Data Sonification for Users with Visual Impairment: A Case Study with Geo-referenced Data

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Exploring U.S. Mortality: Dynamic Trend Maps
National Center for Health Statistics / Univ. of Maryland

The GovStat Project
Find what you need, understand what you find.

Improve access to government statistics - www.ils.unc.edu/govstat/
Treemap - Stock market, clustered by industry

Microsoft -10.87%
MSFT: last sale 104.06, change -12.69
(click for more detail)
www.babynamewizard.com
(here started typing: “c”)

More about the Baby Name Wizard.

Buy the complete Wizard name guide at Amazon.
How to make an interactive map such as this accessible?
Related work

- Sonification of tables, menus, desktops…
- Maps for navigation in real world (e.g. how do I get to the bus)
- OUR FOCUS: maps as visualization of abstract data
State of the art of citizen web access to statistical info on map
State of the art of citizen web access to statistical info on map
Unemployment Rate (percent) - 2001

Map with 51 items.

AK is 6.2. Value is in the 5.4 - 6.5 range, Label: AK, Alaska: 6.2, Detail for AK.
AL is 5.3. Value is in the 4.8 - 5.3 range, Label: AL, Alabama: 5.3, Detail for AL.
AR is 5.1. Value is in the 4.8 - 5.3 range, Label: AR, Arkansas: 5.1, Detail for AR.
AZ is 4.6. Value is in the 4.4 - 4.7 range, Label: AZ, Arizona: 4.6, Detail for AZ.
CA is 5.3. Value is in the 4.8 - 5.3 range, Label: CA, California: 5.3, Detail for CA.
CO is 3.7. Value is in the 3.7 - 4.3 range, Label: CO, Colorado: 3.7, Detail for CO.
CT is 3.2. Value is in the 2.8 - 3.6 range, Label: CT, Connecticut: 3.2, Detail for CT.
DC is 6.5. Value is in the 5.4 - 6.5 range, Label: DC, District of Columbia: 6.5, Detail for DC.
DE is 3.5. Value is in the 2.8 - 3.6 range, Label: DE, Delaware: 3.5, Detail for DE.
FL is 4.7. Value is in the 4.4 - 4.7 range, Label: FL, Florida: 4.7, Detail for FL.
GA is 3.9. Value is in the 3.7 - 4.3 range, Label: GA, Georgia: 3.9, Detail for GA.
HI is 4.6. Value is in the 4.4 - 4.7 range, Label: HI, Hawaii: 4.6, Detail for HI.
IA is 3.3. Value is in the 2.8 - 3.6 range, Label: IA, Iowa: 3.3, Detail for IA.
ID is 4.9. Value is in the 4.8 - 5.3 range, Label: ID, Idaho: 4.9, Detail for ID.
IL is 5.3. Value is in the 4.8 - 5.3 range, Label: IL, Illinois: 5.3, Detail for IL.
IN is 4.3. Value is in the 3.7 - 4.3 range, Label: IN, Indiana: 4.3, Detail for IN.
KS is 4.2. Value is in the 3.7 - 4.3 range, Label: KS, Kansas: 4.2, Detail for KS.
KY is 5.4. Value is in the 5.4 - 6.5 range, Label: KY, Kentucky: 5.4, Detail for KY.
LA is 5.9. Value is in the 5.4 - 6.5 range, Label: LA, Louisiana: 5.9, Detail for LA.
MA is 3.6. Value is in the 2.8 - 3.6 range, Label: MA, Massachusetts: 3.6, Detail for MA.
MD is 4. Value is in the 3.7 - 4.3 range, Label: MD, Maryland: 4, Detail for MD.
ME is 3.9. Value is in the 3.7 - 4.3 range, Label: ME, Maine: 3.9, Detail for ME.
MI is 5.3. Value is in the 4.8 - 5.3 range, Label: MI, Michigan: 5.3, Detail for MI.
MN is 3.6. Value is in the 2.8 - 3.6 range, Label: MN, Minnesota: 3.6, Detail for MN.
MO is 4.7. Value is in the 4.4 - 4.7 range, Label: MO, Missouri: 4.7, Detail for MO.
MS is 5.5. Value is in the 5.4 - 6.5 range, Label: MS, Mississippi: 5.5, Detail for MS.
MT is 4.5. Value is in the 4.4 - 4.7 range, Label: MT, Montana: 4.5, Detail for MT.
NC is 5.5. Value is in the 5.4 - 6.5 range, Label: NC, North Carolina: 5.5, Detail for NC.
Traditionally, tactile approaches to maps

Learning maps with a printed tactile Braille atlas
Tactile approaches to maps

Braille mouse gives Braille feedback for different regions
Tactile approaches to maps

Embossed map attached to touchscreen  (www.touchgraphics.com)
but

• All require custom input devices or special printed tactile materials

• i.e. not really providing access for all

• Instead, we use what users have:
Sonification

Use of non-speech audio to represent data

Still use speech output

Note: other direction is text summarization
Closest related project: Use of “Real world” sounds

BATS project at UNC
Uses open library of spatial sounds as icons
Sonification

- **Mono audio**
- **Stereo audio**
- **Spatial audio**
  - Left – Right
  - Up - Down
  - Front – back
  - Distance

Sounds generated using high performance dual processors or by saving very large files of sound libraries
Iterative Process

• First prototype
  Pilot study (9 users)

• Second prototype
  Controlled experiment (48 users)
  of 4 design variations

• Third Prototype: iSonic  [Presented here]

• Continuous feedback <- design partners
VIDEO
Evaluation

• 7 participants (no residual vision)
• Computer users (familiar with excel)
• Have use of statistics in their work
• Most had college education
• Volunteers, paid for their time

• Average of 6 hours of observation and interviews, over 2 separate days
7 participants, 42 hours
Sample Tasks

• T1: Name counties with 5 lowest values
• T4: For which factors does County X do better than County Y?  
  
  Not really geospatial

• T6: Find all 3 counties that border Frederick. Which one has the highest housing vacancy?

• T7: Among 2 given variables which one increases from east to west?
  
  Geospatial
Procedure 1/3: Training

• 1st Day: Training
  – iSonic self paced tutorial (1h 50 min. average)
  – US map, 2003 census data – 8 variables
  – 67% of tasks performed without help
Procedure 1/3: Testing

• 2\textsuperscript{nd} Day
  – Testing with Maryland and its 24 counties
  – Each task with Excel alone, then with iSonic
  – 12 variables
  – NO retraining
Procedure 2/2: Testing

- When no geographical information needed
  - Similar success rate (86%)
  - iSonic preferred over Excel
    (7.9 over 7.0 on a 10 pt scale; 10=easiest)

- When geospatial information needed
  - iSonic: 95% success
  - Excel:
    67% for 2 users with good knowledge of Maryland
    20% for 5 others (who guessed or gave up)
Procedure 2/2: Testing

• When no geographical information needed
  – Similar success rate (86%)
  – iSonic preferred over Excel
    (7.9 over 7.0 on a 10 pt scale; 10=easiest)
• - Sound/Pitch helpful
  - Sorting easier
  - Isolating regions helpful
  - Different information levels helpful
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Procedure 2/2: Testing

- Map easy to use and helpful
- Switching between table and map
- Pitch helpful to compare
- More than one way to find answers

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Users did find steps on their own

Exception: correlation (i.e. sorting one column, then listening to other column - with inf. level 1 = only pitch)
• VIDEO AGAIN?
Suggestions

• Provide the data (can be loaded in excel)
• Consider sonification (hard but effective)
• Improve table viewers
• Coordinate map and table
• Navigate with numerical keypad
• Synchronize visual and sound → cooperation

• Use/Expand our toolkit
  Java webstart
  Source code, tutorials and extra utilities available for DOWNLOAD
Not just maps!
www.cs.umd.edu/hcil/audiomap

plaisant@cs.umd.edu

and FYI:

HCIL Symposium May 28-29, 2009 (200+ attendees)

Universal Usability
Jonathan Lazar (Ed.)
2007

Designing the User Interface (5th Edition)
Shneiderman and Plaisant
Visit Pearson Education Booth
Stereo Sounds: high pitch = high value

Table:

<table>
<thead>
<tr>
<th>region</th>
<th>Population</th>
<th>Population With a disability</th>
<th>percent Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prince Geor</td>
<td>479163</td>
<td>69958</td>
<td>14.6</td>
</tr>
<tr>
<td>Montgomery</td>
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<td>10925</td>
<td>15.4</td>
</tr>
<tr>
<td>Carroll</td>
<td>86493</td>
<td>10379</td>
<td>12.0</td>
</tr>
<tr>
<td>St. Mary's</td>
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<td>9539</td>
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<tr>
<td>Allegany</td>
<td>47416</td>
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Map: Population With a disability
Stereo Sounds: high pitch = high value

Sweep for overview
Num Keypad for partial overview

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Procedure 3/3 – Free exploration

• Post test:
  – Free exploration of Idaho (but didn’t know) with 44 counties with both iSonic, and asked to report on things of interest
  – Semi-structured interview