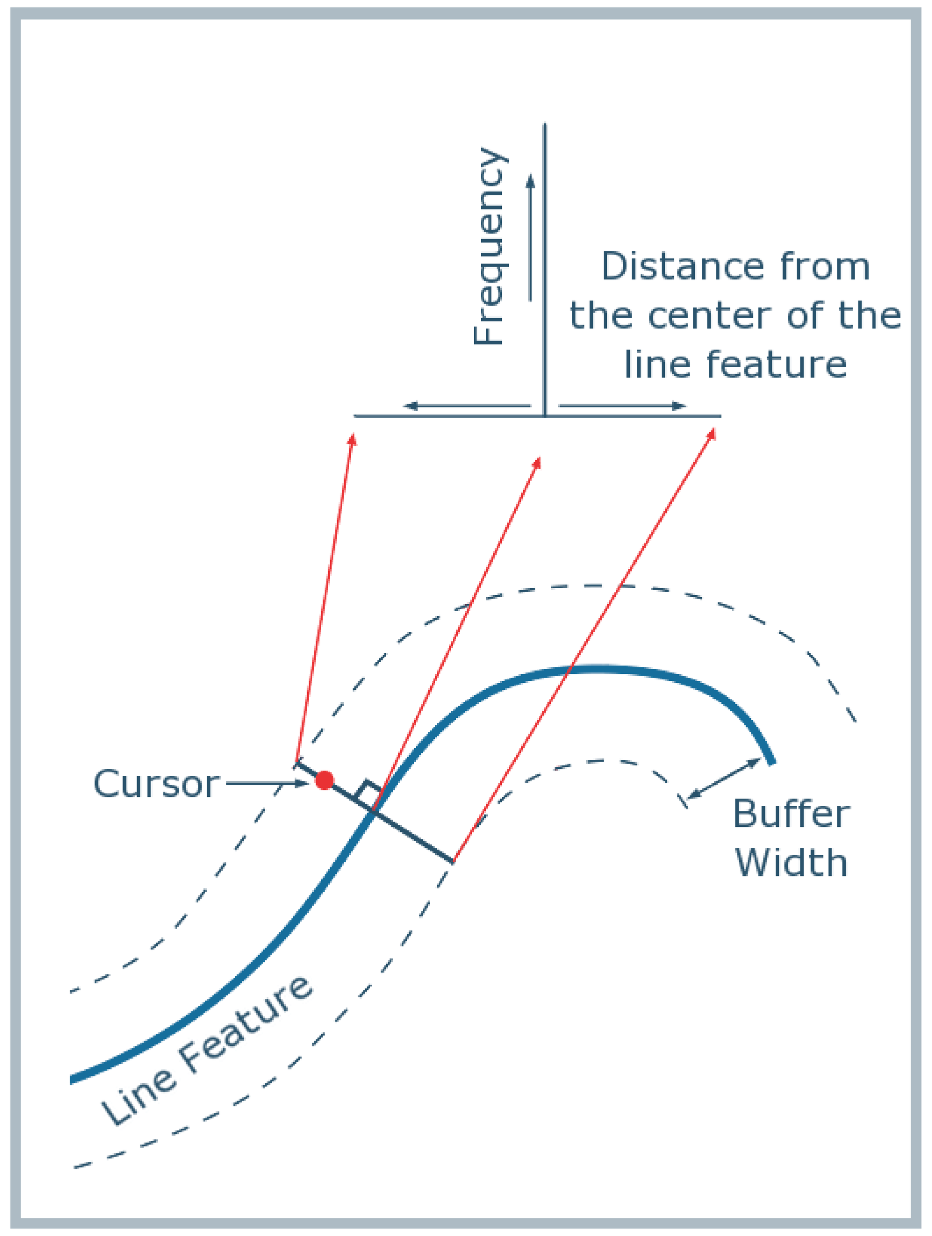

Figure 3: Definition of sound shape

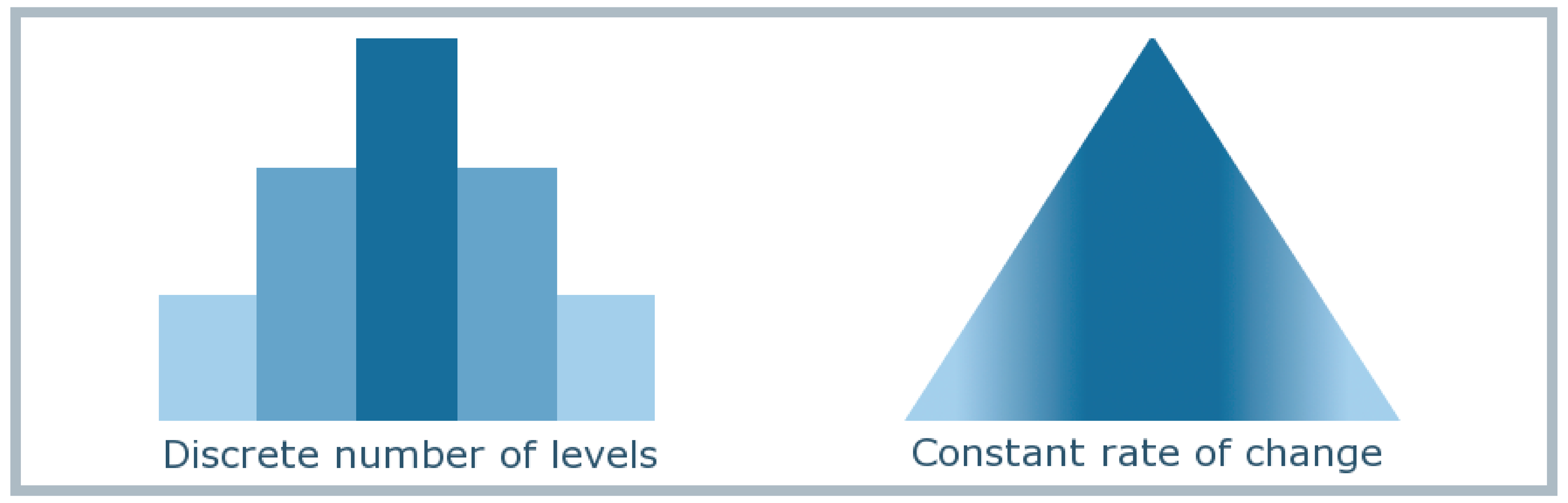

Figure 4: Example sound shapes

Usability Testing

Three visits with a collaborator who is visually impaired (Figure 5) at the Washington State School for the Blind have provided considerable insight to the effectiveness of our designs. Improvements based on feedback include increased area of symbols to represent map features, a combination of naturalistic sound clips and synthesized sound, and modified frequency intervals.

Unanticipated challenges were uncovered through our interactive sessions. Following lines, for example rivers, and interpreting overlapping shapes were initially difficult. This prompted investigation into techniques for line following and concurrent audio.

Figure 5: A collaborator who is visually impaired explores a map of Yellowstone National Park using a touch screen.

Future Work

Experimental testing will evaluate the effectiveness of our new techniques for following lines and discriminating between overlapping objects. Results will guide implementation of additional tools and enable improvements to existing tools within mGIS.

Acknowledgements

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