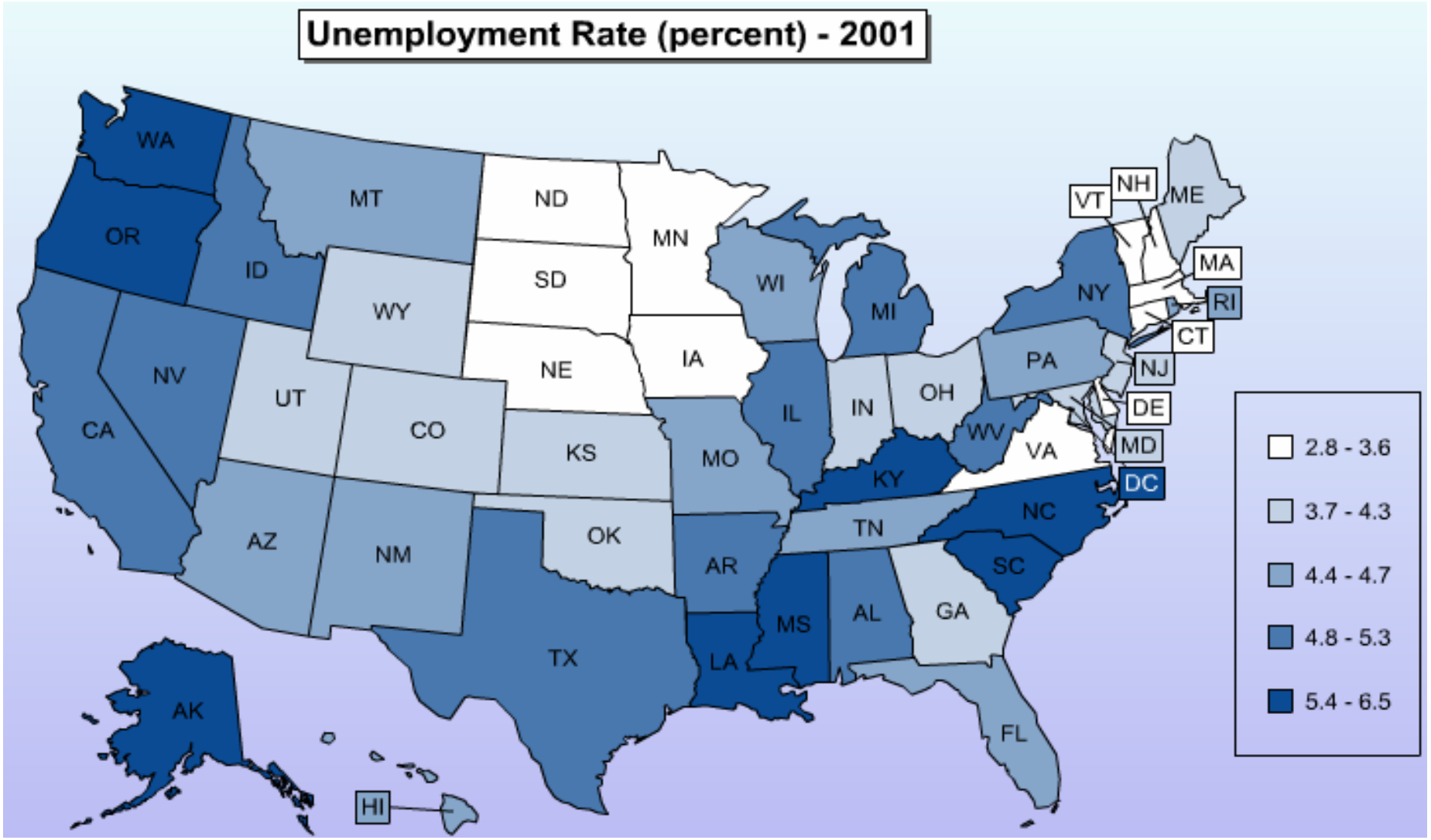
Sonification of geo-referenced statistical data

Catherine Plaisant

Human-Computer Interaction Laboratory
University of Maryland


Unemployment Rate (percent) - 2001
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MA
RI
CT
NJ
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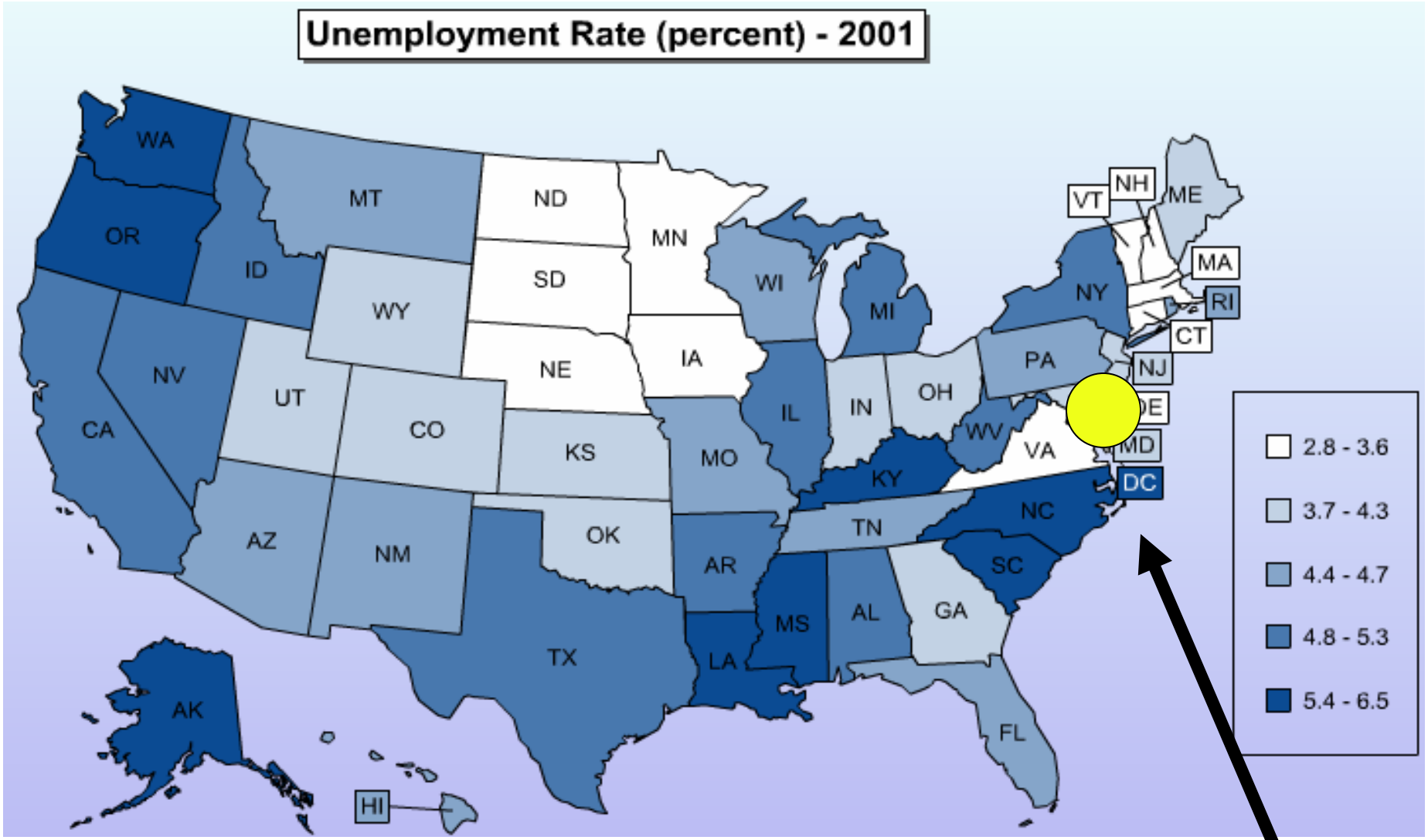
2.8 - 3.6
3.7 - 4.3
4.4 - 4.7
4.8 - 5.3
5.4 - 6.5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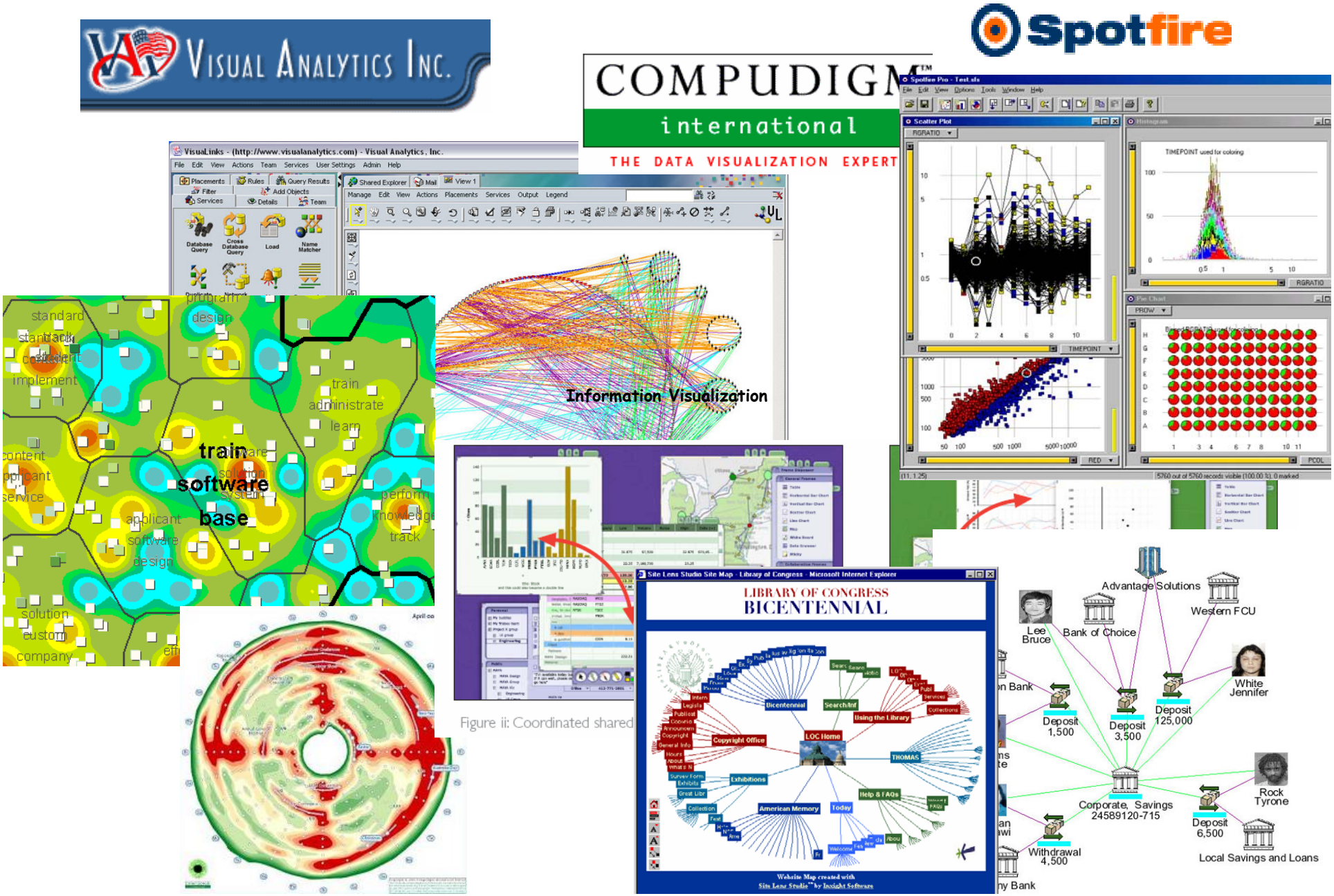
SC
PA
NY
VT
NH
ME
MA
RI
CT
NJ
DE
MD
DC
AK
HI
2.8 - 3.6
3.7 - 4.3
4.4 - 4.7
4.8 - 5.3
5.4 - 6.5

Information Visualization

Computer-supported
interactive visual representation
of abstract data

discover and explain
patterns, trends, clusters, gaps, outliers...
take decisions

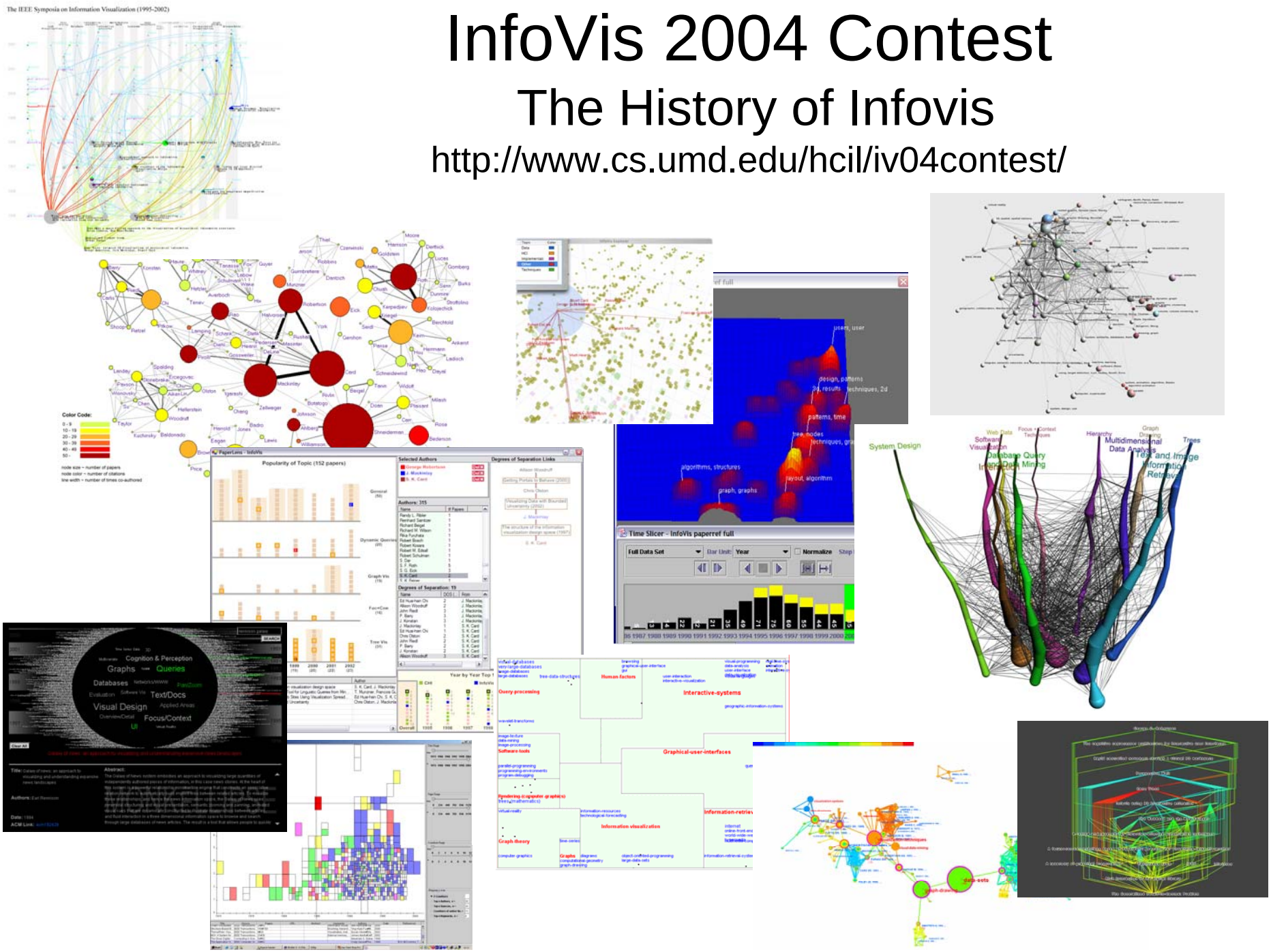
Information Visualization

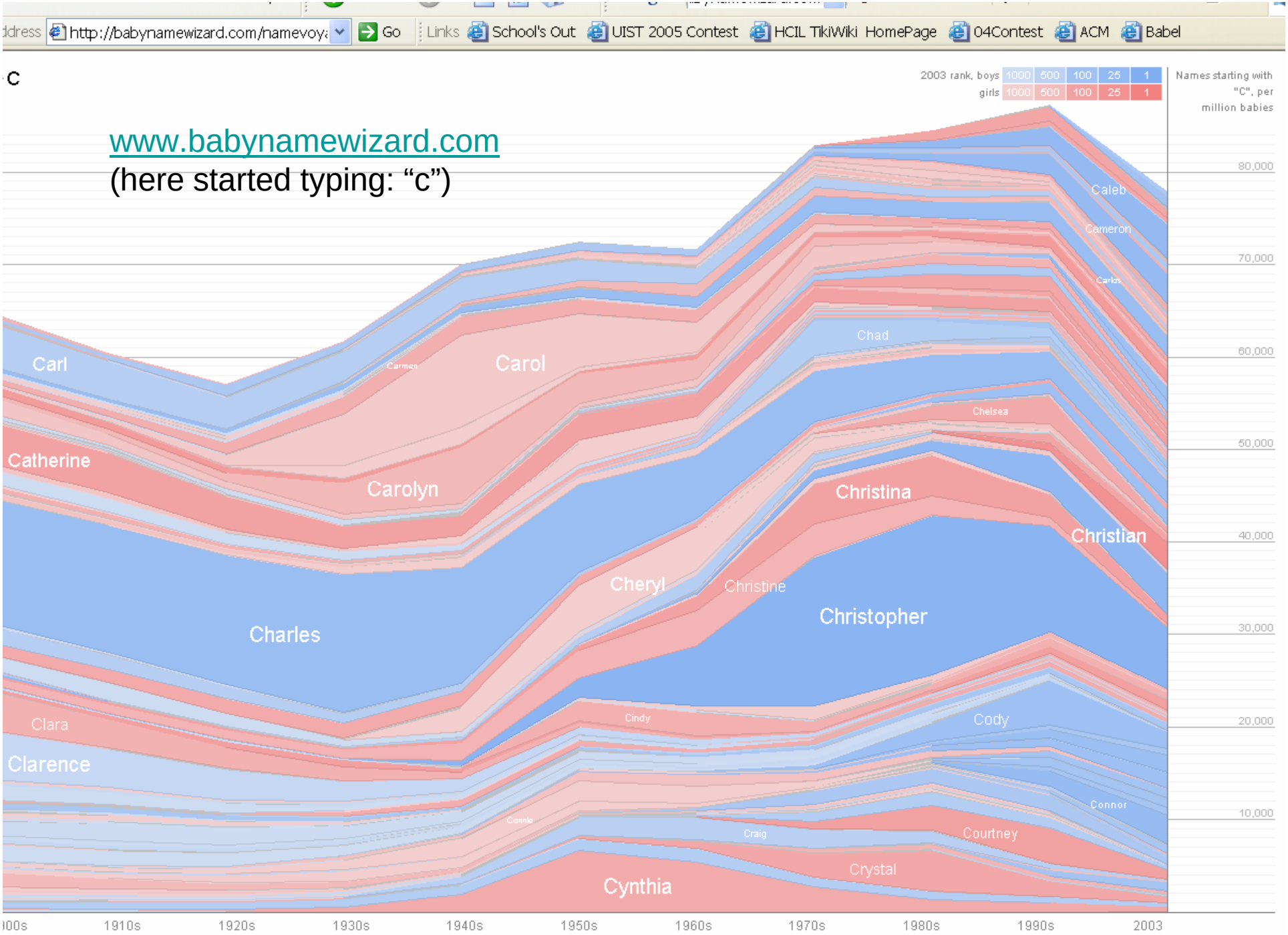


InfoVis 2004 Contest

The History of Infovis

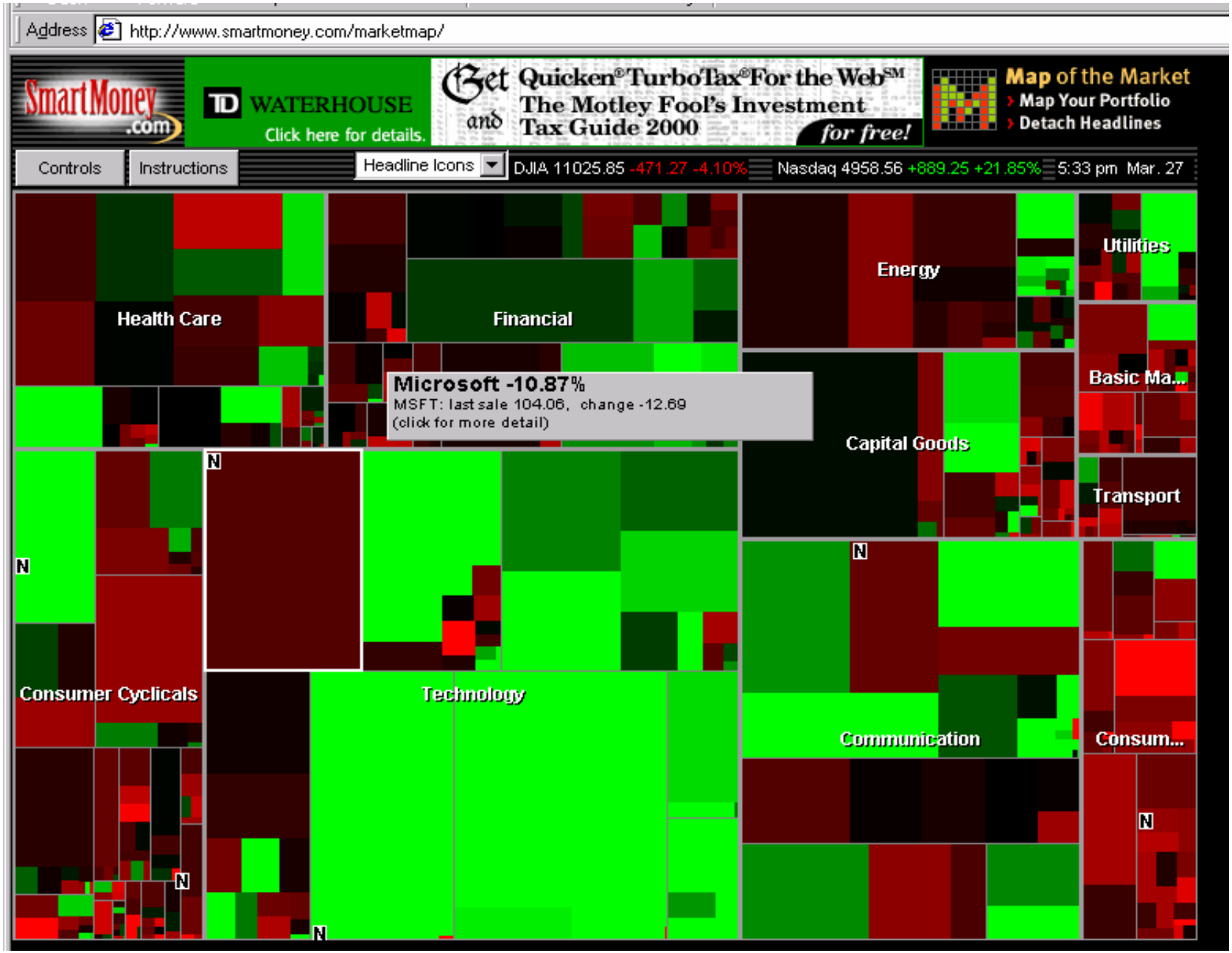
http://www.cs.umd.edu/hcil/iv04contest/



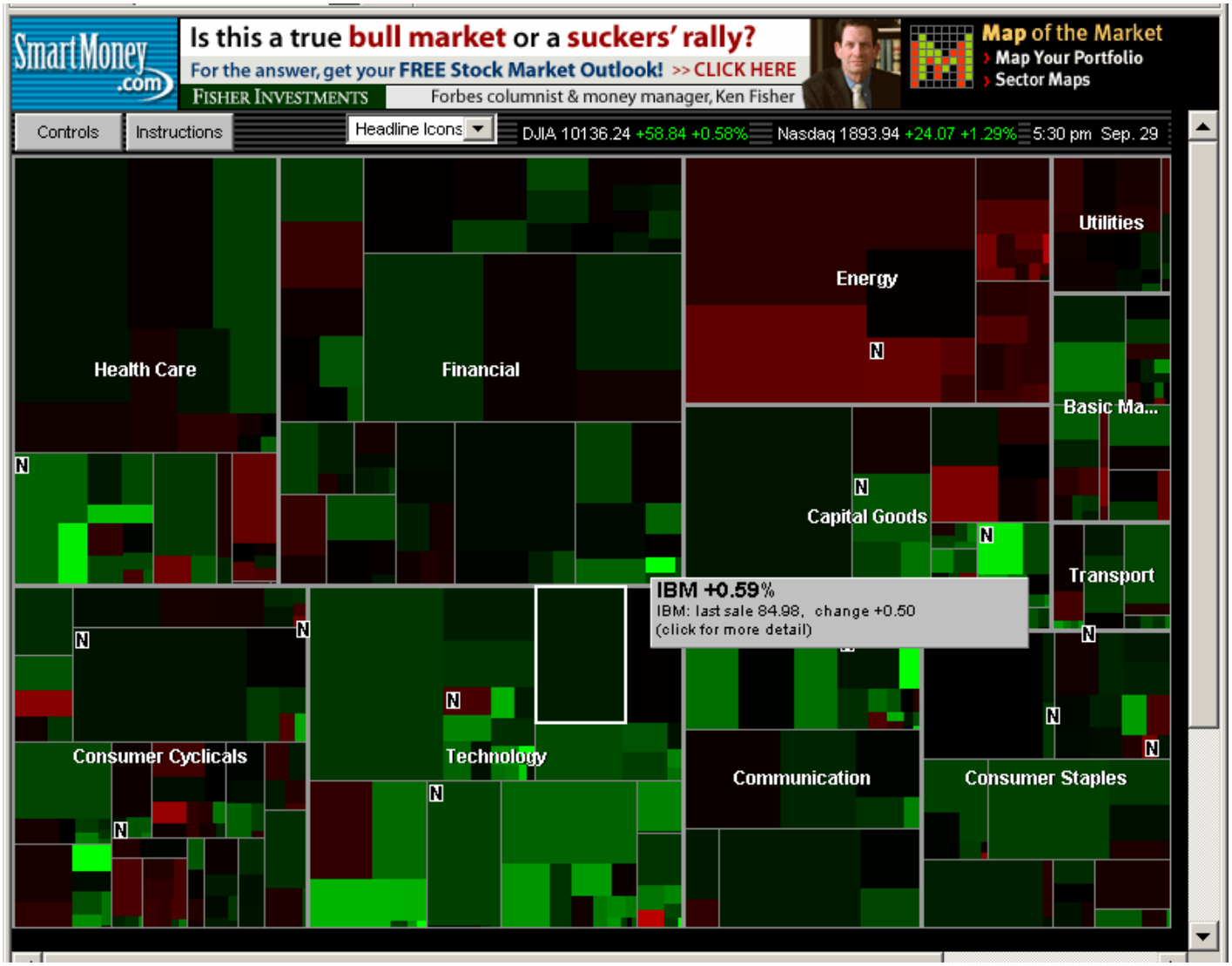


www.babynamewizard.com
(here started typing: “c”)

Treemap - Stock market, clustered by industry

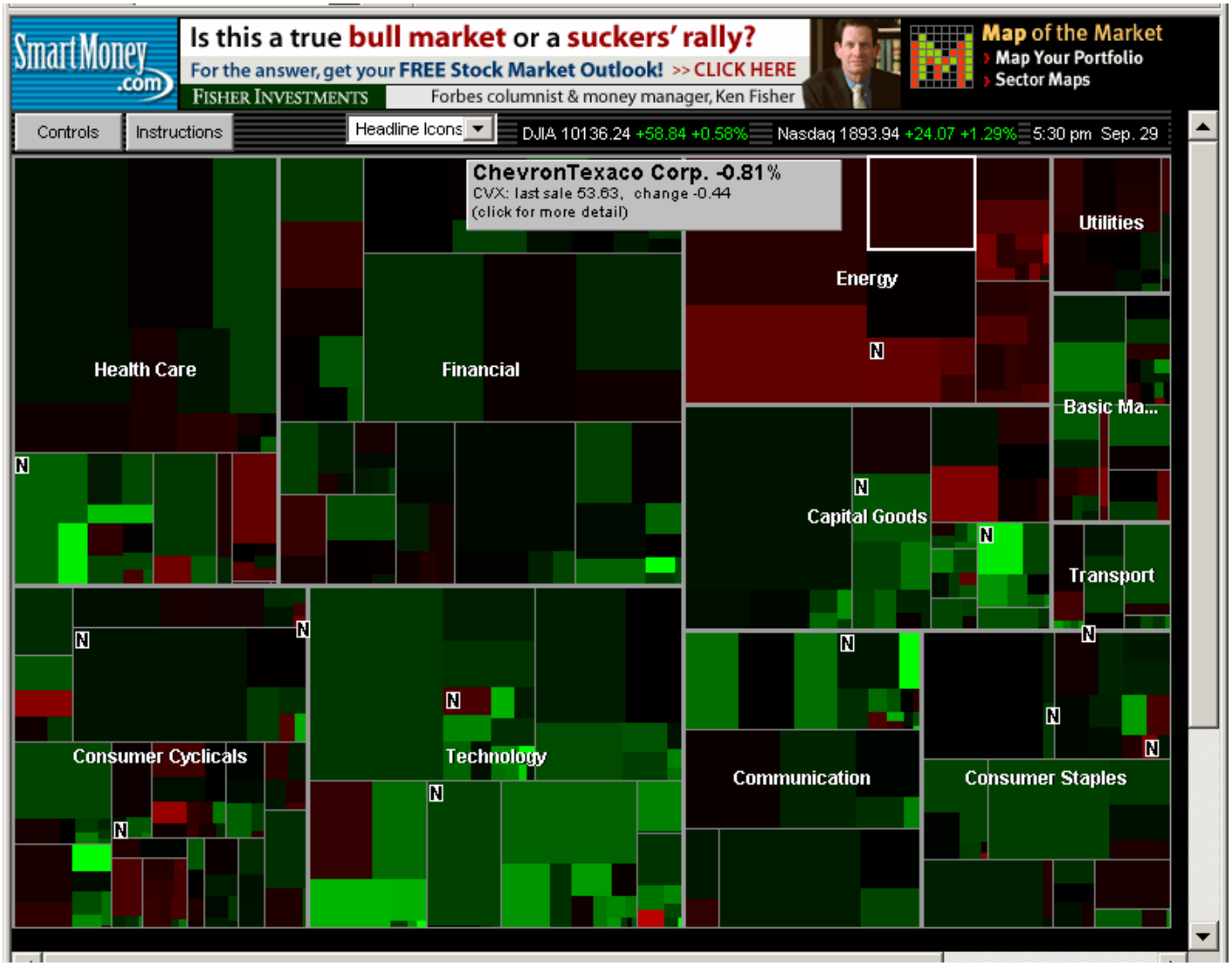


Another day…



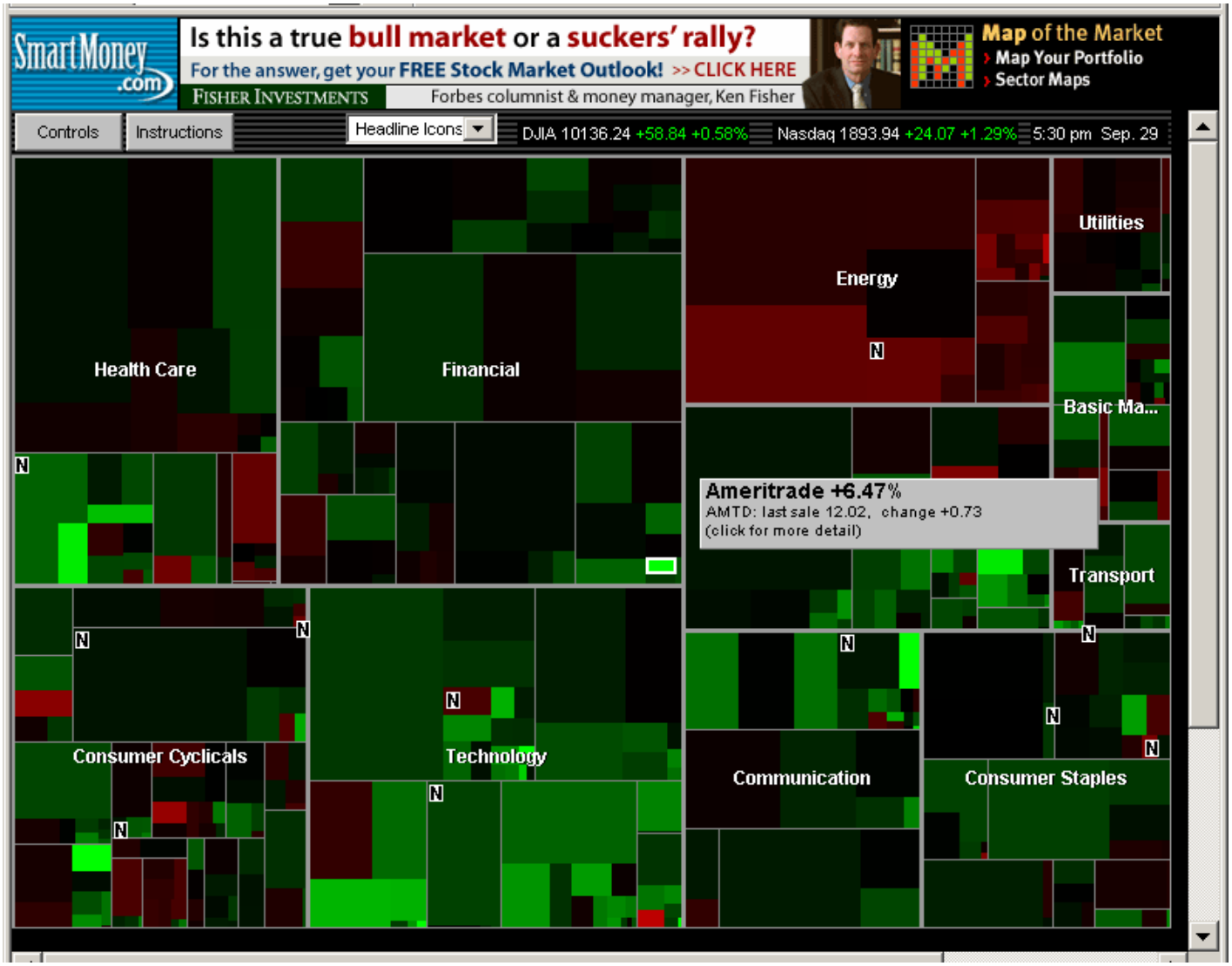
Stock market data, clustered by industry www.smartmoney.com/marketmap

Another day…



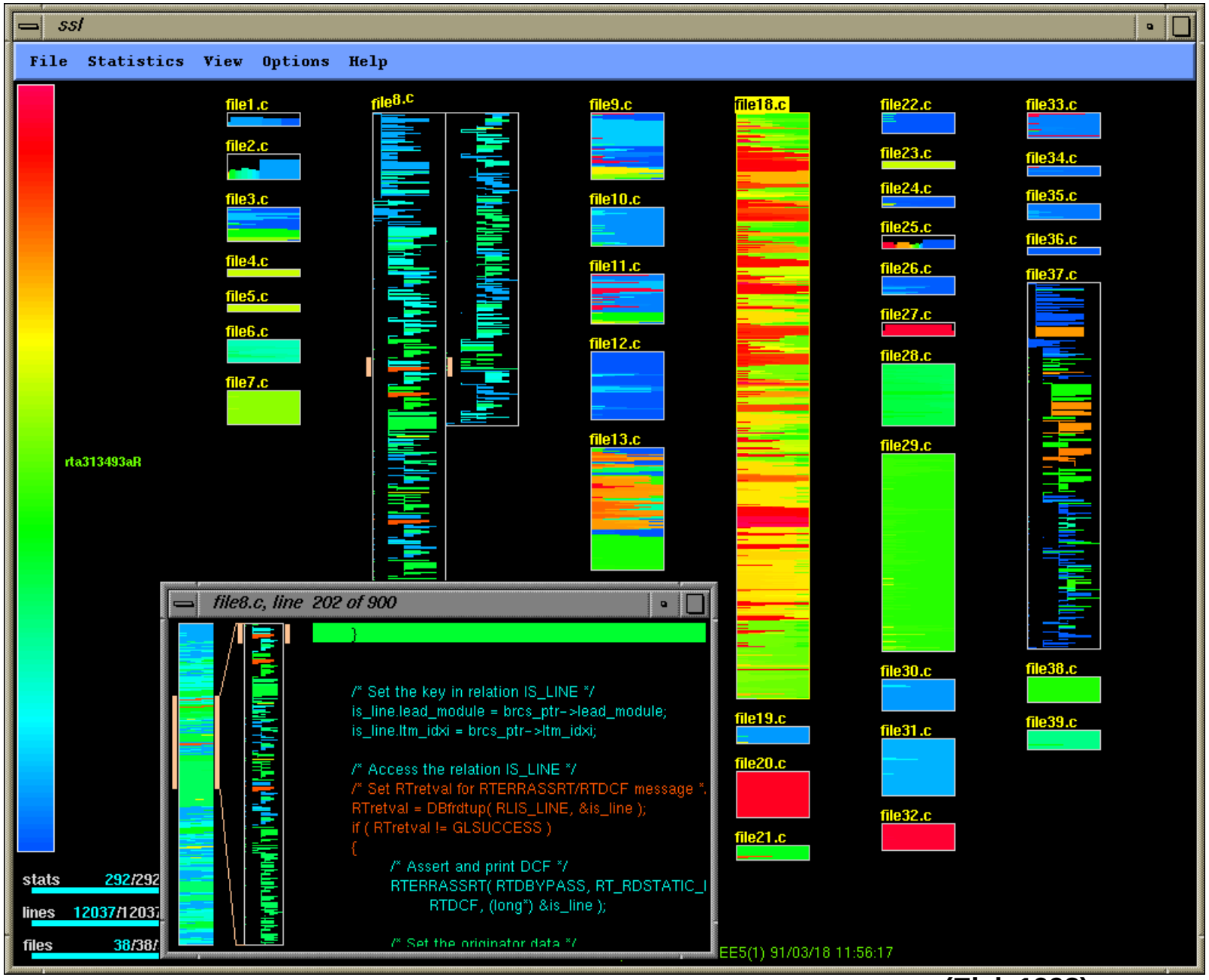
Stock market data, clustered by industry www.smartmoney.com/marketmap

Another day…



Stock market data, clustered by industry www.smartmoney.com/marketmap

SeeSoft – Lines of software code



(Eick 1998)

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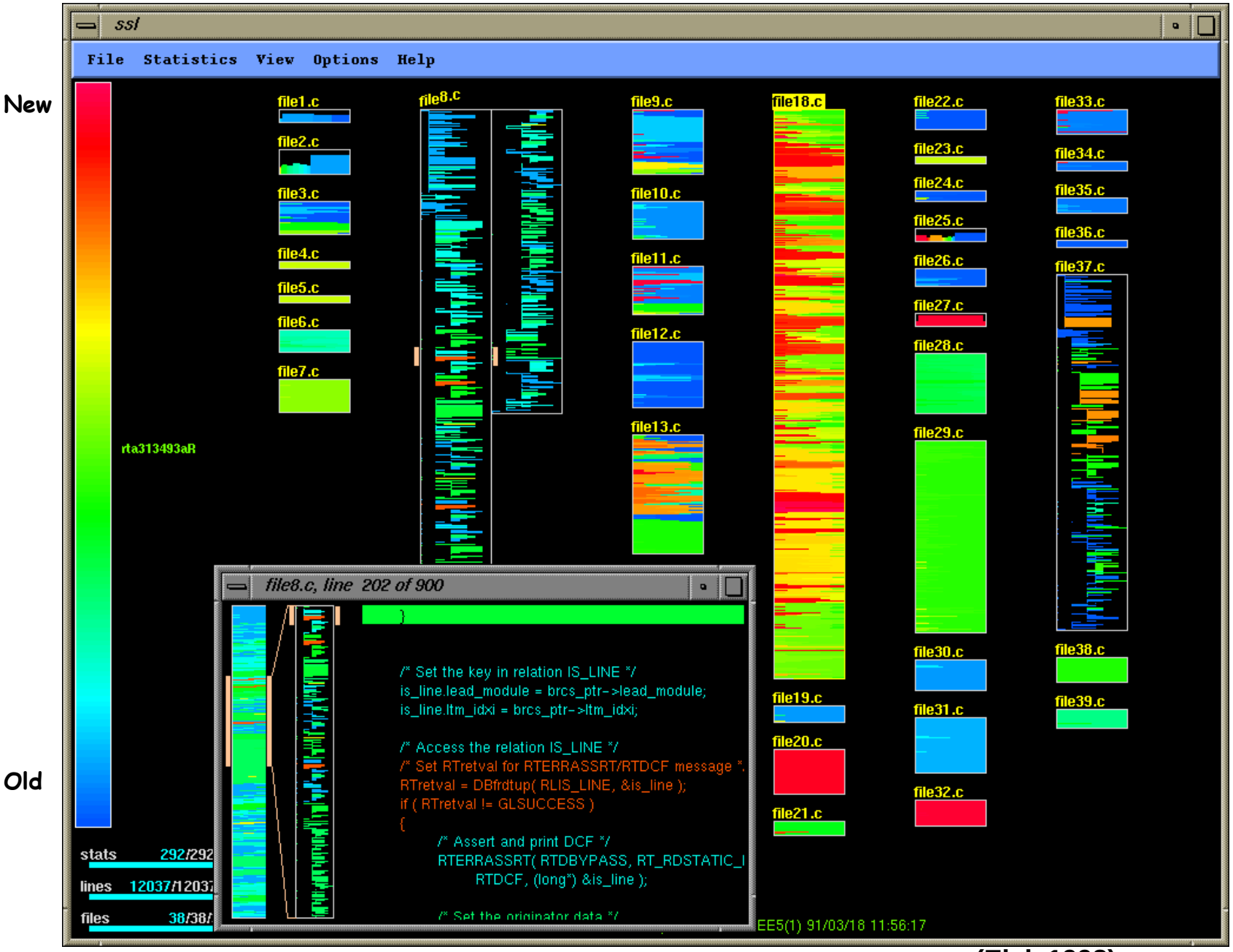
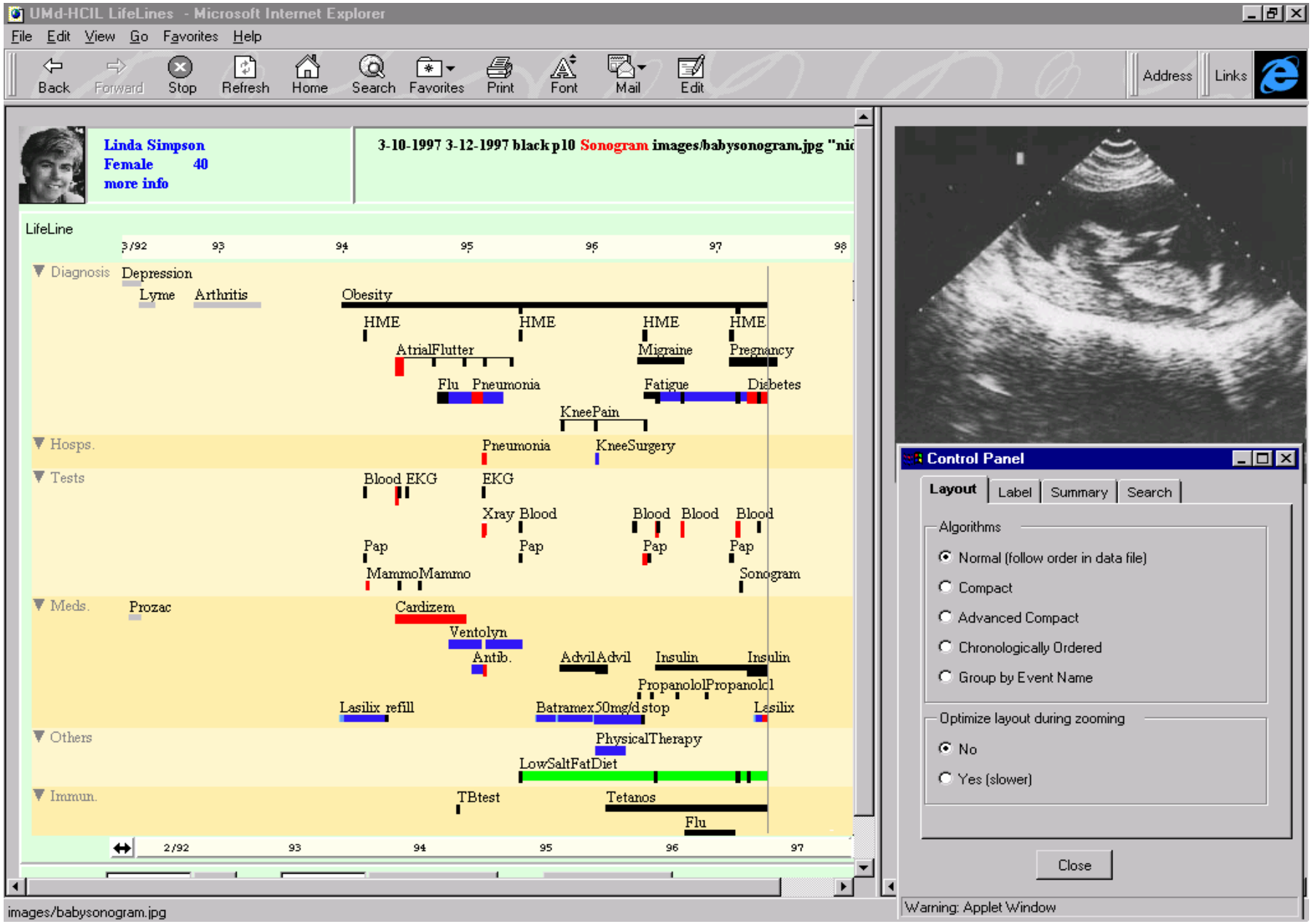


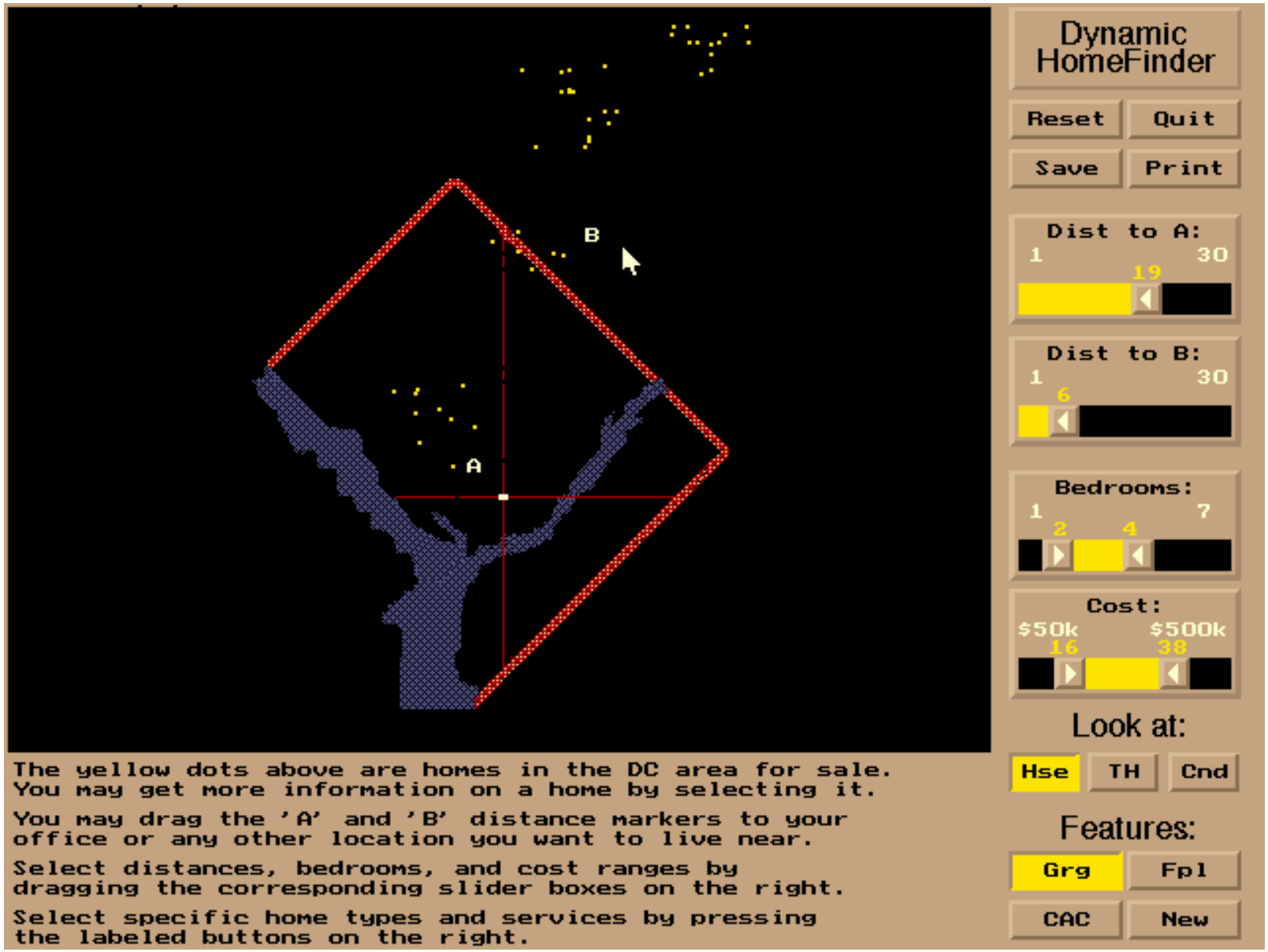
(Eick 1998)

Temporal e.g. LifeLines

www.cs.umd.edu/hcil/lifelines



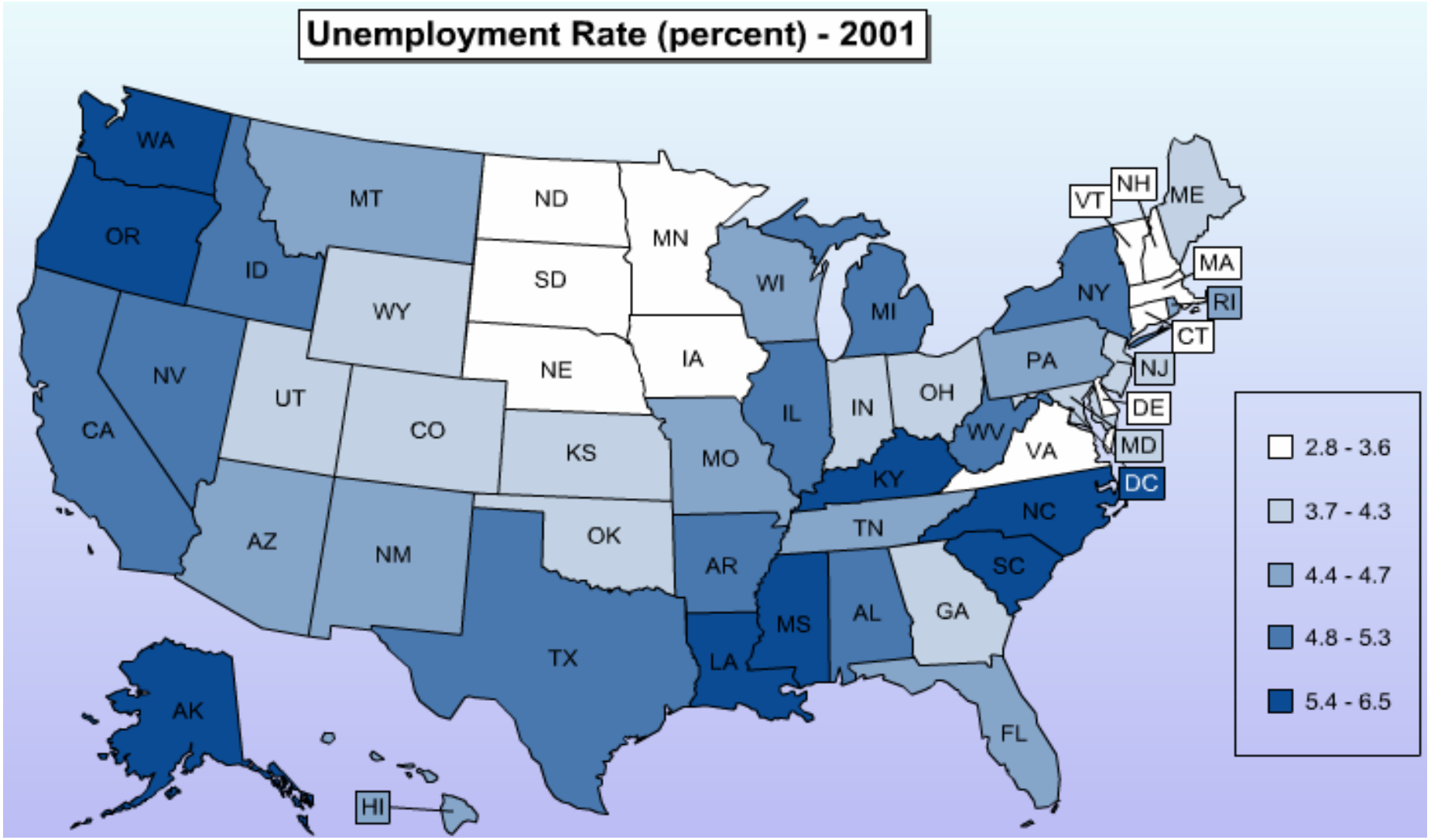
Dynamic Queries - Finding a home



www.cs.umd.edu/hcil/spotfire (Shneiderman, 92)

- OK… but what about blind users!

- Universal Usability
- Important for public access
  - e.g. publishing government data



How to make an interactive map such as this accessible?

Sonification of geo-referenced statistical data

Catherine Plaisant

Human-Computer Interaction Laboratory
University of Maryland

Sonification of geo-referenced statistical data

Catherine Plaisant

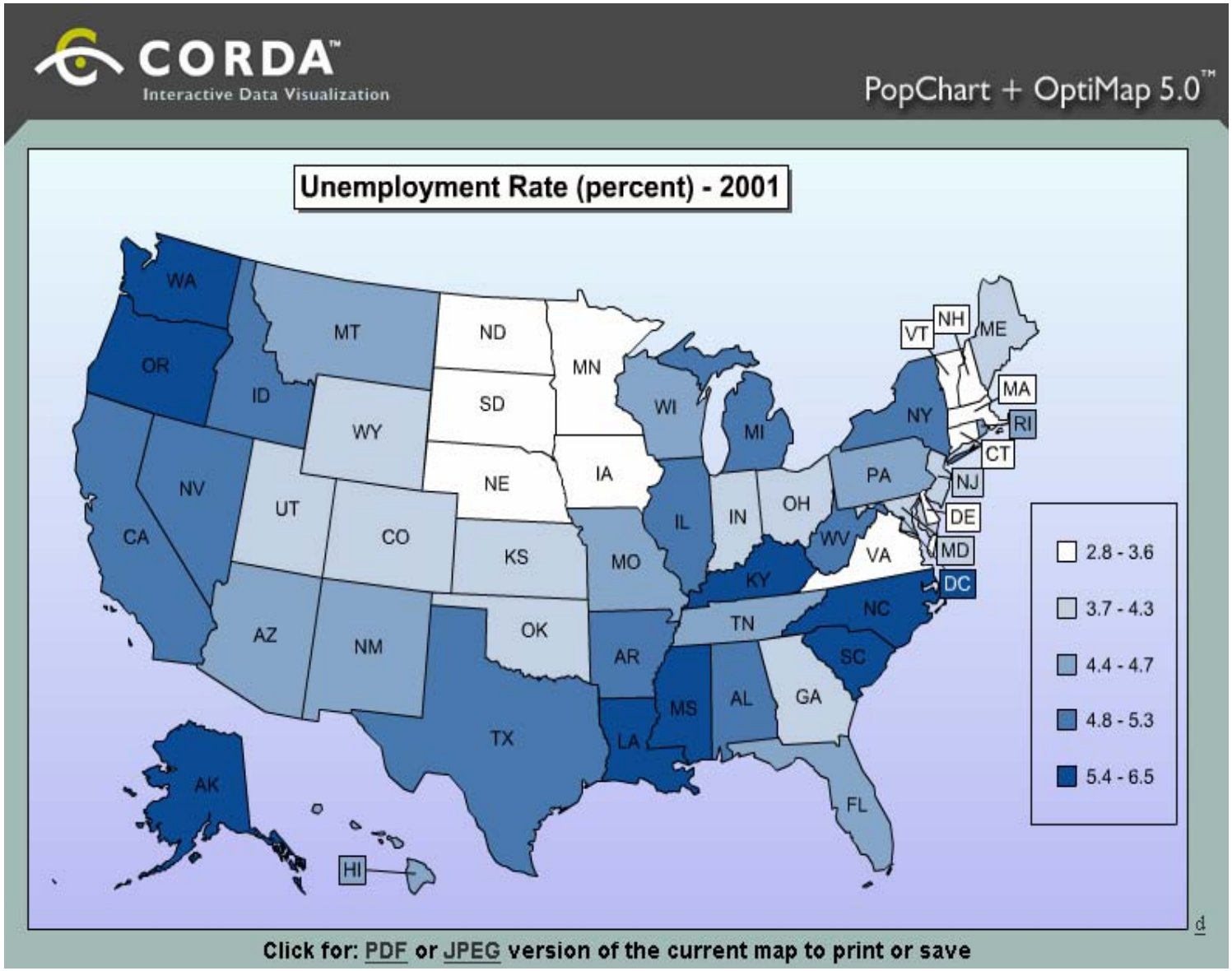
Haixia Zhao, PhD student

Ben Shneiderman

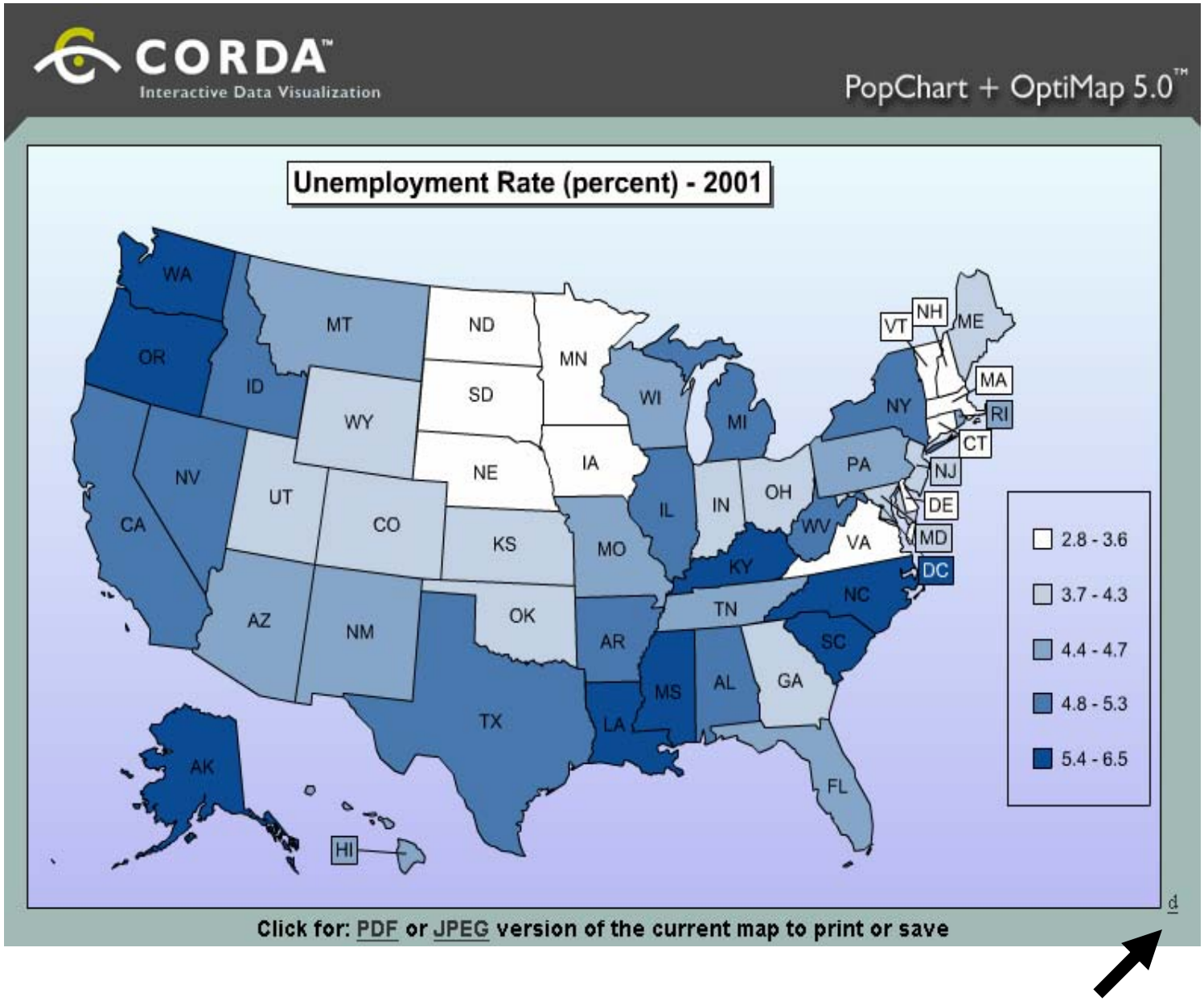
Context of this project

- Expand on other work done (by others) on sonification of tables, menus, desktops, VR etc.
- Lots of work on maps for navigation in real world (e.g. how do I get to the bus)
- But almost nothing for 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



CORDA™
Interactive Data Visualization

PopChart + OptiMap 5.0™

Unemployment Rate (percent) - 2001

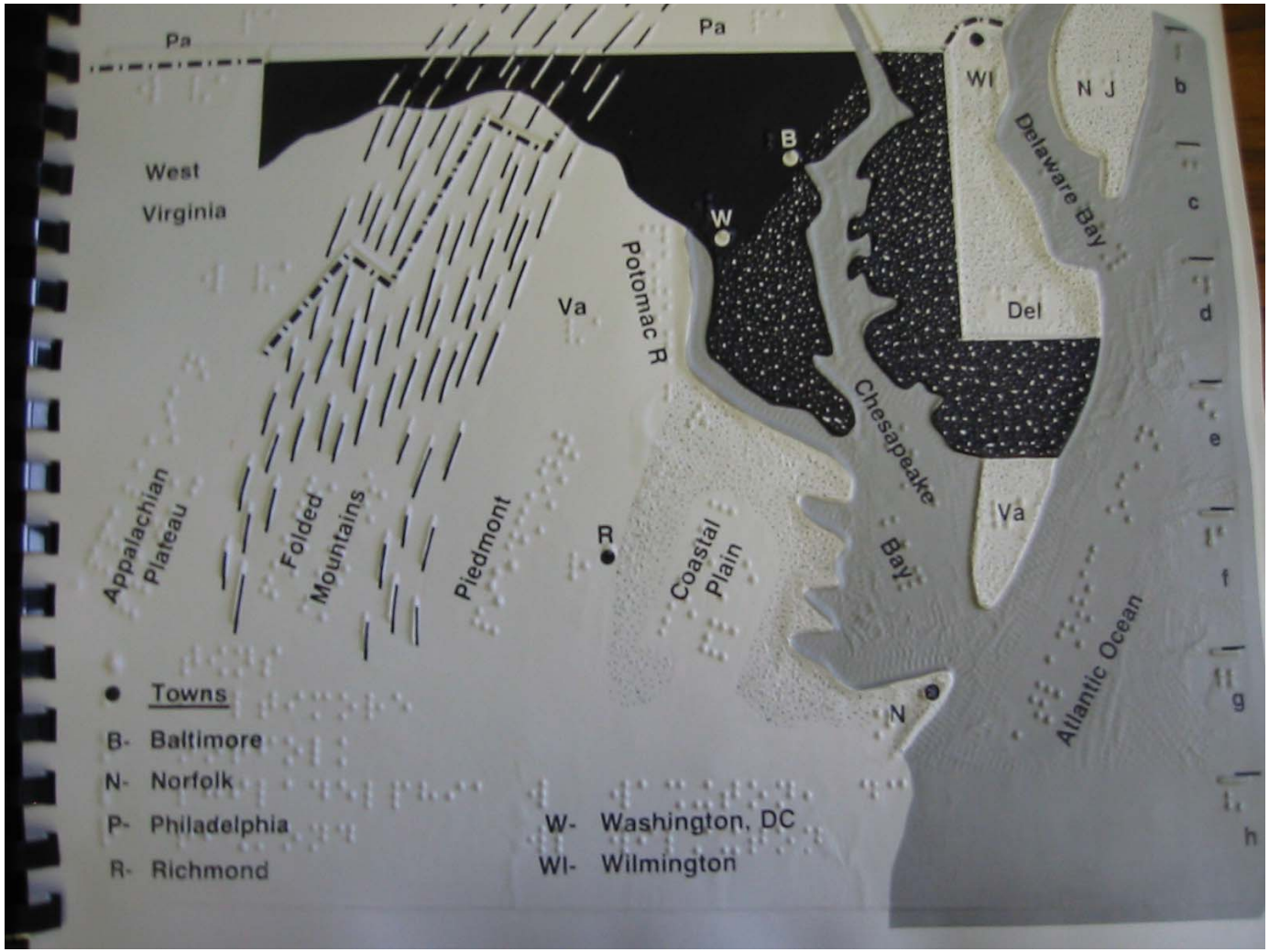
Map with 51 items.

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.

Text version generated automatically

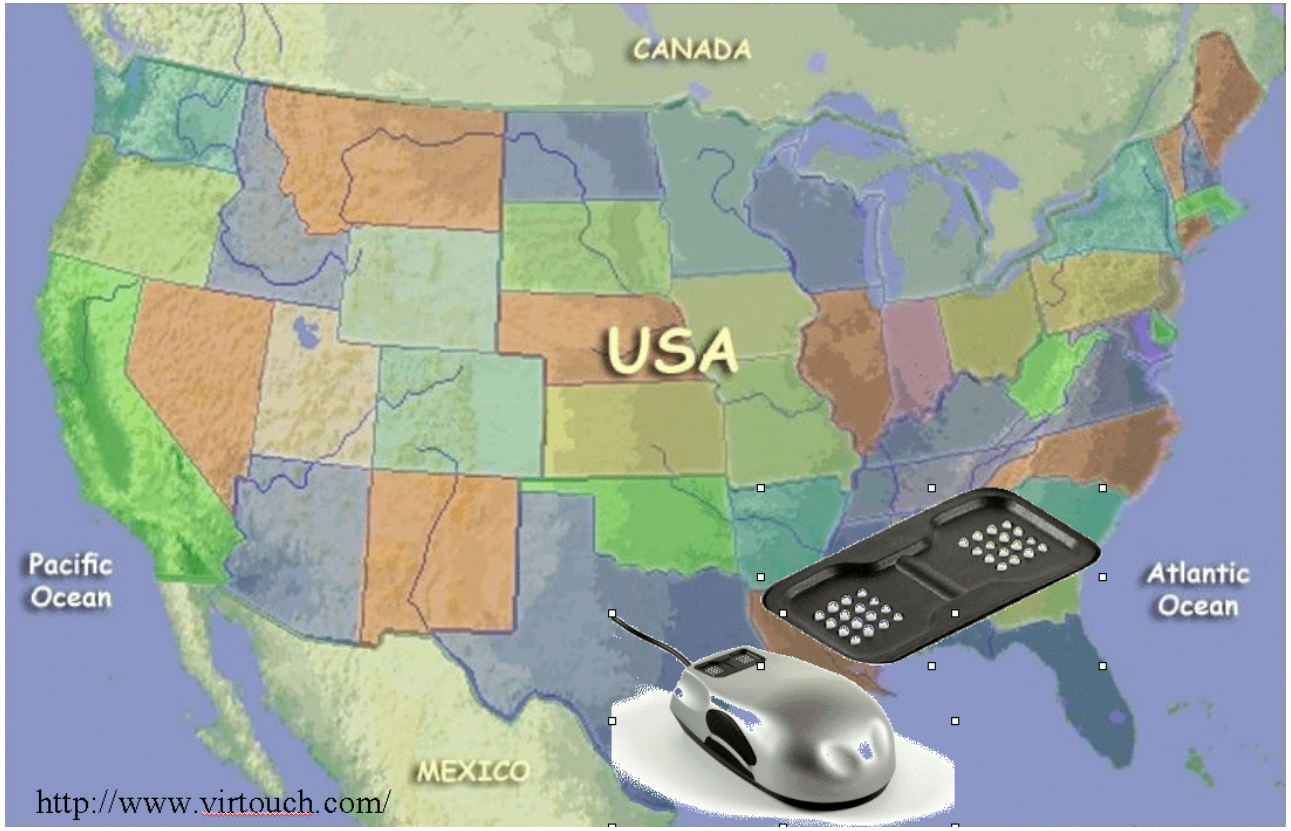
Usable with screen readers

Traditionally, tactile approaches to maps



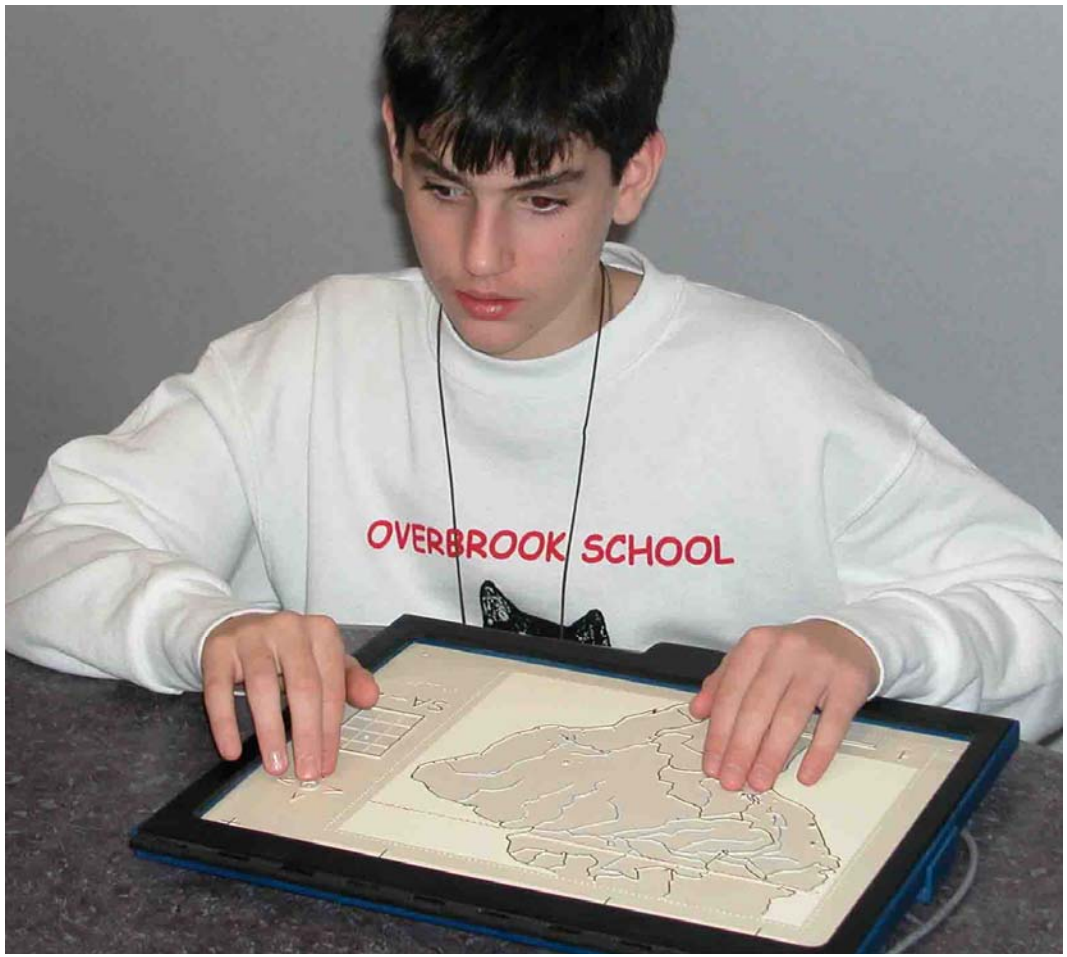
Learning maps with
a printed tactile Braille atlas

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

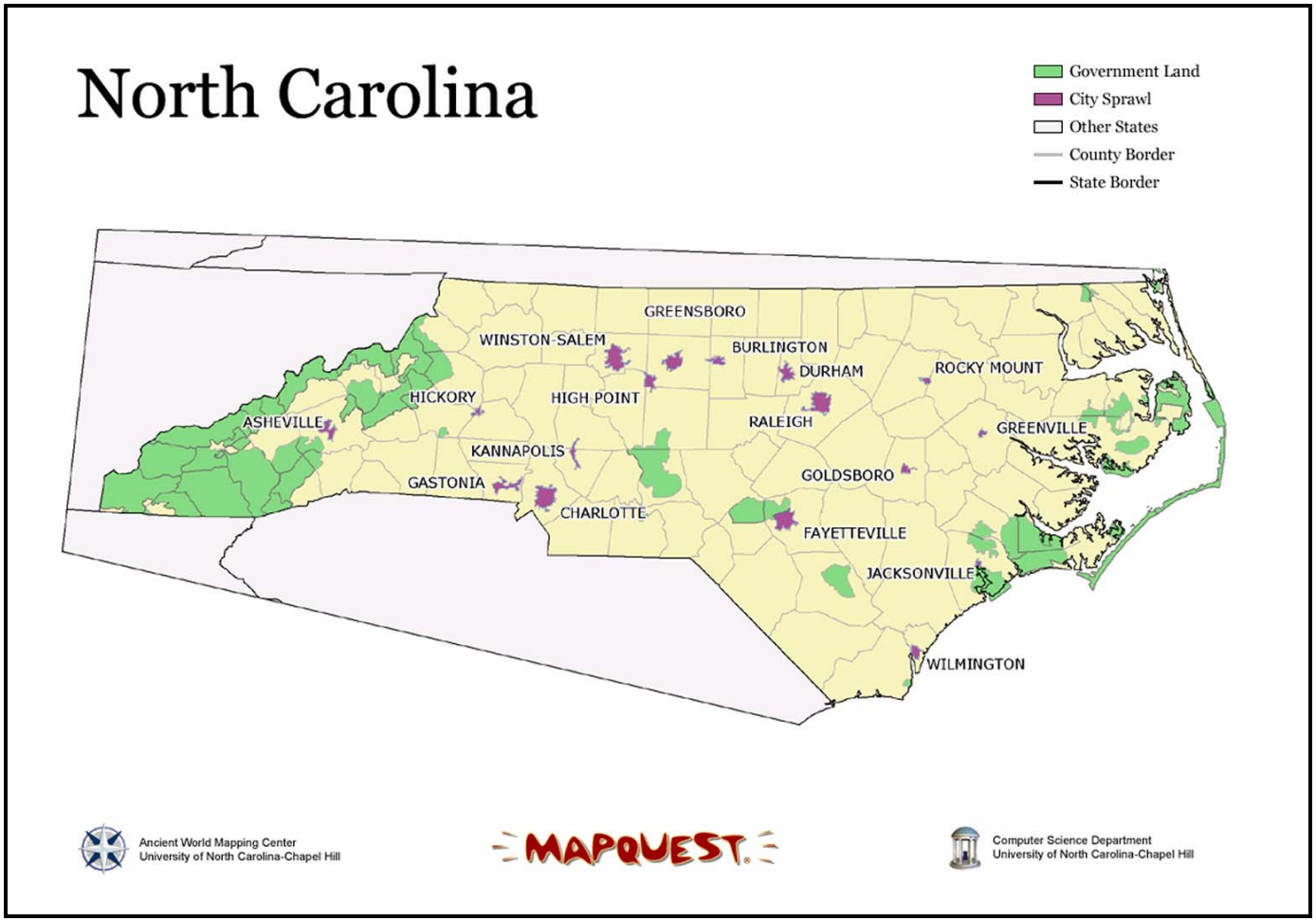
- Instead, we are trying to use audio ONLY

~~Visualization~~

Sonification

Use of non-speech audio to represent abstract data

Closest related project: Use of "Real world" sounds



BATS project at UNC

Uses open library of spatial sounds as icons

Sonification

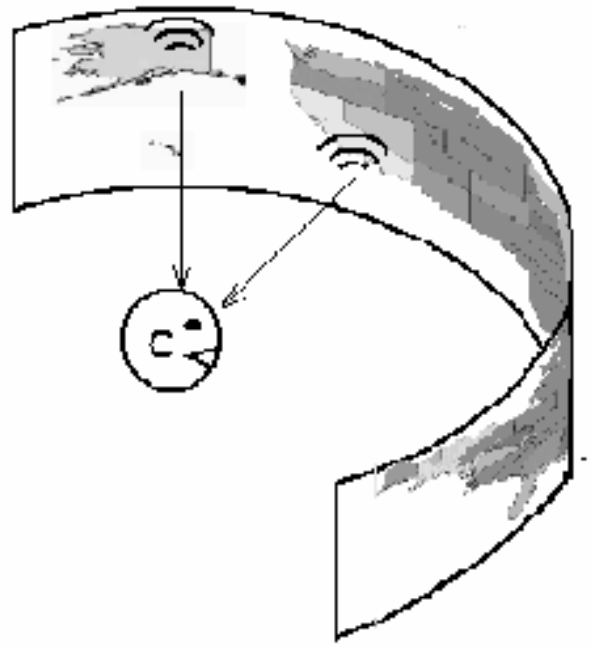
- Mono audio
- Stereo audio
- Spatial audio

  Left - Right

  Up - Down

  Front – back

  Distance



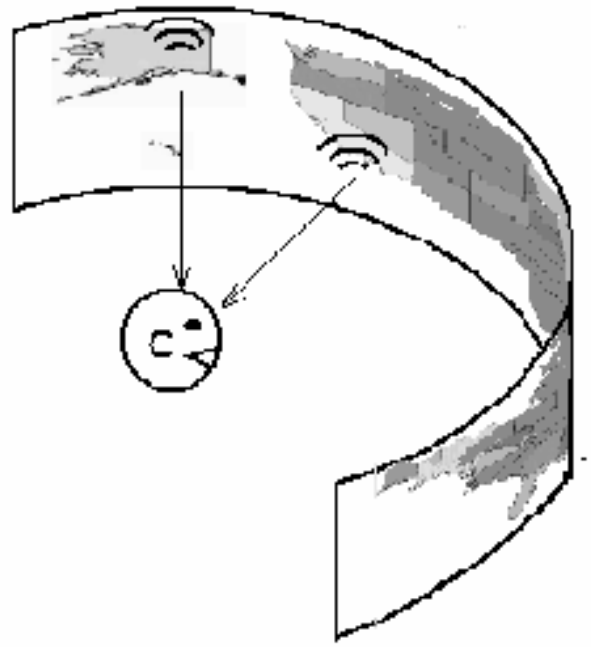
head-related transfer function (HRTF)

Perception of spatial effects improves
when using "personal" HRTF

Generated using high performance dual performance processor
or by saving large files of sound libraries

Sonification

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



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Work in Progress…

- First prototype
  - Pilot study (9 users)
- Second prototype
  - Controlled experiment (48 users) of 4 design variations
- Current prototype: InterSon
- Next: controlled experiment
  (being designed with Psych Dept. colleagues from La Sapienza in Rome)

- All along… Feedback from blind design partners

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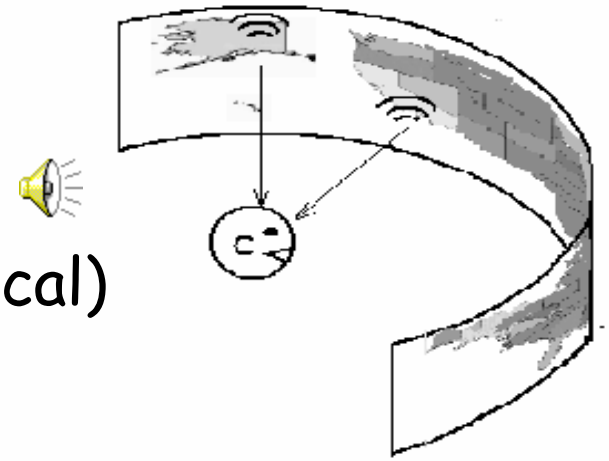
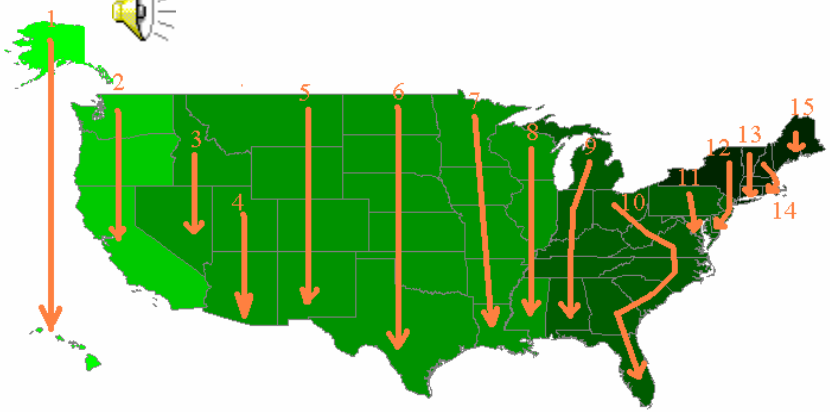
First Prototype

- Two sounds for each state
  - Data value = Piano pitch, followed by
    Vertical position on map = short string pitch



- Overview: Spatial sweeping (vertical)
  - up->down then to the right,
  - sweeping grid according to relative geographic locations.
  - Bell indicates a column.



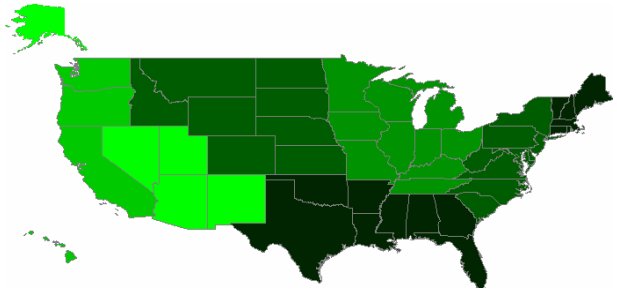
- Navigation
  Keyboard arrow keys

- Detail-on-demand:
  Space key: Read aloud name & value

Pilot study

9 “blind-folded” sighted users

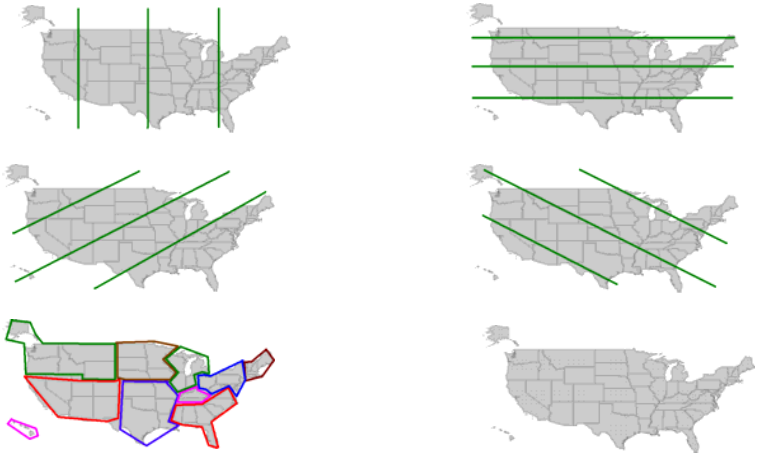
Spatial pattern recognition tasks (6 steps)



1- Listen to overview once

2- Recognize a **pattern type**

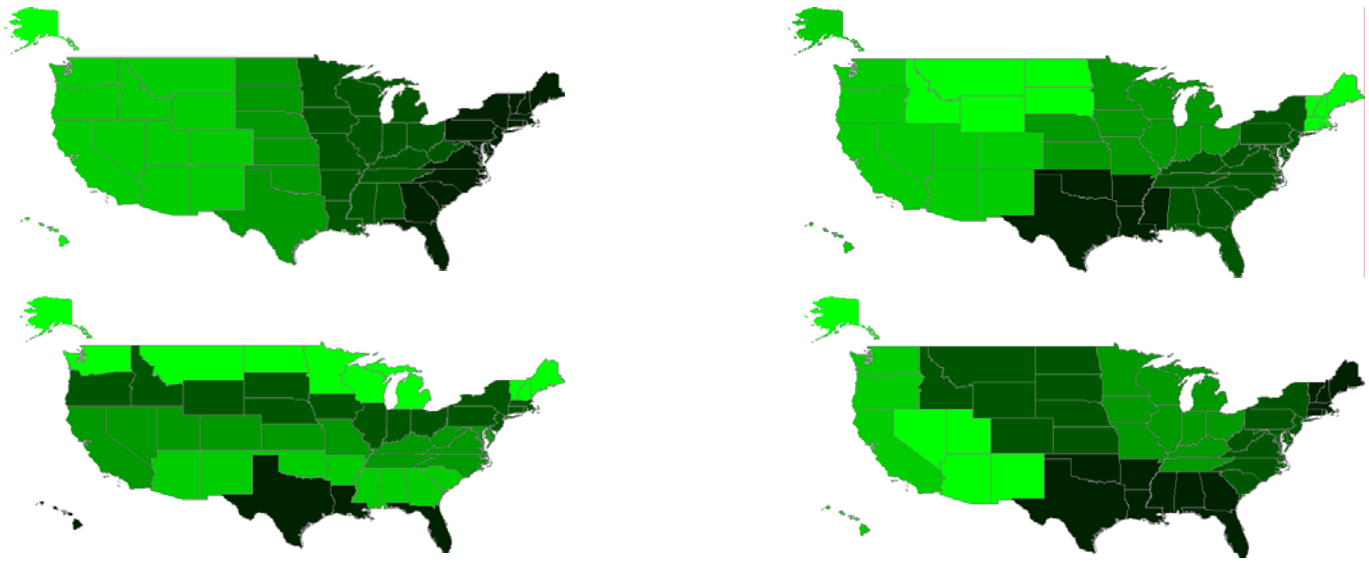
Vertical strip / horizontal strip / diagonal strip / cluster patterns / no pattern



Pilot study

3- Free exploration of the map

4- Recognize **detail pattern** among four choices, e. g.

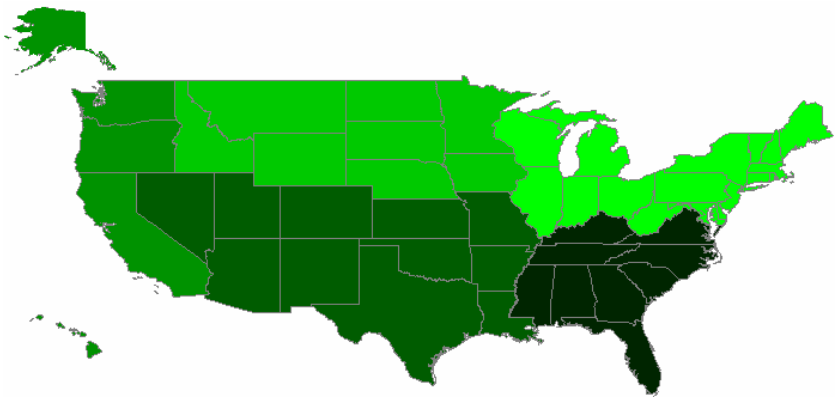


5- Select confidence level

6- Comment on strategy

Pilot study

- Able to recognize patterns
- Pattern type
  - 56% accuracy after first time,
  - 89% accuracy after long exploration.
- Detail pattern
  - 75% accuracy after long exploration



- Strong learning effect
- Large individual differences (hard task!)
- Vertical position extra sound is confusing
- Navigation with arrow keys hard
  because of irregular shapes of states

Map vs. Ordered Table

- Table
  - All sounds come from front (i.e. no stereo effect)
  - Same order as map sweep order (instead of alphabetical order)
  - Only next/previous keys

Alaska	1
Hawaii	1
Washington	2
Oregon	2
California	2
Idaho	3
Nevada	3
Utah	3
Arizona	3
Montana	3
Wyoming	3
Colorado	3
New Mexico	3
North Dakota	3
South Dakota	3
Nebraska	3
Kansas	3
Oklahoma	3

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Nebraska	3
Kansas	3
Oklahoma	3

- No performance difference
- Maps preferred

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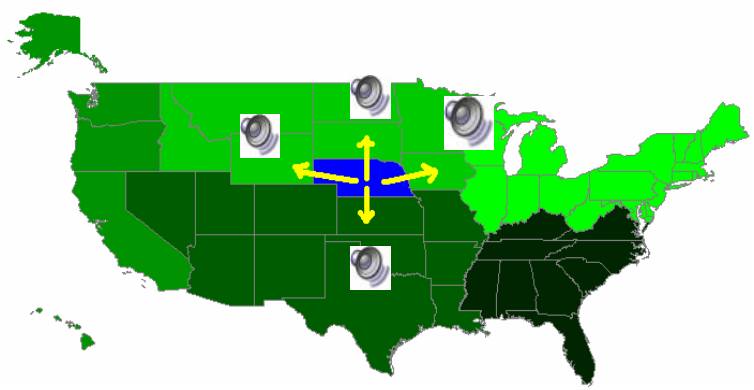
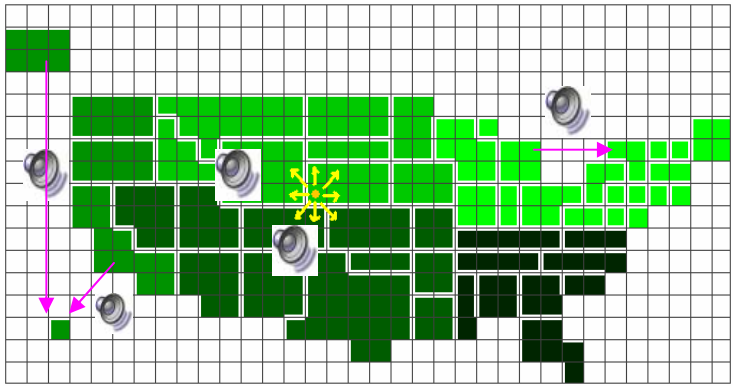
Second Prototype

- 2 design variations
  - WITH or WITHOUT vertical position sound
  - Keyboard exploration done

    STATE BY STATE or CELL BY CELL (grid)





Second Study

- 48 subjects
- Compared the 4 variations

Second Study

- 48 subjects
- Compared the 4 variations
- No performance differences!

- but performance significantly affected by:
  - Geographic knowledge
  - Pitch differentiation ability
  - Task strategy
    trying to visualize the map, listening for changes, ignoring vertical position sound (!)

Next steps

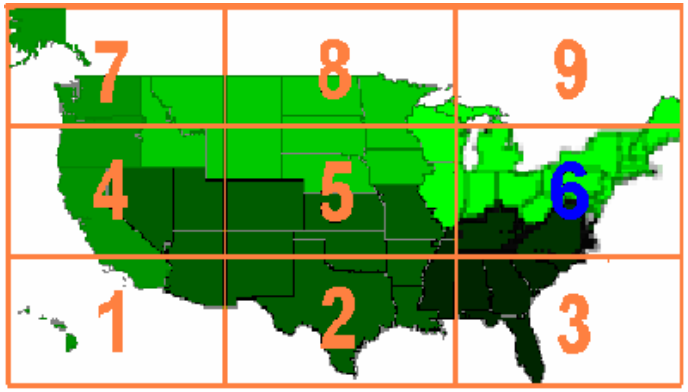
- Abandon extra vertical position sound

- Long automatic sweeping overwhelming
  - may be OK if only local sweep?
  - Use more active exploration
  - vertical sweep (instead of horizontal)

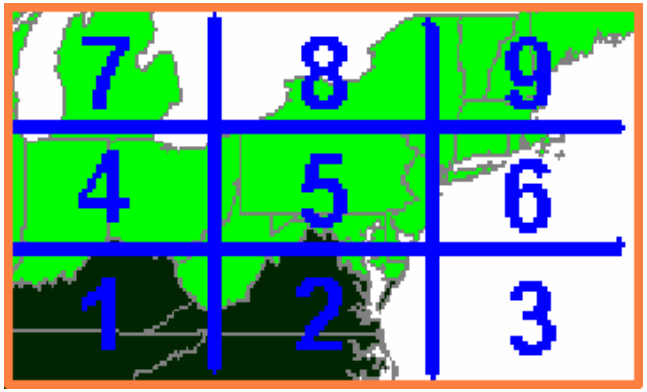
- Use with keyboard only is important BUT could ALSO use generic devices when available (e.g. tablet)

Current Prototype: InterSon

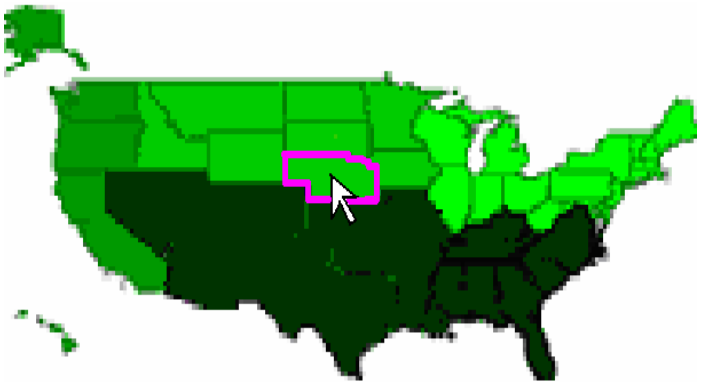
- Keyboard



•Zoom



- Generic touchpad (no tactile map)



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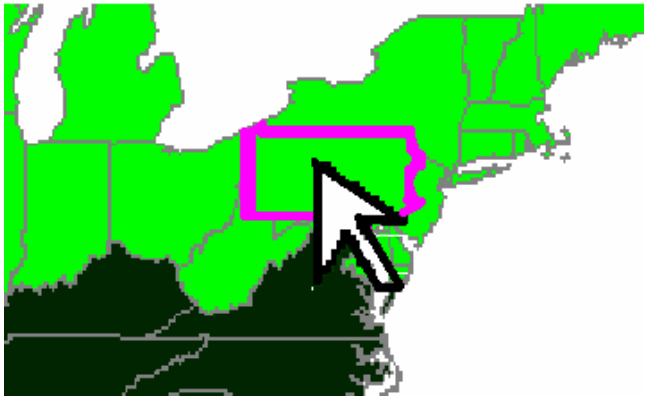

Lessons

- Hard but possible!
- Feels like a return to command language interface!
  - Need extensive but multilevel help
- Synchronize visual and audio
  - to permit collaboration
- Allow multiple devices
- Still many questions… e.g. choice of sounds,
- Further testing

HCIL

HUMAN COMPUTER
INTERACTION
LABORATORY

Grazie !

www.cs.umd.edu/hcil/audiomap

plaisant@cs.umd.edu