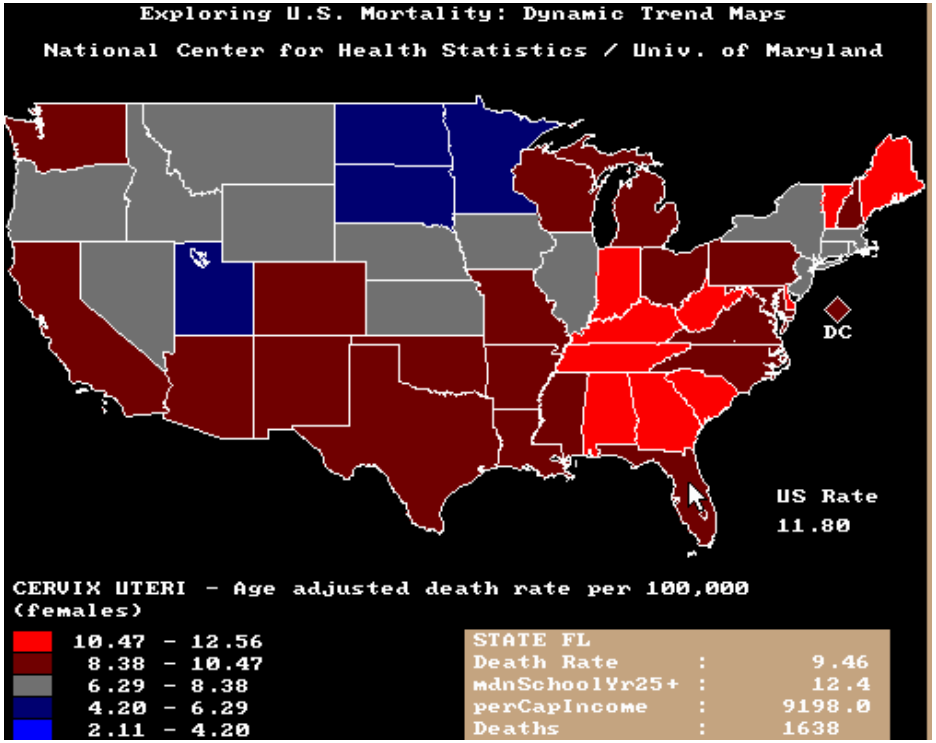
Data Sonification for Users with Visual Impairment: A Case Study with Geo-referenced Data

Haixia Zhao, Catherine Plaisant, Ben Shneiderman
University of Maryland

Jonathan Lazar
Towson University



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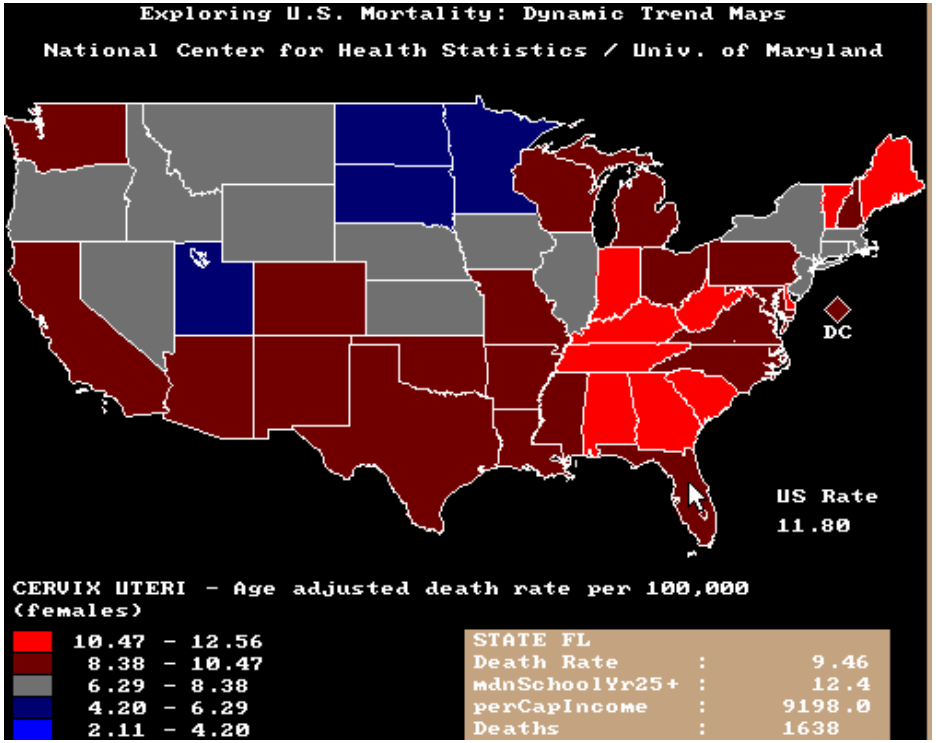

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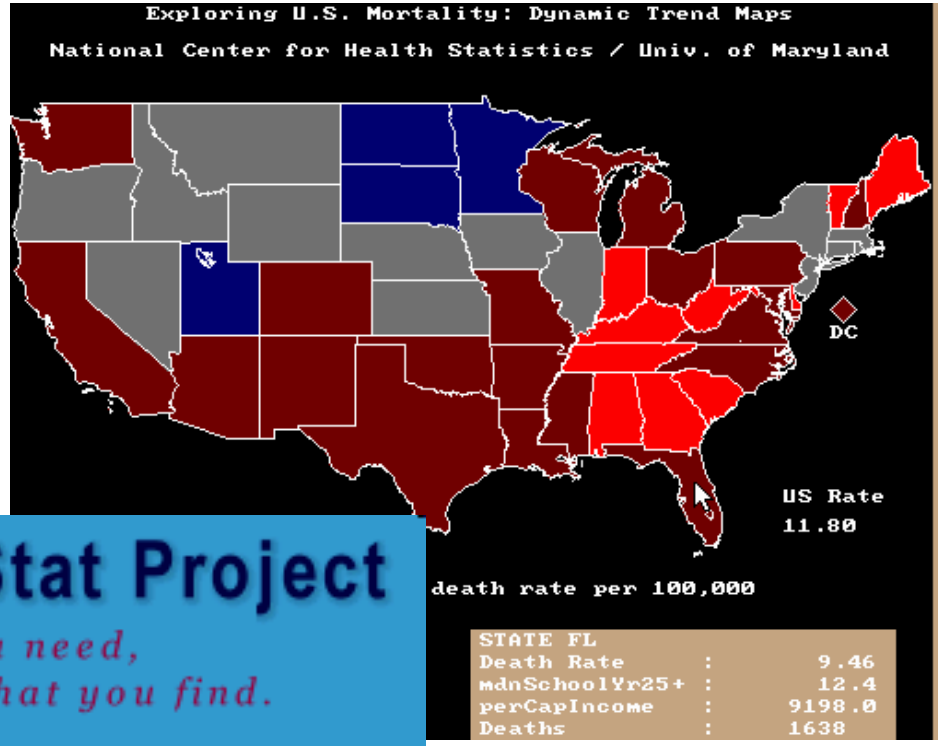
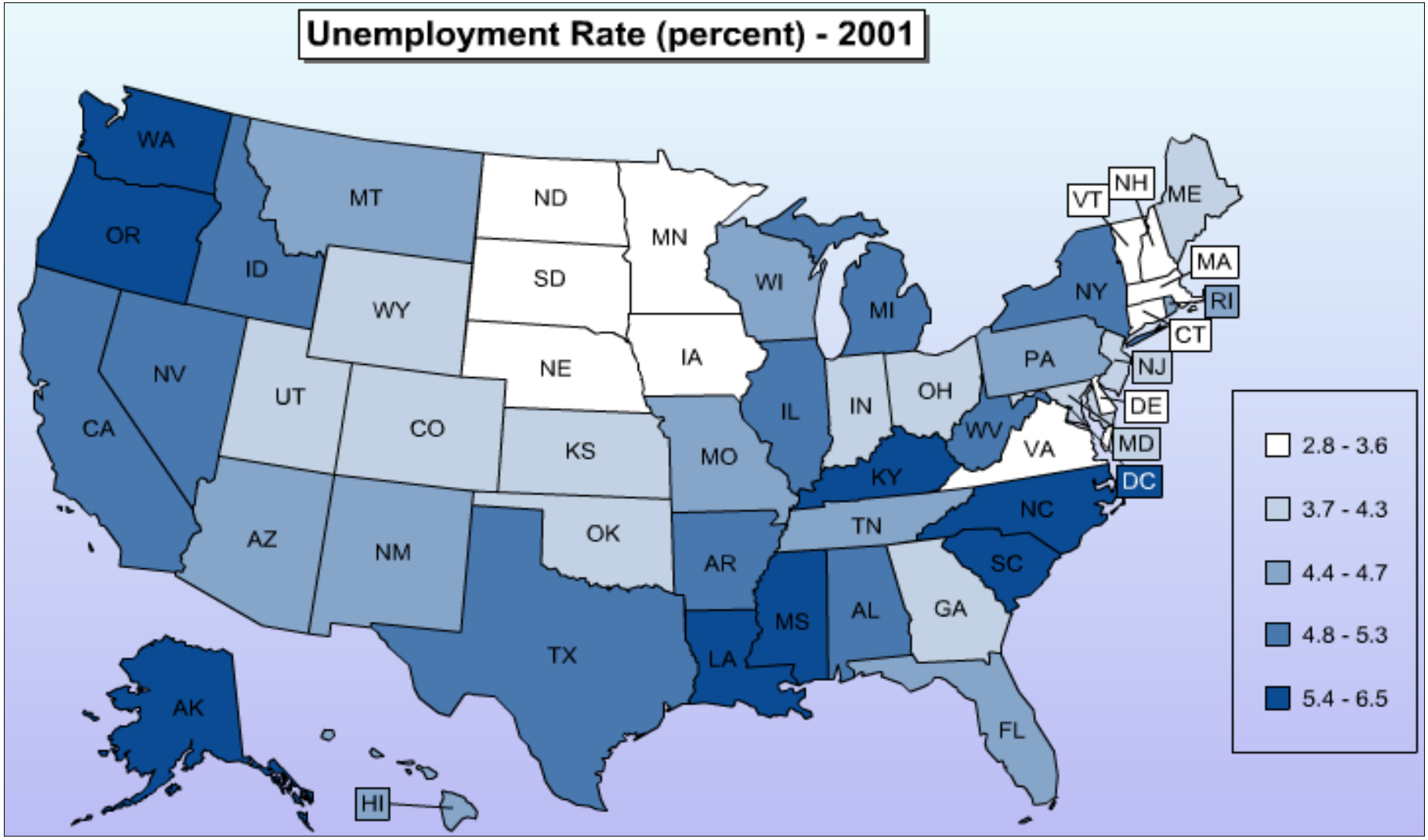


The GovStat Project

Find what you need, understand what you find.

Improve access to government statistics - www.ils.unc.edu/govstat/


Unemployment Rate (percent) - 2001
WA
OR
CA
ID
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CO
NM
ND
SD
NE
KS
OK
TX
MN
IA
MO
AR
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WI
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KY
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OH
WV
GA
FL
SC
NC
VA
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

WA
OR
CA
NV
AK
The New York Times
Tuesday, December 09, 2008
Election Results 2008
Election Results
PRESIDENT
SENATE
HOUSE
GOVERNORS
STATE RESULTS
President Map
SHARE
E-MAIL
Big Board | Map | Electoral Explorer | Obama: Victory Speech | McCain: Concession Speech | Exit Polls
365 Obama
Electoral Votes
Projected Winner
0
undecided
173 McCain
Electoral Votes
Popular vote: 66,862,039
270 needed to win
Popular vote: 58,319,442
State winners
County bubbles
County leaders
Voting shifts
ZOOM IN
Year
'08 '04 '00 '96 '92
Map key
DEMOCRATS
Lead Win
REPUBLICANS
Lead Win
Wash.
Ore.
Calif.
Idaho
Nev.
Mont.
Wyo.
Utah
Ariz.
Colo.
N.M.
N.D.
S.D.
Neb.
Kan.
Okla.
Tex.
Minn.
Iowa
Mo.
Ark.
La.
Wis.
Ill.
Mich.
Ind.
Ohio
Ky.
Tenn.
Miss.
Ala.
Ga.
Fla.
S.C.
N.C.
Va.
W.Va.
Pa.
N.Y.
Me.
D.C.
Alaska
Hawaii
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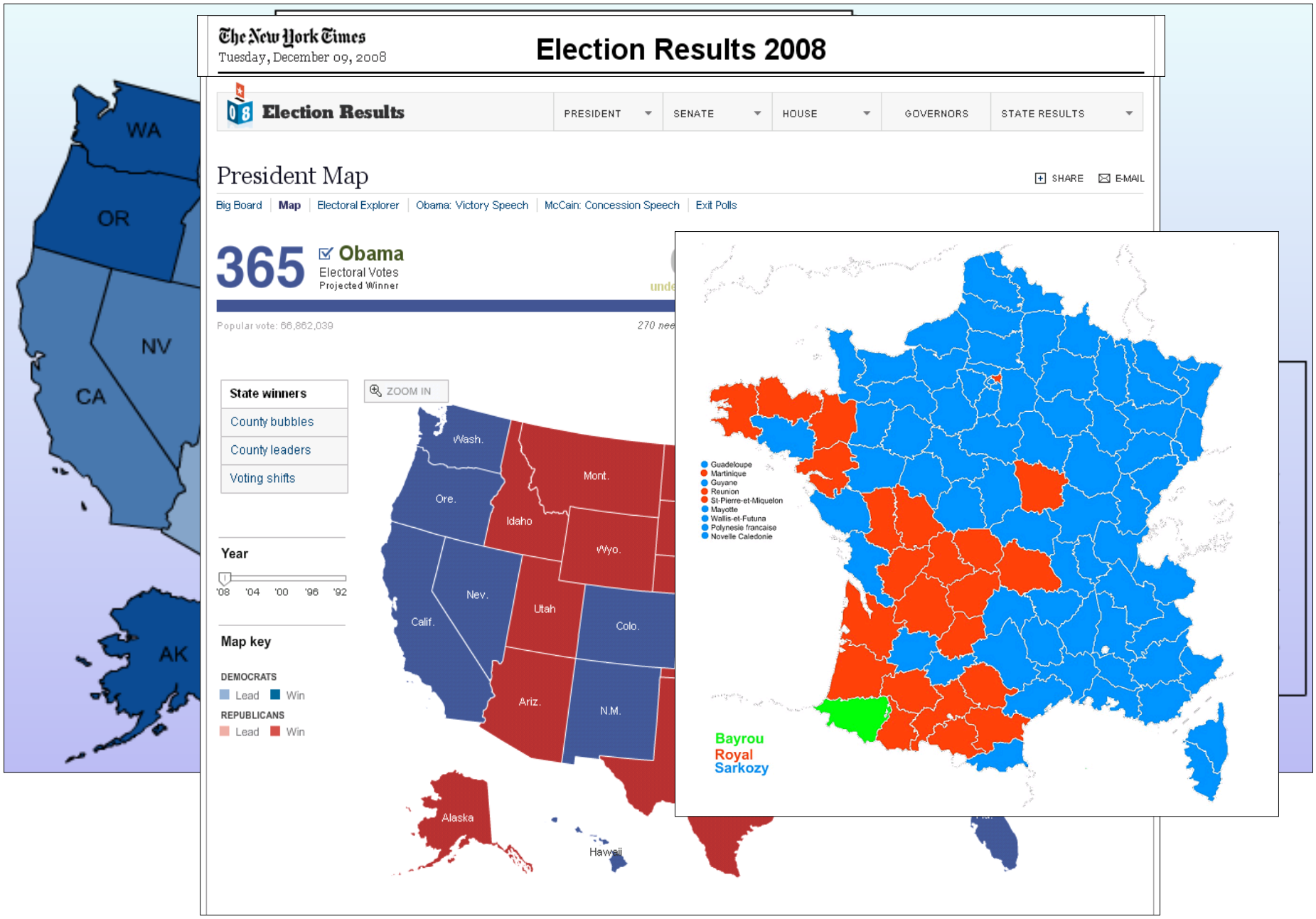
3.7 - 4.3
4.4 - 4.7
4.8 - 5.3
5.4 - 6.5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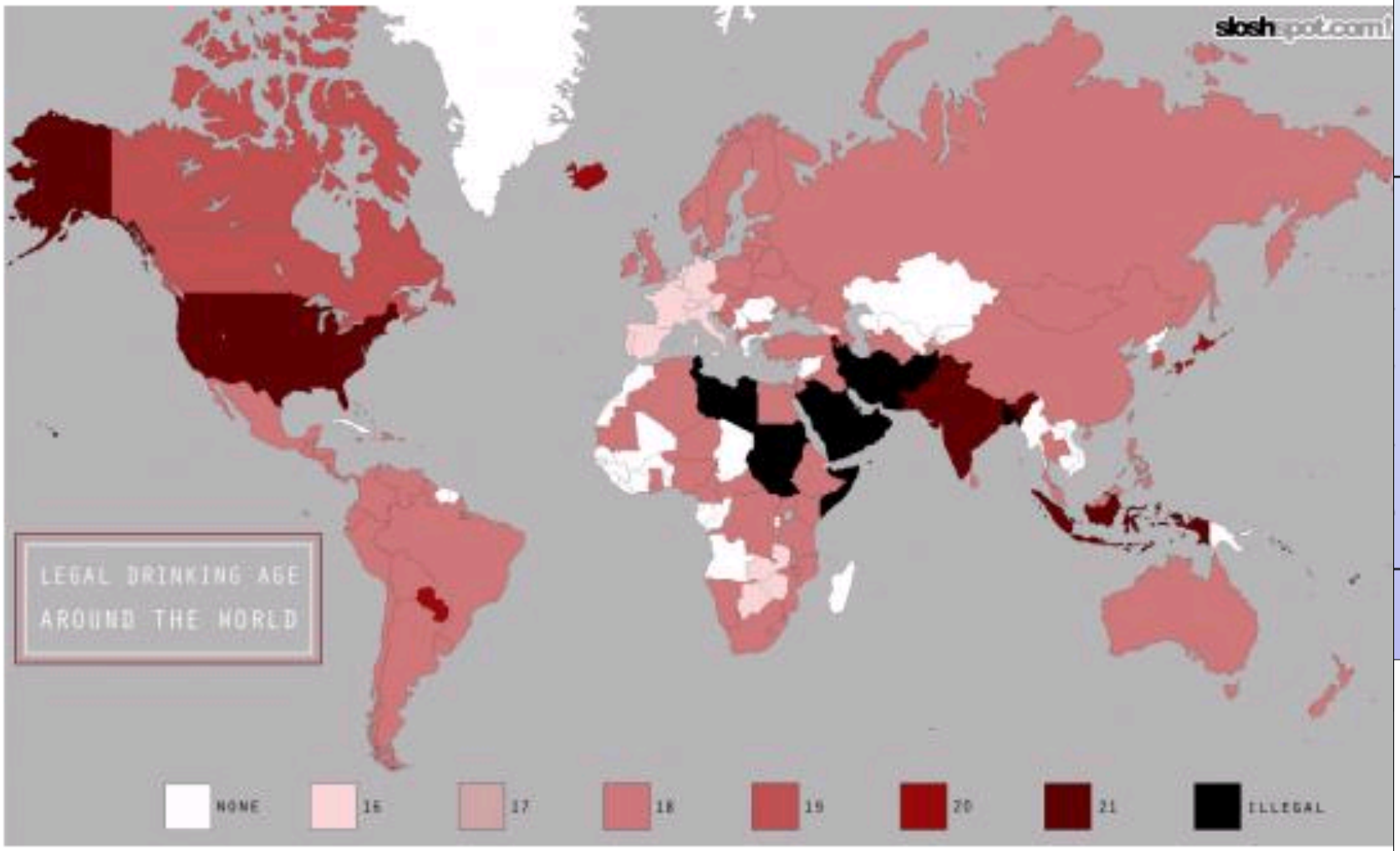
Ariz.
N.M.
Alaska
Hawaii
Guadeloupe
Martinique
Guyane
Reunion
St-Pierre-et-Miquelon
Mayotte
Wallis-et-Futuna
Polynesie francaise
Novelle Caledonie
Bayrou
Royal
Sarkozy

The New York Times
Tuesday, December 09, 2008

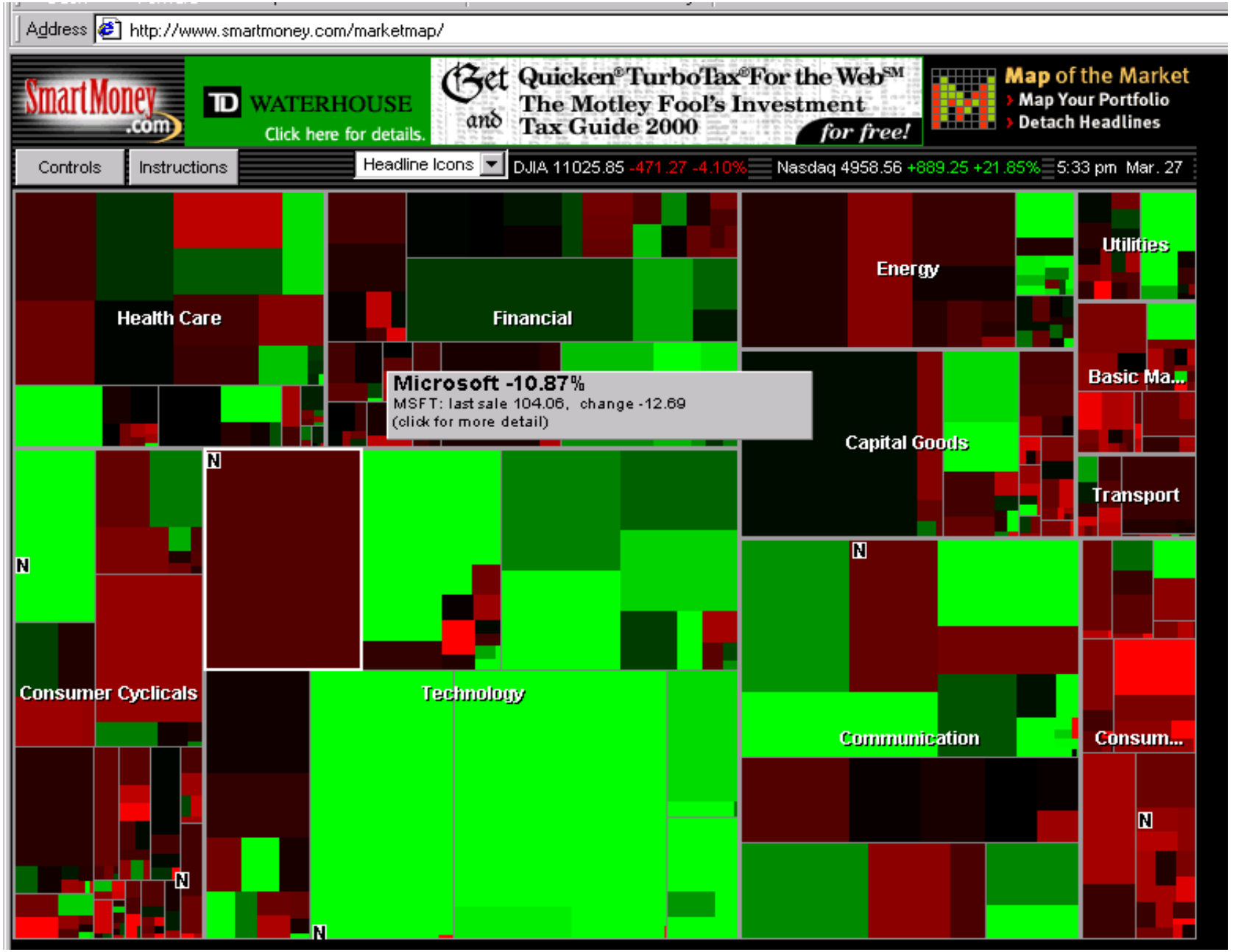
Election Results 2008

Legal Drinking Age Around the World

Posted: 27 Mar 2009 05:46 AM PDT

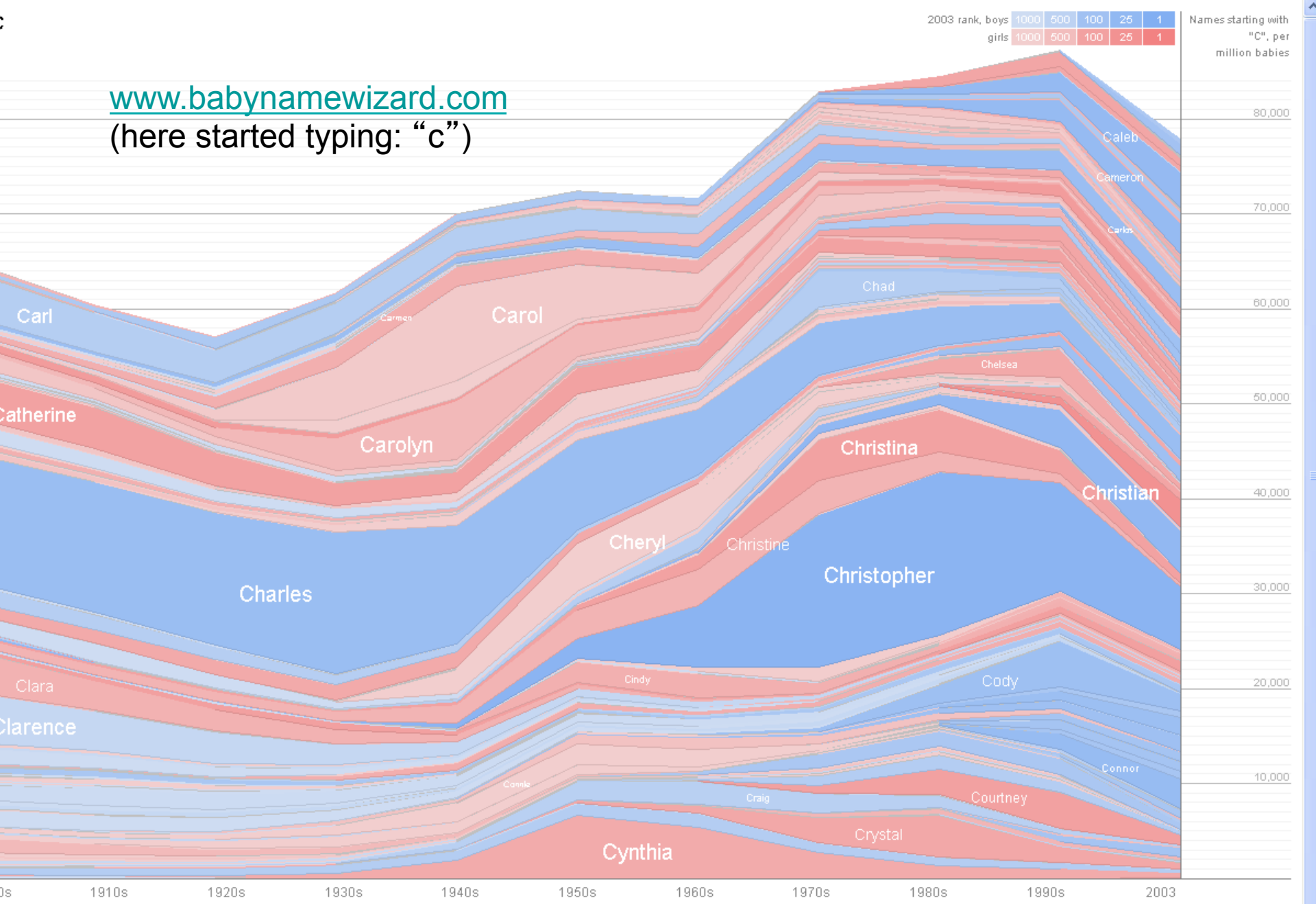


Treemap - Stock market, clustered by industry

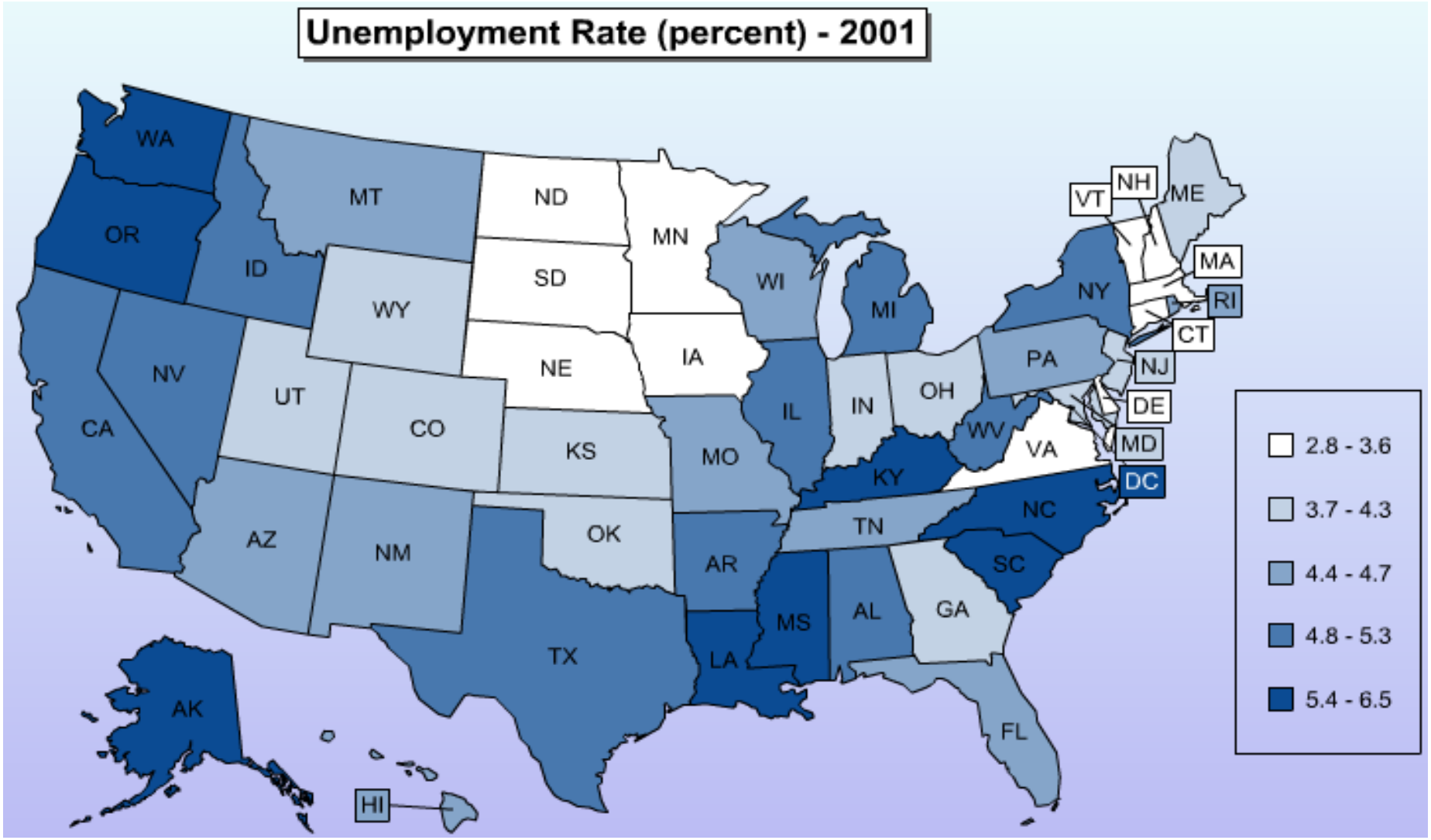


http://babynamewizard.com/namevoy Go Links School's Out UIST 2005 Contest HCIL TikiWiki HomePage 04Contest ACM Babel

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



Buy the complete Wizard name guide at Amazon

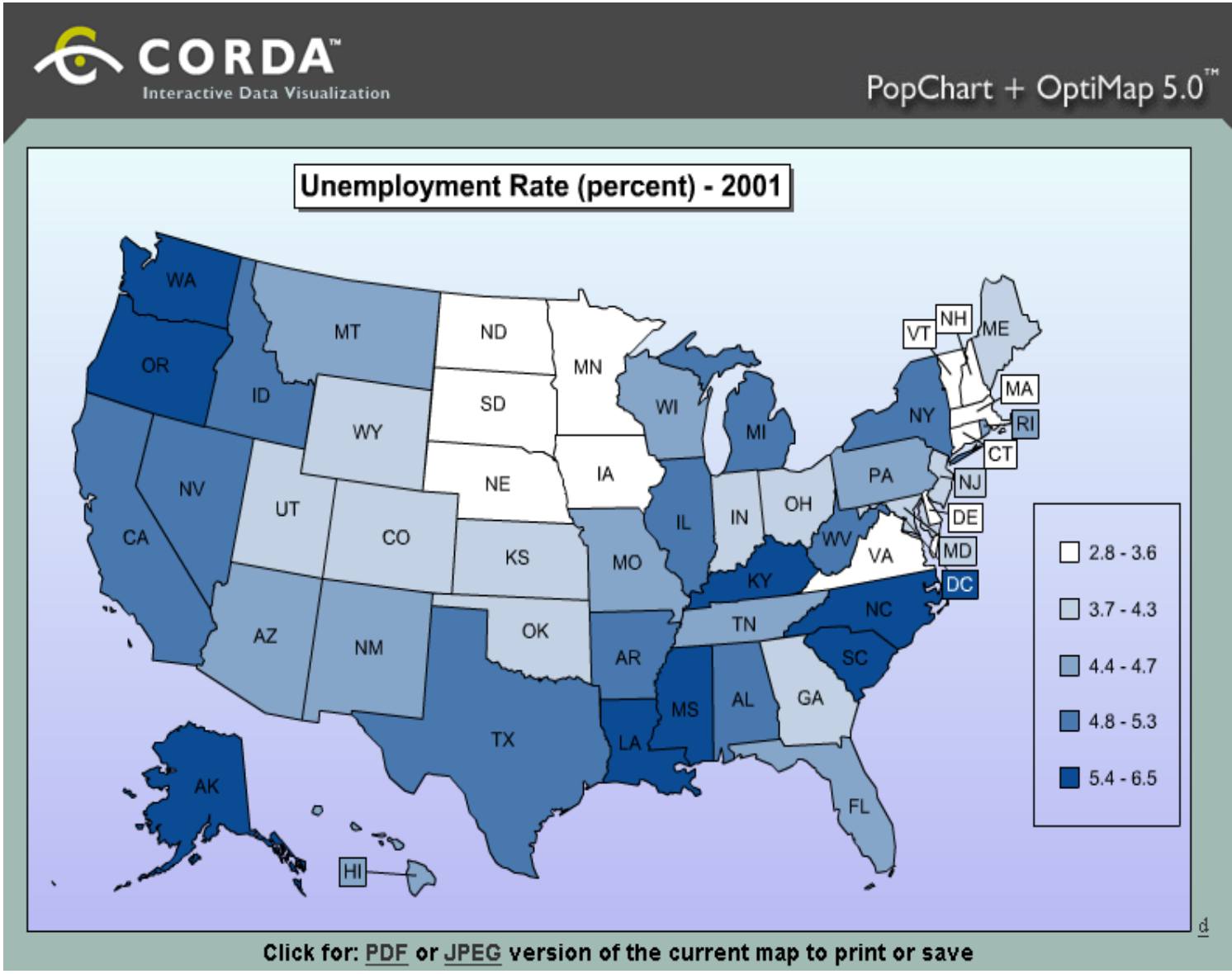


How to make an interactive map such as this accessible?

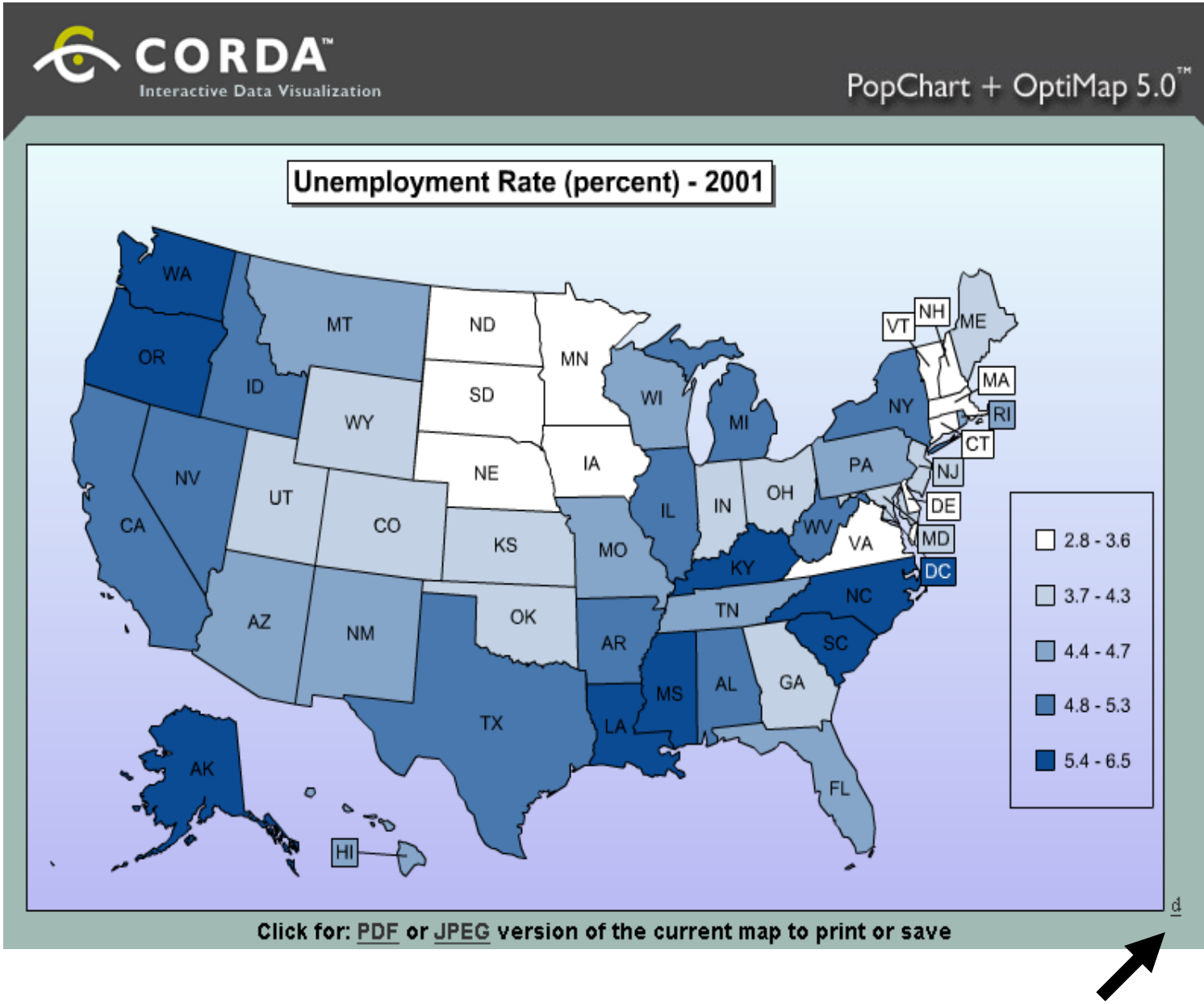
Related work

- 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

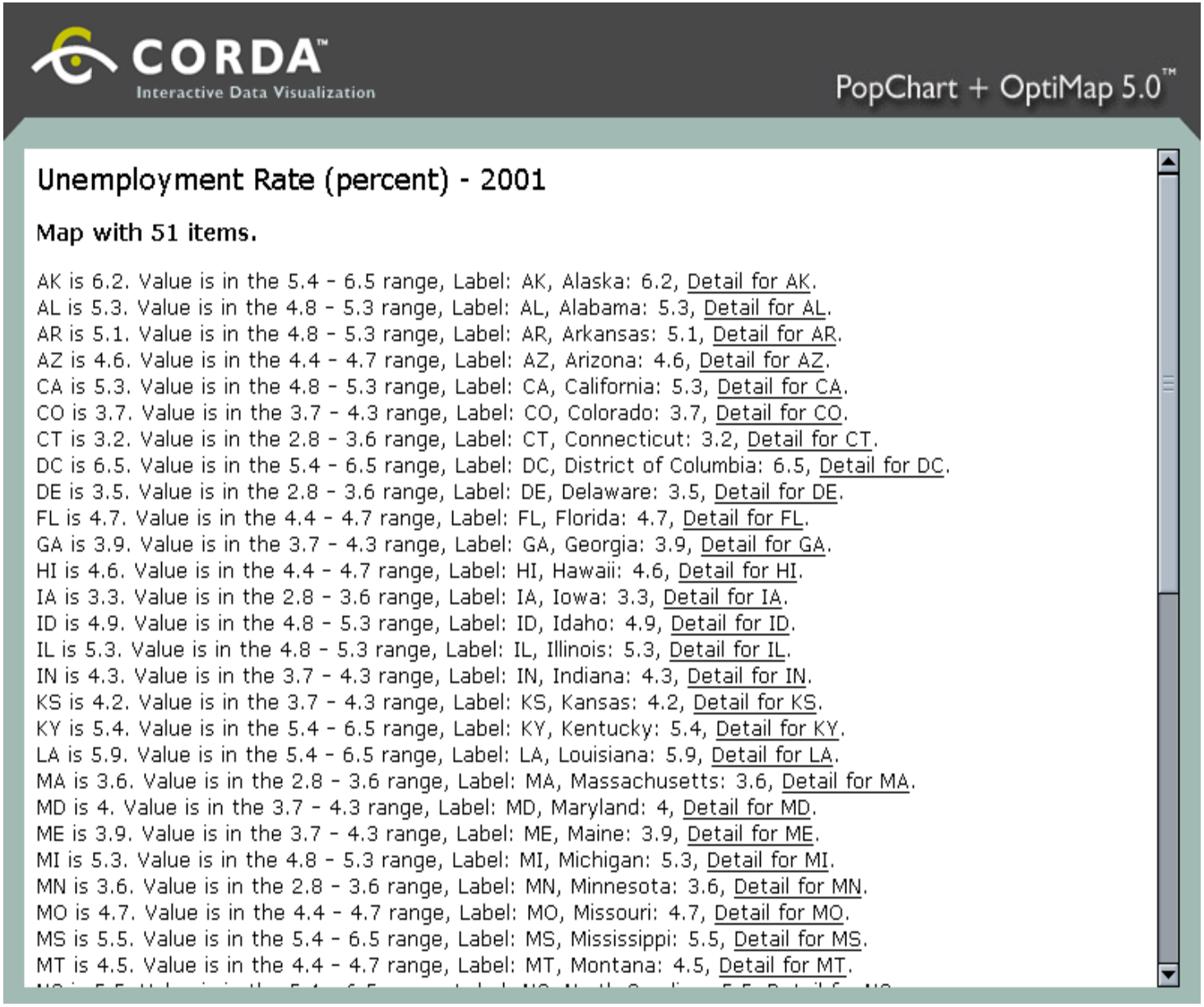


State of the art of citizen web access to statistical info on map

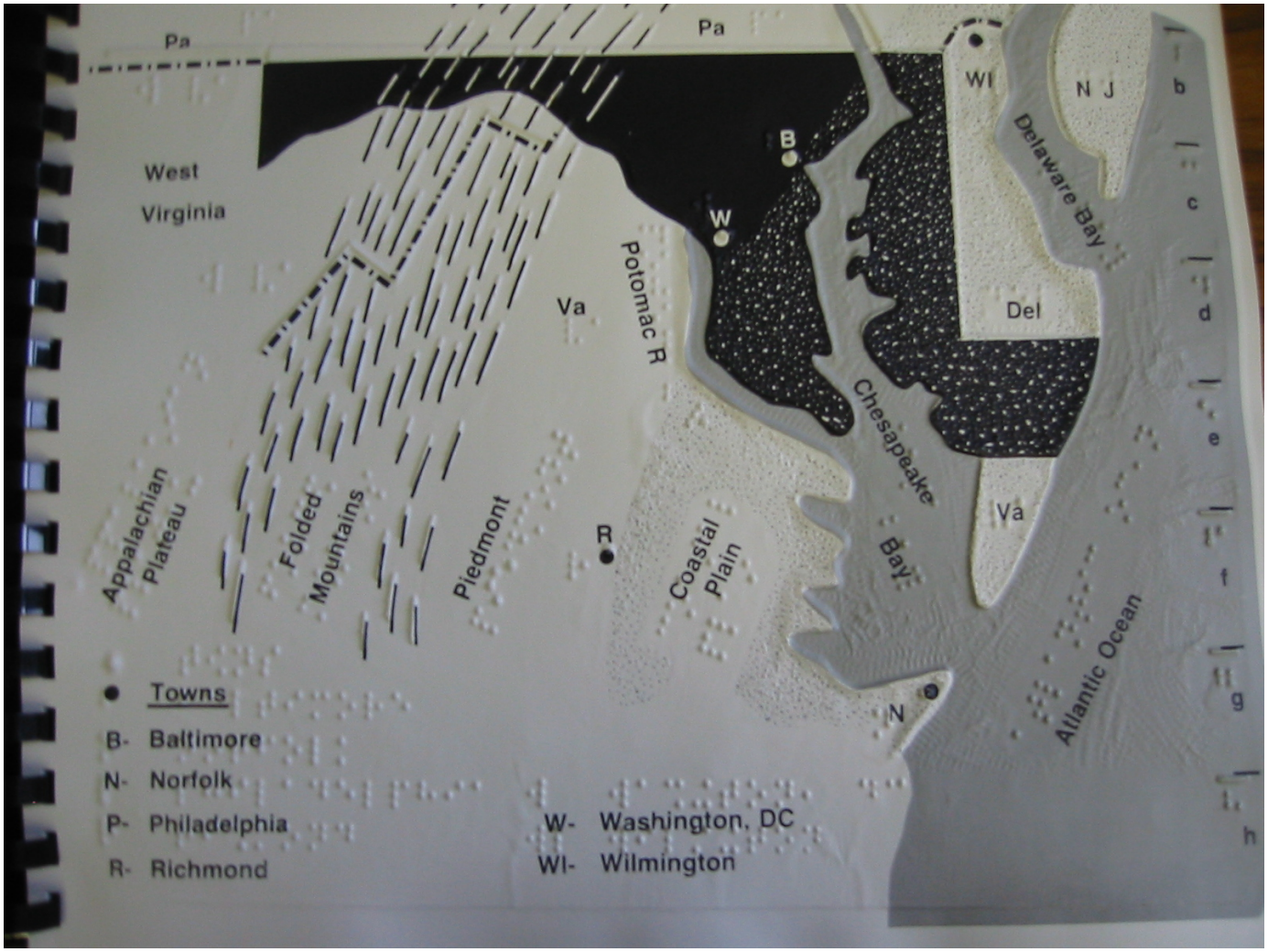


Text version generated automatically

Usable with screen readers

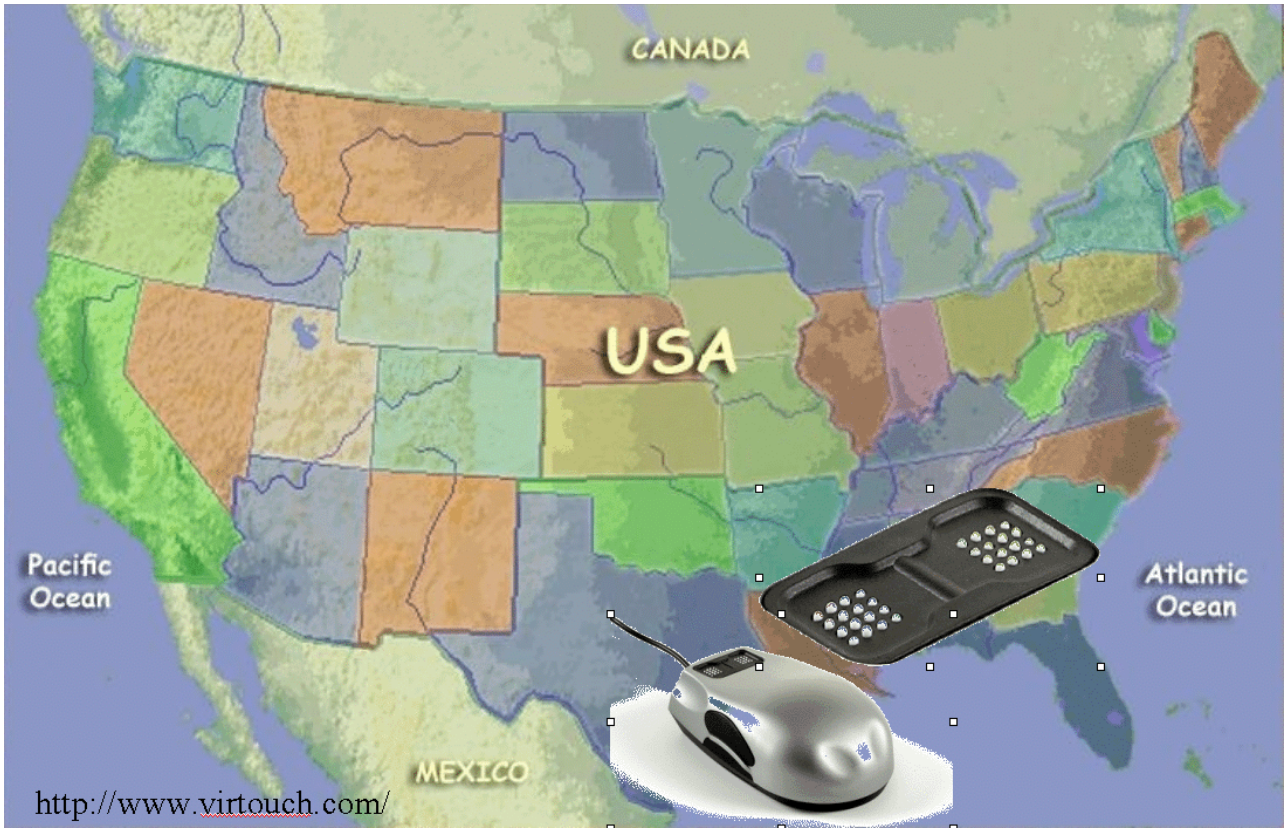


Traditionally, tactile approaches to maps



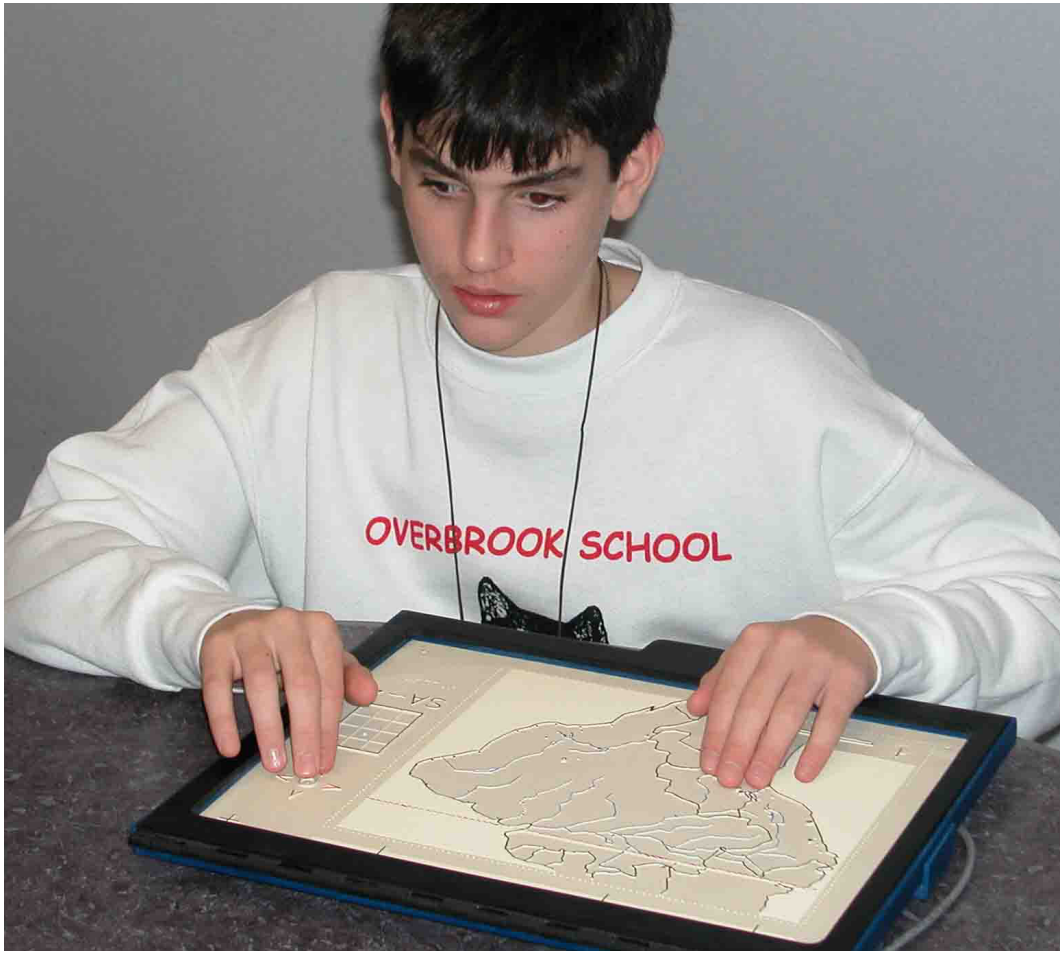
Learning maps with
a printed tactile Braille atlas

Tactile approaches to maps



Braille mouse gives Braille feedback for different regions

Tactile approaches to maps

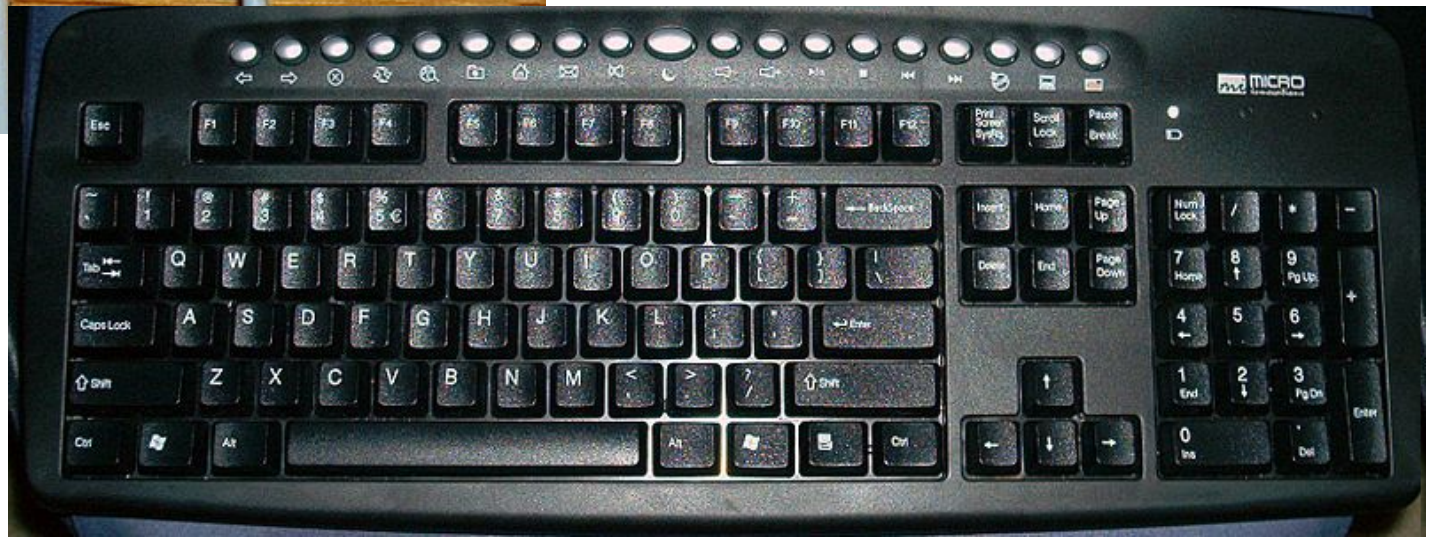


Embossed map attached to touchscreen (www.touchgraphics.com)

but

- All require custom input devices or special printed tactile materials
- i.e. not really providing access for all
- Instead, we use what users have:

L


Esc
F1
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F12
Print Screen SysRq
Scroll Lock
Pause Break
Backspace
Insert
Home
Page Up
Num Lock
Tab
Q
W
E
R
T
Y
U
I
O
P
Delete
End
Page Down
7 Home
8
9 Pg Up
Caps Lock
A
S
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K
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Ctrl
Alt
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Del
Enter

~~Visualization~~

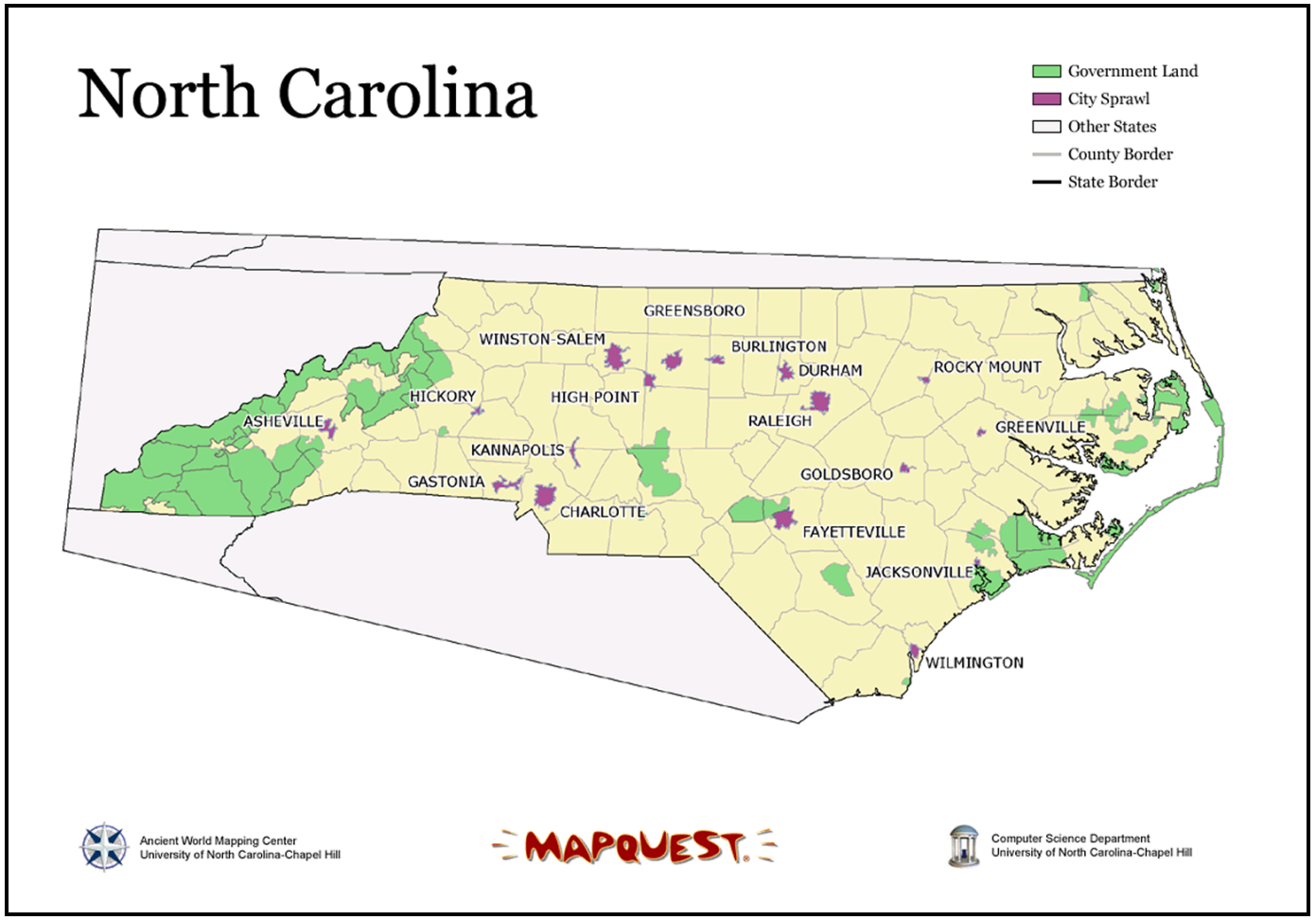
Sonification

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

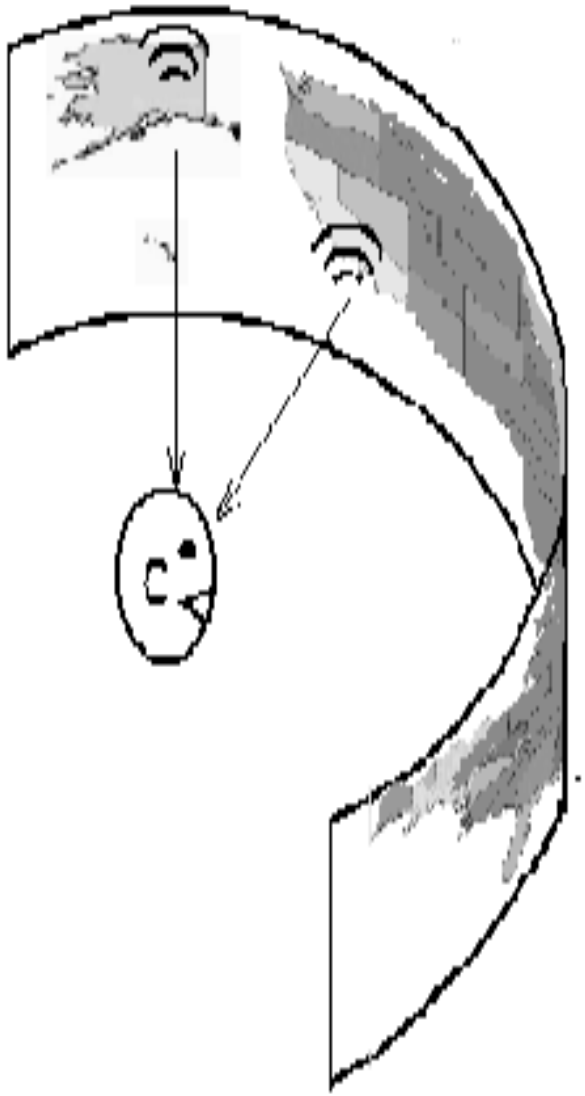


BATS project at UNC

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)

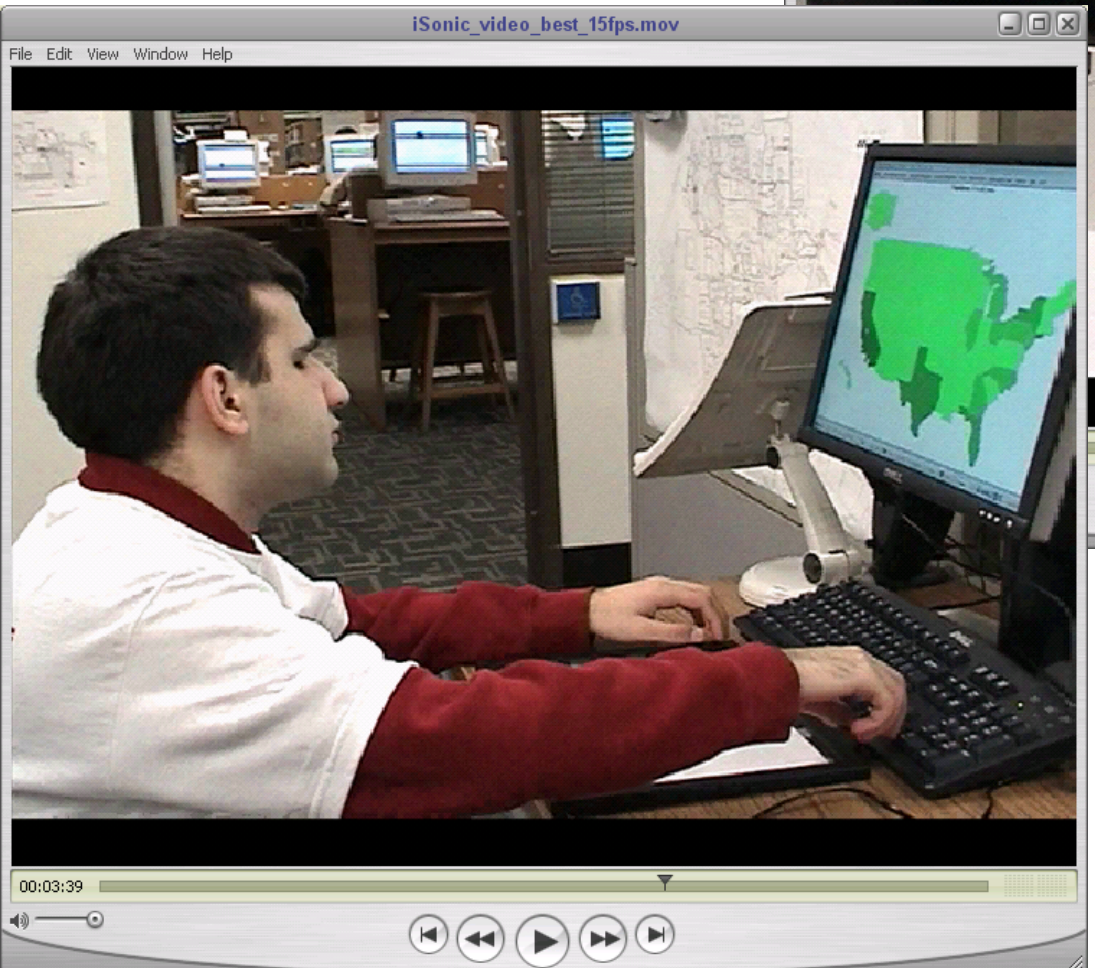
- Second prototype

  Controlled experiment (48 users)
  of 4 design variations

- Third Prototype: iSonic [Presented here]

- Continuous feedback <- design partners

iSonic_video_best_15fps.mov
File Edit View Window Help


iSonic_video_best_15fps.mov
File Edit View Window Help
00:03:39

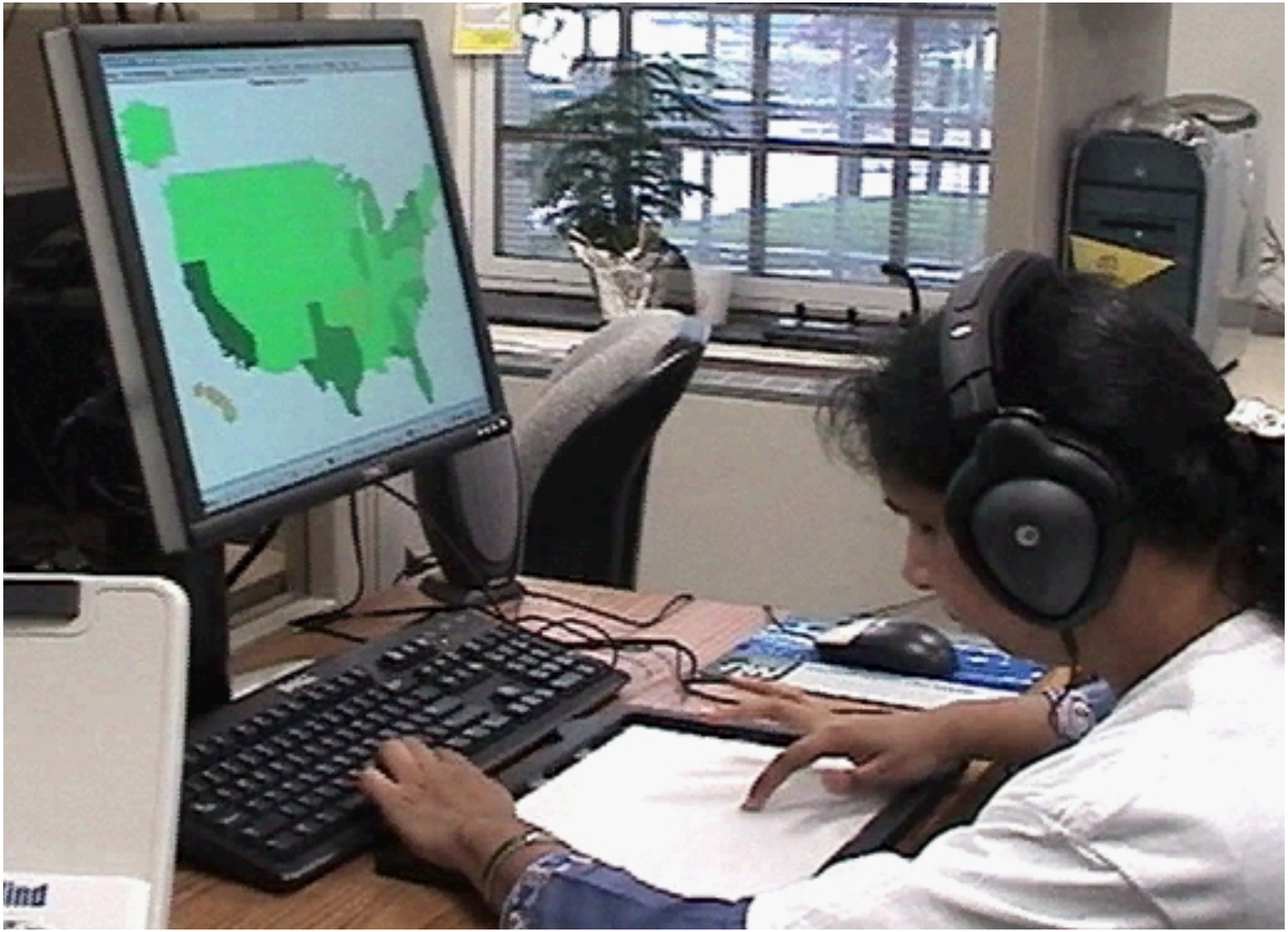
VIDEO

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 geospacial

- 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?

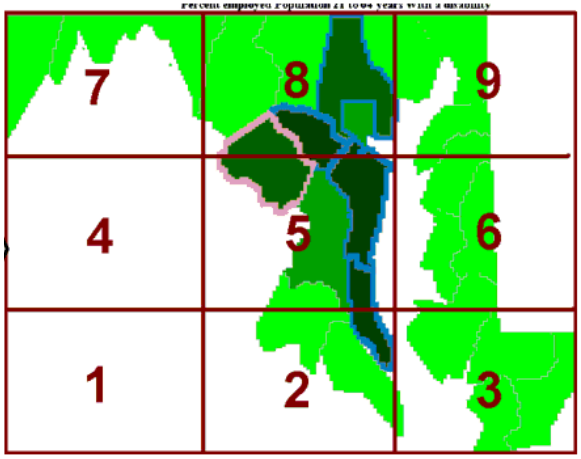
Geospacial

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

- 2nd 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

Maryland
p)

Procedure 2/2: Testing

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  - iSonic preferred over Excel
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  - Similar su
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    (7.9 over 7
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    20% for 5 others (who guessed or gave up)

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

Pro

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  - Similar su
  - iSonic pre
    (7.9 over 7
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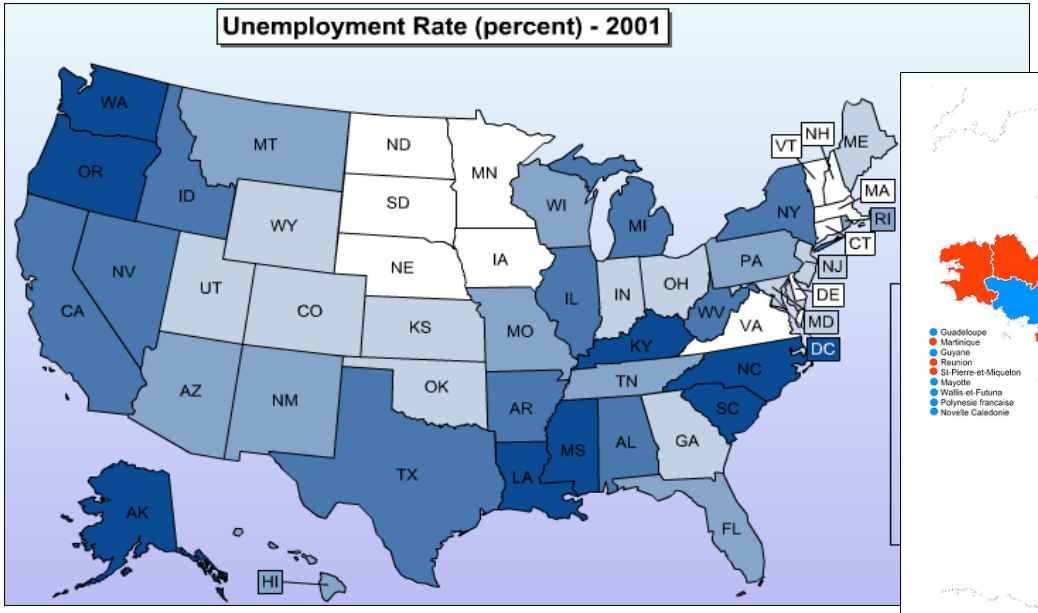
Users did find steps on their own

Exception: correlation (i.e. sorting one column, then listening to other column – with inf. level 1 = only pitch)

- VIDEO AGAIN?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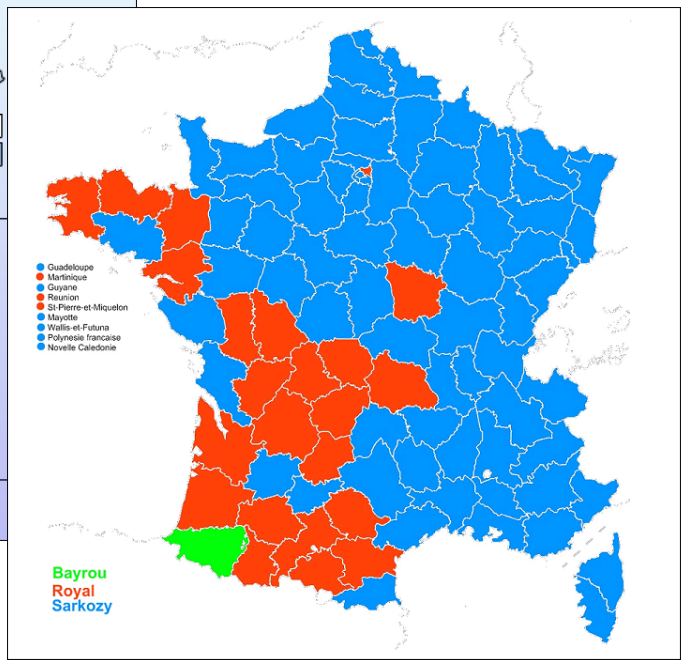
Guadeloupe
Martinique
Guyane
Reunion
St-Pierre-et-Miquelon
Mayotte
Wallis-et-Futuna
Polynesie francaise
Noveile Caledonie
Bayrou
Royal
Sarkozy

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270 needed to win
State winners
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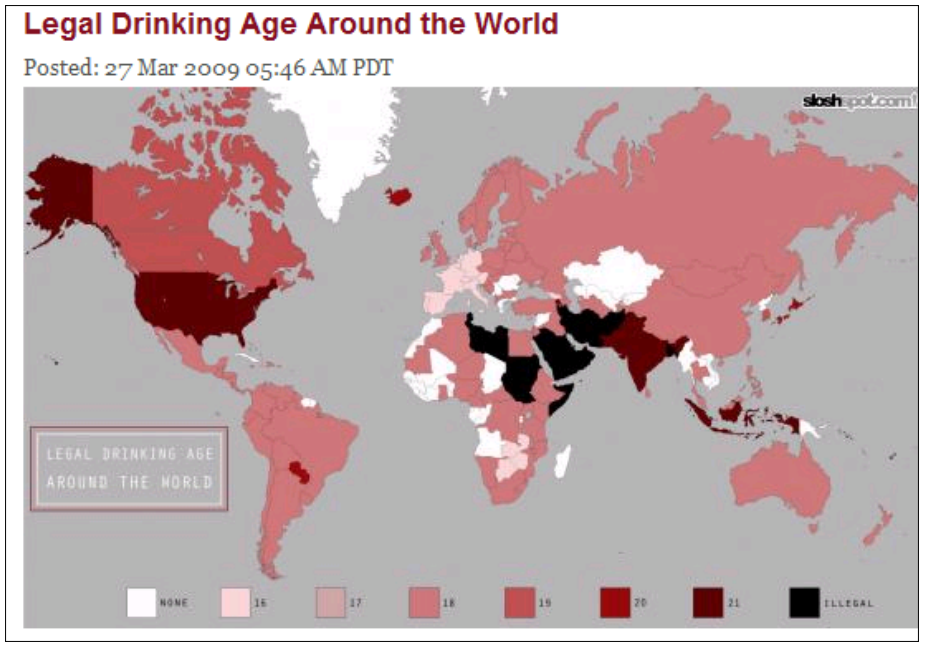
County leaders
Voting shifts
ZOOM IN
Year
Map key
DEMOCRATS
Lead
Win
REPUBLICANS
Lead
Win
D.C.

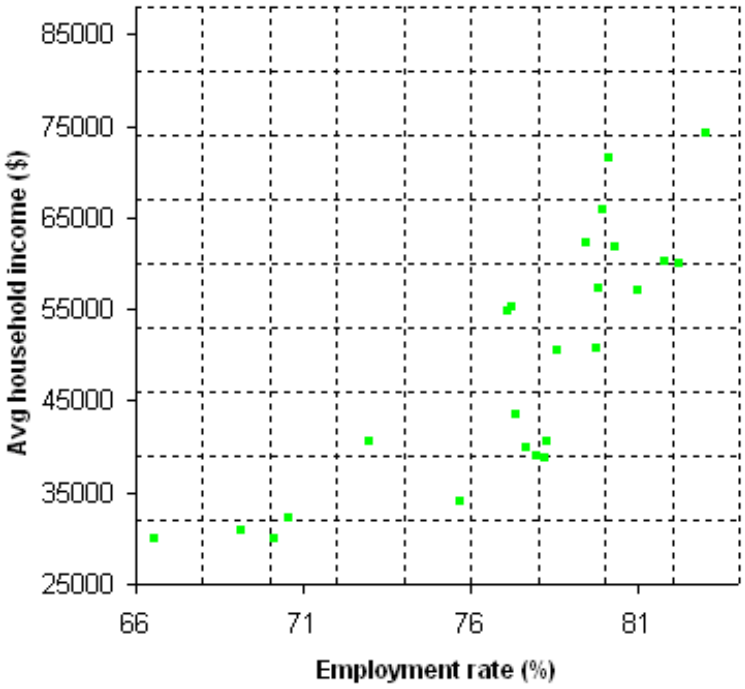

Legal Drinking Age Around the World
Posted: 27 Mar 2009 05:46 AM PDT
sloshspot.com
LEGAL DRINKING AGE AROUND THE WORLD
NONE
16
17
18
19
20
21
ILLEGAL

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

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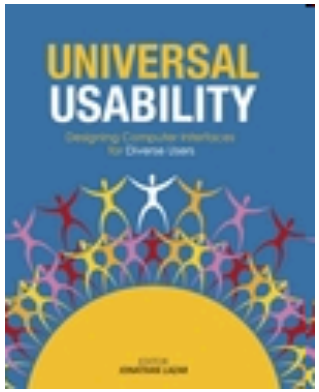
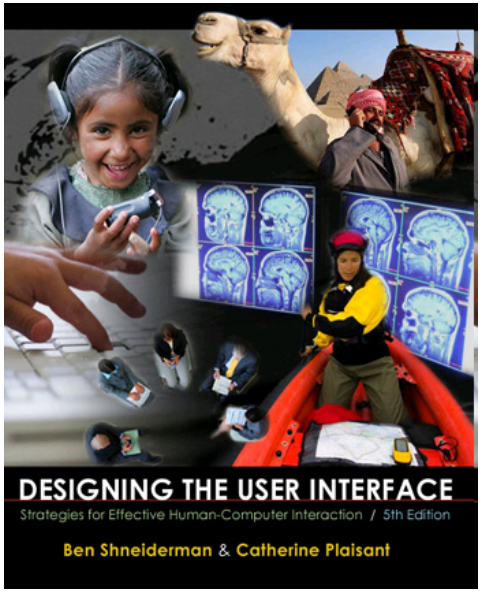
and FYI:

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



Universal Usability
Jonathan Lazar (Ed.)
2007

2009
Designing the User Interface (5th Edition)
Shneiderman and Plaisant
Visit Pearson Education Booth



Stereo Sounds: high pitch = high value

region	Populati...	Population With...	percent Pop...
Prince Georg	479163	69958	14.6
Montgomery	527217	64848	12.3
Baltimore	433820	52058	12.0
Baltimore city	363171	43581	12.0
Anne Arundel	284800	41866	14.7
Howard	151751	19576	12.9
Harford	127011	16511	13.0
Frederick	114675	13761	12.0
Charles	69664	12191	17.5
Washington	70943	10925	15.4
Carroll	86493	10379	12.0
St. Mary's	47934	9539	19.9
Wicomico	47416	9493	20.0

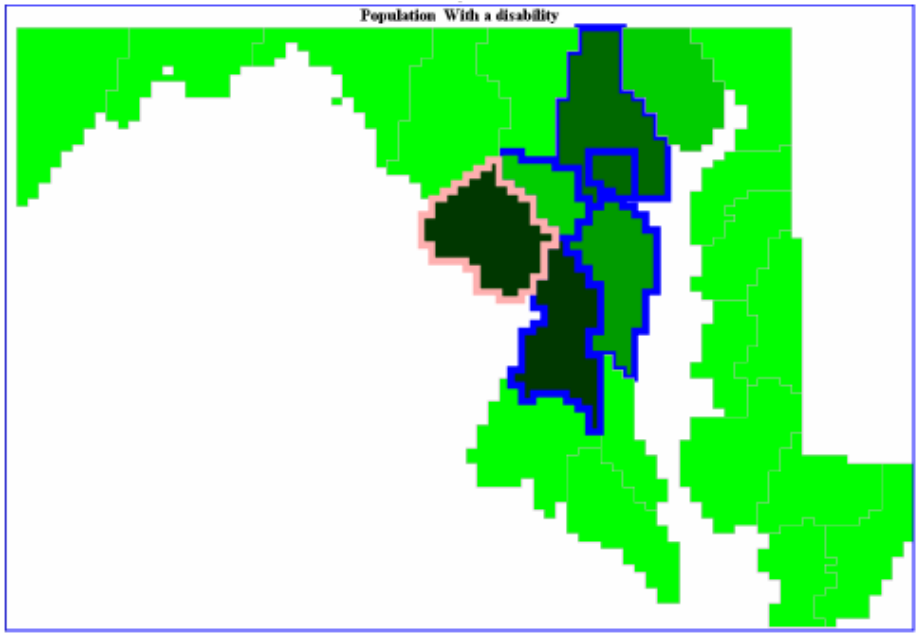


Table and Map

Sweep for overview

region	Populati...	Popula on With...	percent Pop...
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Baltimore	433820	52058	12.0
Baltimore citv	363171	43581	12.0
Anne Arundel	284800	41866	14.7
Howard	151751	19576	12.9
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Charles	69664	12191	17.5
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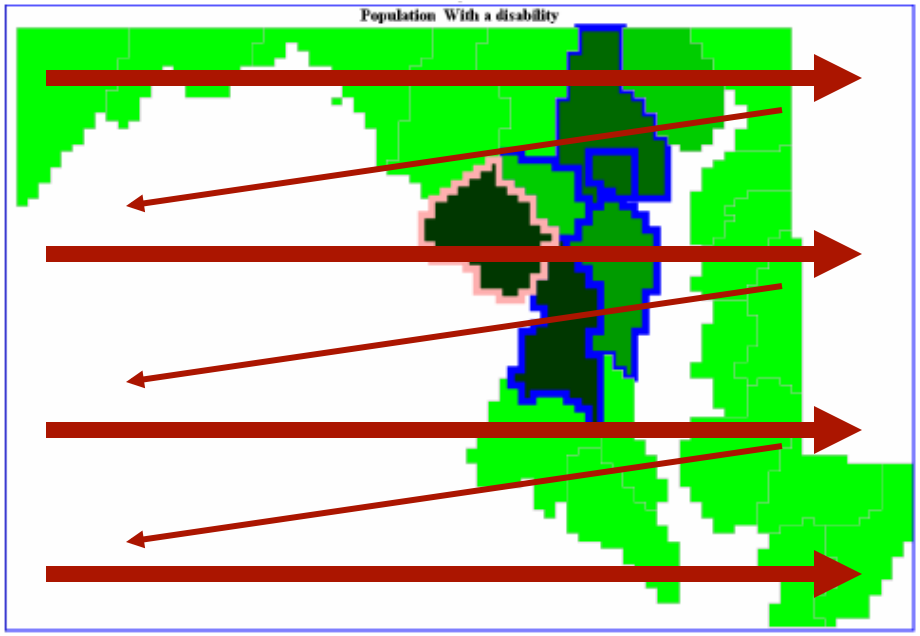
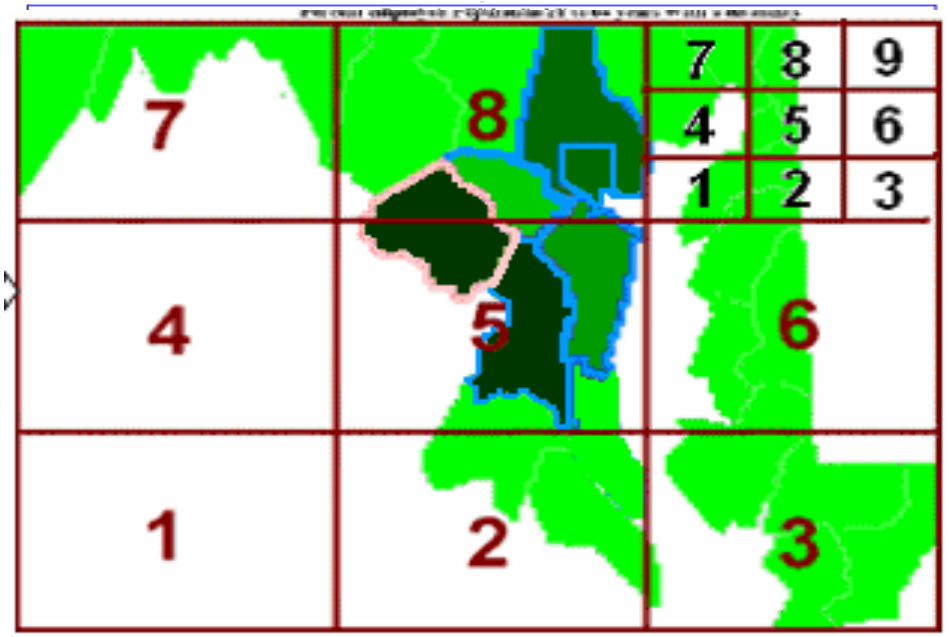
Carroll	86493	10379	12.0
St. Mary's	47934	9539	19.9
Wicomico	47416	9493	20.0



Num Keypad for partial overview

region	Populati...	Population With...	percent Pop...
Prince Georg	479163	69958	14.6
Montgomery	527217	64848	12.3
Baltimore	433820	52058	12.0
Baltimore city	363171	43581	12.0
Anne Arundel	284800	41866	14.7
Howard	151751	19576	12.9
Harford	127011	16511	13.0
Frederick	114675	13761	12.0
Charles	69664	12191	17.5
Washington	70943	10925	15.4
Carroll	86493	10379	12.0
St. Mary's	47934	9539	19.9
Wicomico	47416	9493	20.0



and many more excellent ideas…

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