Useful and Usable
Geovisualization for Crime Analysis
GeoVISTA CrimeViz  http://www.geovista.psu.edu/CrimeViz

an extensible web-based geovisualization application that supports exploration of & sensemaking about criminal activity in space & time
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State College, PA: 18 March 2011
THEORETICAL & APPLIED GISCIENCE

GISCIENCE
THEORY

alters

informs

EVALUATION

APPLICATIONS

permits

Roth & Harrower (2008)
Addressing map interface usability
PRESENTATION STRUCTURE

Part #1
3. Prototyping
4. Interaction & Usability Studies

Useful and Usable Geovisualization

Part #2
Geovisualization for Crime Analysis

Part #3
Tech Transition & the Mission of Science
Part 1: Background
Useful and Usable Geovisualization
GEOVISUALIZATION

Cartography³

MacEachren (1994)
Visualization in modern cartography: Setting the agenda
IMPROVISE
multiple, coordinated views

Weaver et al. (2007)
Visual exploration and analysis of historic hotel visits

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GOOGLE MAPS
one entry point
CARTOGRAPHIC INTERACTION

the dialogue b/w a human and a map mediated through a computing device

human(s)  computing device  map

user-centered  technology-centered  interface-centered
CARTOGRAPHIC INTERACTION: Tech-centered

emphasis on the platform (hardware) on which interaction is provided

computing device

human(s)  user-centered

map  interface-centered

technology-centered
CARTOGRAPHIC INTERACTION: UI-centered

emphasis on the digital tools (software) through which interaction is provided

human(s)  computing device  map
user-centered  technology-centered  interface-centered
USABILITY vs. UTILITY
from usability engineering

Fuhrmann et al. (2005)
Making useful and usable geovisualization

utility
(usefulness)

benchmark tasks

sensemaking

decision support

ease of learning

hypothesis generation

efficiency of use

utility
(ease-of-use)

memorability

flexibility

workload

knowledge construction

insight

error severity

error frequency
USABILITY vs. UTILITY
from usability engineering
USABILITY vs. UTILITY
spatiotemporal crime mapping tools

high usability

high utility

Spot Crime
Oakland Crimespotting
Azavea Hunchlab

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CARTOGRAPHIC INTERACTION: User-centered

emphasis on user’s intentions (needs/goals) for initiating interaction

human(s)

computing device

technology-centered

map

interface-centered

user-centered
INTERACTION SUCCESS

three U’s of interaction success
USER-CENTERED DESIGN (UCD)

1. Work Domain Analysis
2. Conceptual Development
3. Prototyping
4. Interaction & Usability Studies
5. Implementation
6. Debugging

interface design that includes numerous iterations of end user evaluation and subsequent interface revision to improve its usability and utility

Robinson et al. (2005)
Combining Usability Techniques to Design Geovisualization Tools for Epidemiology
USER-CENTERED DESIGN (UCD)

1. Work Domain Analysis
   ↙
2. Conceptual Development
   ↙
3. Prototyping
   ↙
4. Interaction & Usability Studies
   ↙
5. Implementation
   ↙
6. Debugging
   ↙

Discount Interface Evaluation Methods

Nielsen (1992)
The usability engineering life cycle
Part 2: GeoVISTA CrimeViz
Geovisualization for Crime Analysis
**CRIME ANALYSIS**

the systematic collection, preparation, interpretation, and dissemination of information about criminal activity to support the mission of law enforcement

"At present, the most under-researched area of spatial criminology is that of spatio-temporal crime patterns"

Ratcliffe (2009: 14)

_Crime Mapping: Spatial & Temporal Challenges_
USER-CENTERED DESIGN (UCD)

1. Work Domain Analysis
   → 2. Conceptual Development
      ↓ 3. Prototyping
         ↓ 4. Interaction & Usability Studies
            ↓ 5. Implementation
               ↓ 6. Debugging

1. Prototyping
   ↓ 2. Interaction & Usability Studies
      ↓ 3. Work Domain Analysis
         ↓ 4. Conceptual Development
            ↓ 5. Implementation
               ↓ 6. Debugging
• only have initial seed money for a limited prototype
• a design or consulting firm joins midway through a project
• lack of initial access to targeted end users
• targeted audience is poorly defined (or does not yet exist)
• initial application was designed for a constrained set of users and purposes but must now be made more general or transitioned to other domains
USER-CENTERED DESIGN (UCD)

1. Prototyping
2. Interaction & Usability Studies
3. Work Domain Analysis
4. Conceptual Development
5. Implementation
6. Debugging

Study #1:
Think Aloud Study

Study #2:
Needs Assessment Interviews

Study #3:
User Satisfaction Survey

Study #4:
In-depth Case Study (in progress)
STUDY #1: Discount Think Aloud Activity

users are asked to complete a set of benchmark tasks with an application and to describe verbally why they are doing what they are doing

Participants: n=5, varying level of experience with spatiotemporal visualization

Data Collection: one administrator, two note takers recording critical incidents

Think Aloud Protocol (60 minutes):

• Introduction (5 minutes)
• Opening (5 minutes)
• Tasks (35-40 minutes)
• Cognitive interview (10-15 minutes)
**STUDY #1: Think Aloud Results**

**Improvement #1:**
Identify Missing Functionality or Key Impediments to Use

**Improvement #2:**
Adding Support for Each Anticipated Spatiotemporal Task

**Improvement #3:**
Improving Scalability by Providing Spatial Aggregates
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STUDY #2: Needs Assessment Interviews

one-on-one interviews to assess the current crime analysis practice of law enforcement agencies, focusing on currently met and unmet needs

**Participants:** 9 analysts or decision-makers at 6 municipal and 1 federal law enforcement agency

**Data Collection:** one interviewer, audio recorded for later transcription/codification

**Think Aloud Protocol (60 minutes):**

- Introduction & Background Survey (10 minutes)
- Data Information Characteristics (5 minutes planned)
- Mapping and Analysis Practices (20 minutes)
- Use (10 minutes)
- Follow-up survey about the CrimeViz prototype
# STUDY #2: Qualitative Data Analysis

<table>
<thead>
<tr>
<th>Participant #</th>
<th>DATA</th>
<th>CARTOGRAPHIC REPRESENTATION</th>
<th>CARTOGRAPHIC INTERACTION</th>
<th>SPATIAL ANALYSIS</th>
<th>TEMPORAL ANALYSIS</th>
<th>USE</th>
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</tbody>
</table>

**C1: data**

**C2: cartographic representation**

**C3: cartographic interaction**

**C4: spatial analysis**

**C5: temporal analysis**

**C6: map use**
STUDY #2: Interview Results (1 of 2)

Data
- datasets are voluminous and multivariate
- geocoding approach varies and is not completed by all agencies
- data quality hinges on reporting officer, often using paper forms

Representation
- “push-pin” maps are most common; time represented by coloring pins
- “hot spot maps” also common, with direct aggregation to arbitrary grid (not KDE)
- choropleth maps specifically avoided

Interaction
- overall use of interactive maps is limited; only employed by dedicated analysts
- positive view towards web mapping services, although little use
- several agencies employ interactive maps for CompStat meetings
STUDY #2: Interview Results (2 of 2)

**Spatial Analysis**
- overall very limited due to time constraints of analysts
- buffering and journey-to-crime analysis most common
- one reported use of spatial scan statistics (SaTScan & GeoDA)

**Temporal Analysis**
- extreme variation across agencies, although most departments of some form of time series analysis
- two agencies regularly apply advanced analysis, which includes aoristic analysis, predictive trend analysis, & spatio-temporal scan statistics

**Map Use**
- mostly tactical, gaining a situational awareness of current patterns (7-30 days only)
- few agencies have the personnel to conduct strategic analysis
- thus, tools must integrate into workflows and improve efficiency
STUDY #3: User Survey, Usability Results

professional crime analysts and decision-makers are asked to test out the tool on their own and respond to a series of Likert-based questions.

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree (2)</th>
<th>(3)</th>
<th>No Opinion (5)</th>
<th>(6)</th>
<th>Strongly Agree</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>I thought CrimeViz was easy to use.</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>10%</td>
<td>70%</td>
<td>6.4</td>
</tr>
<tr>
<td>I think that most people would learn to use the CrimeViz quickly</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>10%</td>
<td>30%</td>
<td>6.2</td>
</tr>
<tr>
<td>I was often confused about what to click or where to look when using CrimeViz</td>
<td>50%</td>
<td>30%</td>
<td>0%</td>
<td>0%</td>
<td>10%</td>
<td>2.3</td>
</tr>
<tr>
<td>I think that I would need the support of a technical person to be able to use the CrimeViz prototype.</td>
<td>50%</td>
<td>30%</td>
<td>10%</td>
<td>10%</td>
<td>0%</td>
<td>1.8</td>
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</table>
**STUDY #3: User Survey, Utility Results**

Professional crime analysts and decision-makers are asked to test out the tool on their own and respond to a series of Likert-based questions.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>(2)</th>
<th>(3)</th>
<th>No Opinion</th>
<th>(5)</th>
<th>(6)</th>
<th>Strongly Agree</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>CrimeViz has all the necessary functions to explore incident data</td>
<td>0%</td>
<td>30%</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
<td>20%</td>
<td>10%</td>
<td>4.2</td>
</tr>
<tr>
<td>CrimeViz has all the necessary functions to analyze incident data</td>
<td>10%</td>
<td>20%</td>
<td>20%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>20%</td>
<td>4.0</td>
</tr>
<tr>
<td>CrimeViz does not support the type of work that I typically do</td>
<td>50%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
<td>20%</td>
<td>10%</td>
<td>0%</td>
<td>2.9</td>
</tr>
<tr>
<td>I do not think I would use CrimeViz frequently</td>
<td>20%</td>
<td>10%</td>
<td>10%</td>
<td>30%</td>
<td>10%</td>
<td>20%</td>
<td>0%</td>
<td>3.6</td>
</tr>
</tbody>
</table>
Part 3: Outlook
Tech Transition & the Mission of Science
STUDY #4: In-depth Case Study

research and development collaboration with the Harrisburg Bureau of Police for the technology transition & continued evaluation of CrimeViz

Harrisburg Bureau of Police Participants:

- 3 captains
- 2 supervising officers (corporal level)
- 3 information technology personnel
- 2 network personnel
- 1 GIS intern

Data Collection:

- ~monthly remote meetings that includes structured input on paper mockups and early prototypes
- participant observation (planned)
- interaction studies (planned)
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THEORETICAL & APPLIED GISCIENCE

GISCIENCE THEORY

alters

EVALUATION

informs

APPLICATIONS

permits
THEORETICAL & APPLIED GISCIENCE

GISCIENCE THEORY

informs

PRACTICE

alters

APPLICATIONS

permits

EXPERIMENTATION

alters

EVALUATION
USER MOTIVATION

Roth & Harrower (2008)
Addressing map interface usability

INTERFACE COMPLEXITY

USER MOTIVATION

SUCCESS

FAILURE

FAILURE
OUTLOOK: Controlled Interaction Study

identification and elaboration of prototypically successful interaction strategies in support of standardized user tasks
learn more about the project & try out the application at:
http://www.geovista.psu.edu/CrimeViz/

Thanks for your attention!

This material is based upon work supported by the U.S. Department of Homeland Security under Award #2009-ST-061-CI0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security.