



The effectiveness of uncertainty visualization in a “Coordinated Multiple View” environment using a temporal dataset (case study)

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Structure

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2. State of the Art
 1. CMV
 2. Uncertainty Visualization
3. Implementation
4. Evaluation
 1. Experiment
 2. Results
5. Discussion

1 Motivation

- Big amounts of (complex) data, bigger proportions of uncertain data
- Coordinated Multiple Views (CMV) are the perfect exploration environment for complex data

Research objective:

- Analysis of methods to effectively, efficiently and satisfying visualize uncertainty in CMV
- Integrated uncertainty vs. additional uncertainty view

2 State of the Art

2.1 CMV

Definition:

- A CMV is a “specific exploratory visualization technique that enables the user to explore their data” (Roberts, J. C., 2007)
 - To visualize complex data
 - Different visualization forms show different perspectives of the data
 - Interaction allows the user to adopt the visualization

→ Example

2 State of the Art

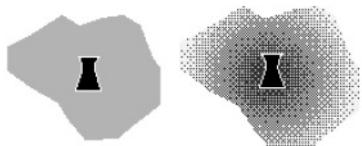
2.1 Uncertainty Visualization

Definition uncertainty:

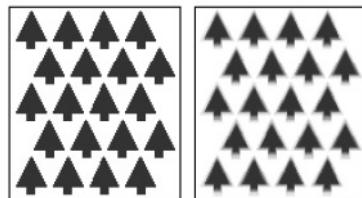
- “The difference between a real geographic phenomenon and the user’s understanding of the geographic phenomenon” (Longley, P. A. et al. 2005).
 - Often also denoted as „data quality“
- Originates from data acquisition, transformation or visualization process

Definition uncertainty visualization:

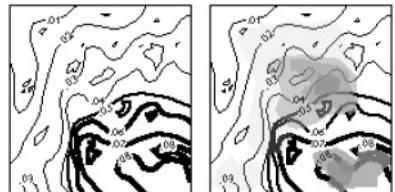
- „The process to display data together with assisting uncertainty information in order to aid the user in data analysis and decision making“ (Pang, A. T., 1996).



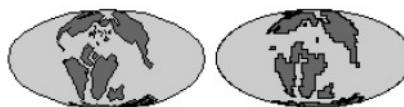
a) Contour crispness



b) Fill clarity



c) Fog



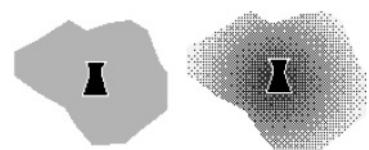
d) Resolution

[1]

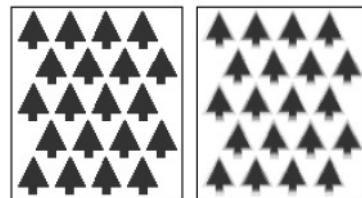
[2]

[3]

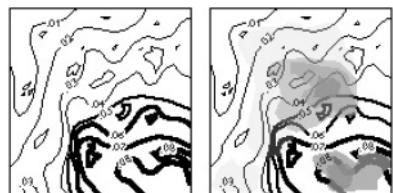
[4]



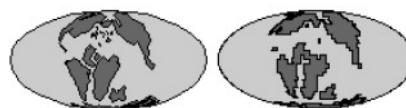
a) Contour crispness



b) Fill clarity

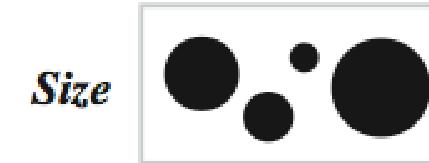


c) Fog



d) Resolution

[1]



Size

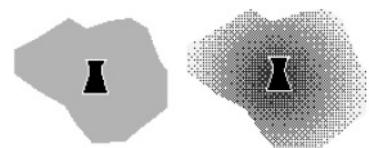


*Color
Hue*

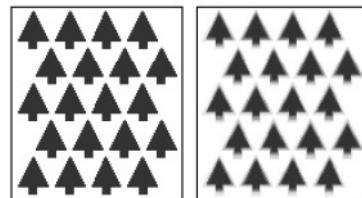
[2]

[3]

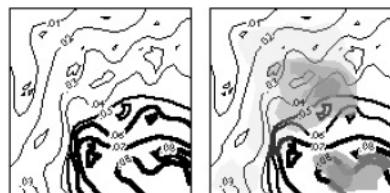
[4]



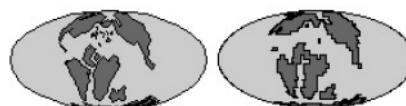
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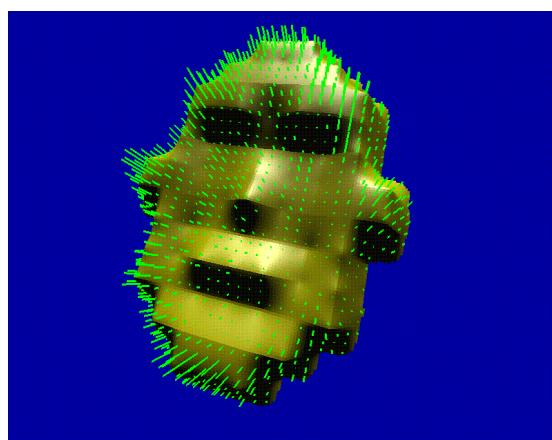


c) Fog

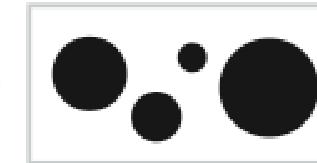


d) Resolution

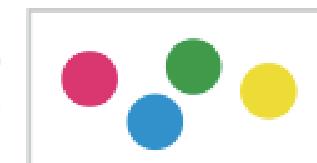
[1]



[3]



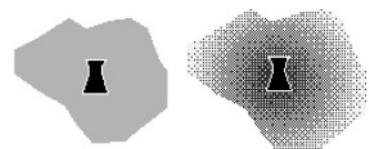
Size



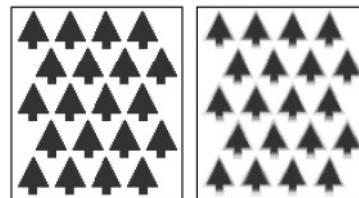
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[2]

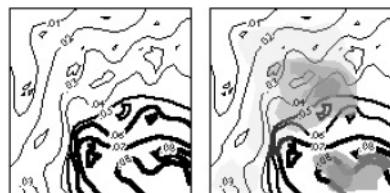
[4]



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b) Fill clarity

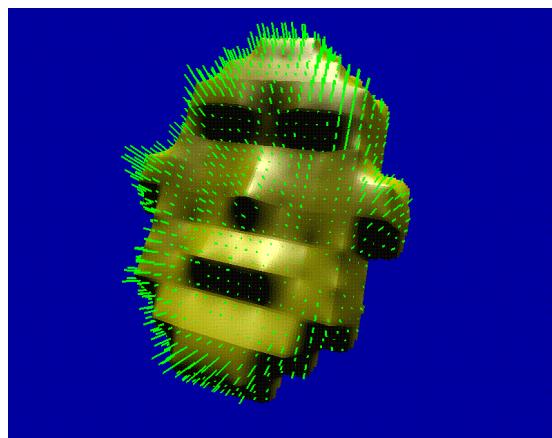


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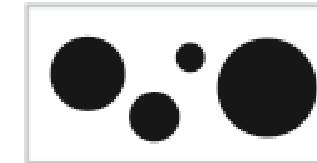


d) Resolution

[1]



[3]

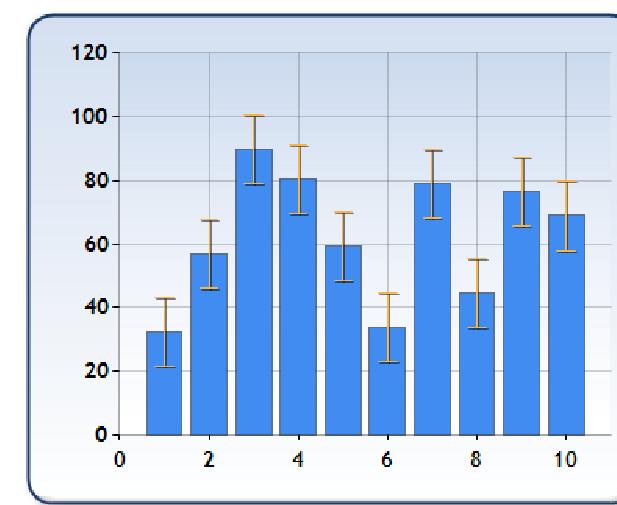


Size



*Color
Hue*

[2]



[4]

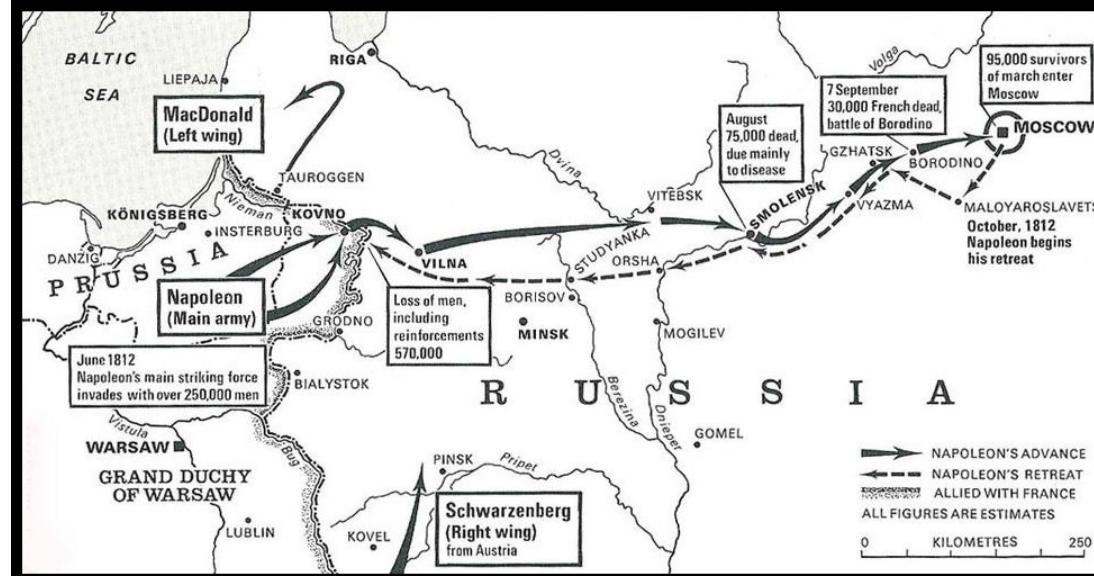
3 Implementation

Case study:

- Napoleon's Campaign in Russia 1812
- Battle at the Berezina 26.-29.11.1812

Dataset:

- number of soldiers from 4 different sources
- time of crossing
- position of the troops



[5]

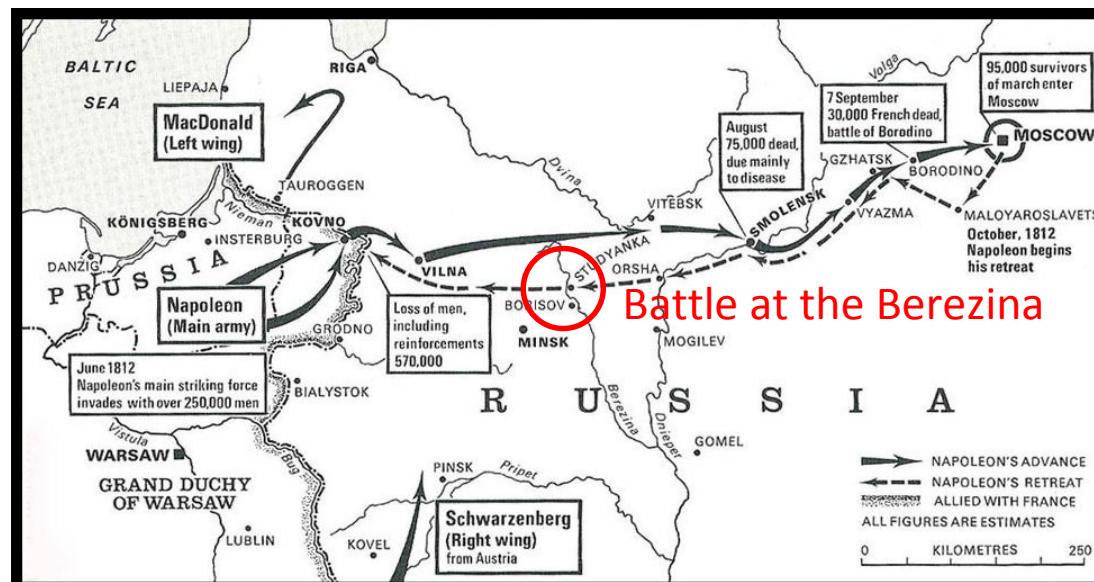
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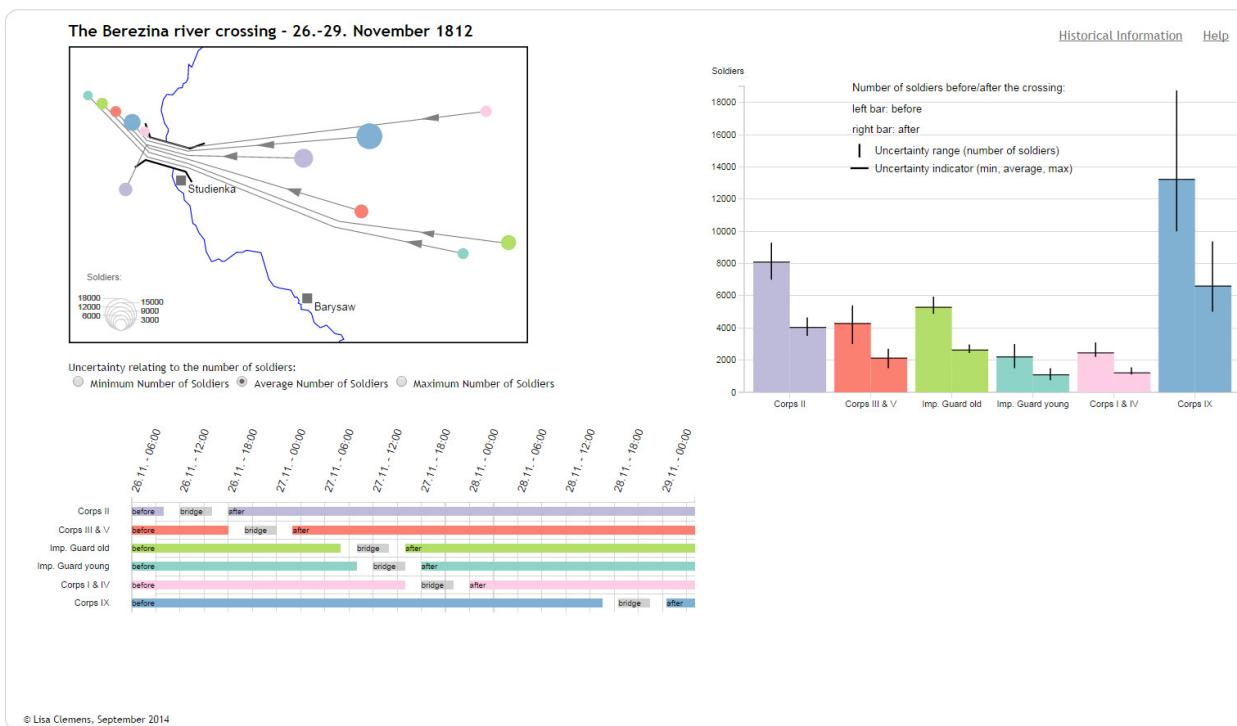
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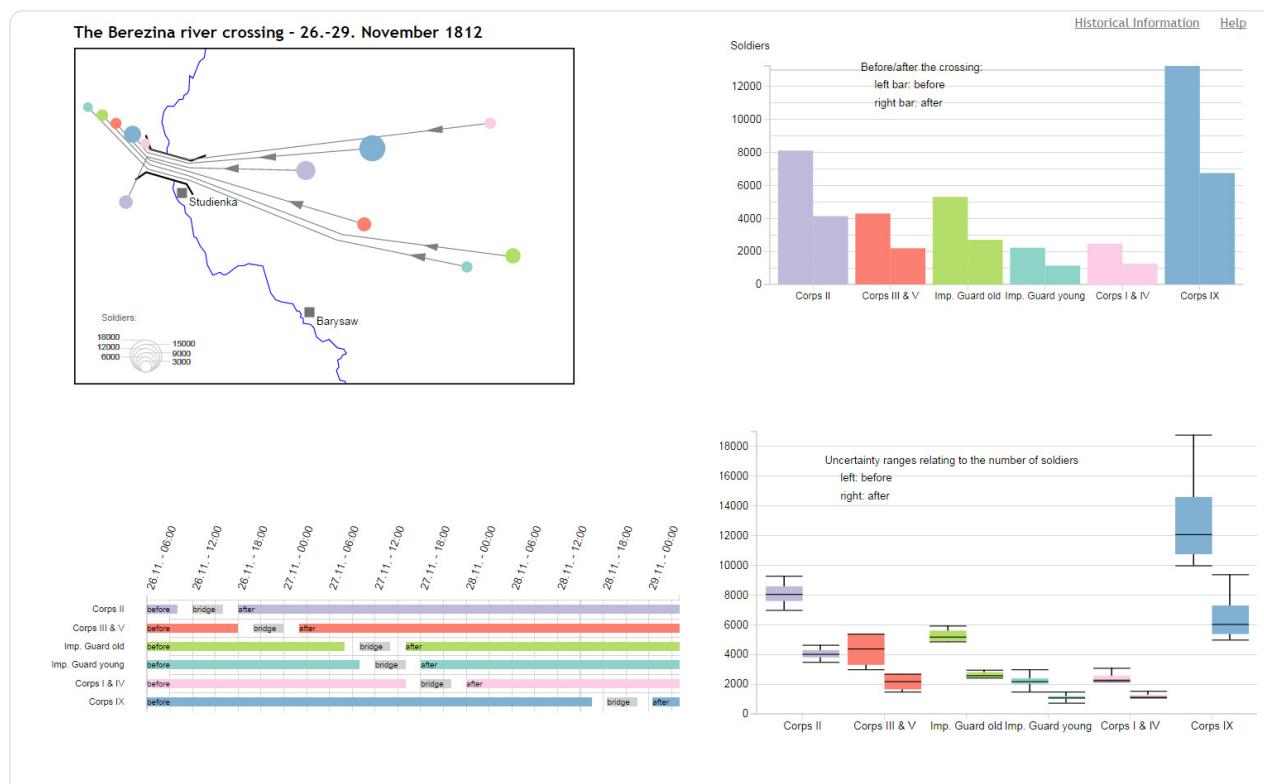
3 Implementation

Uncertainty integrated (3 views)



3 Implementation

Additional Uncertainty view (4 views)



4 Evaluation

4.1 Experiment

Hypothesis:

- 3 views (integrated uncertainty) better
 - Less cognitive load
 - Different visualizations of uncertainty
- But:
 - More complex
 - Takes more time to understand in the beginning

4 Evaluation

4.1 Experiment

Experiment settings

- Think-aloud protocol
- Video recording
- Screen logging

Test users

- 2 equal control groups
- each 8 test users (16 in total)

4 Evaluation

4.1 Experiment

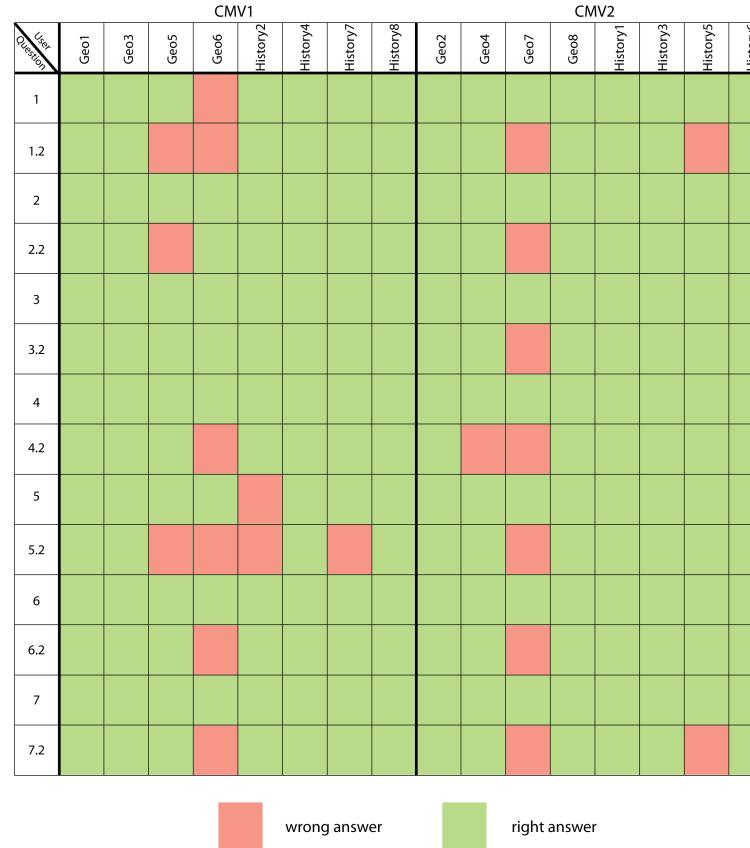
Test procedure

- Introduction
 - Introduction script with information
 - 3 test questions to practice think-aloud
- Test
 - 7 main questions
 - 2 sub-questions
- Feedback:
 - Questionnaire about user satisfaction

4 Evaluation

4.2 Results

Effectiveness



Wrong answers:

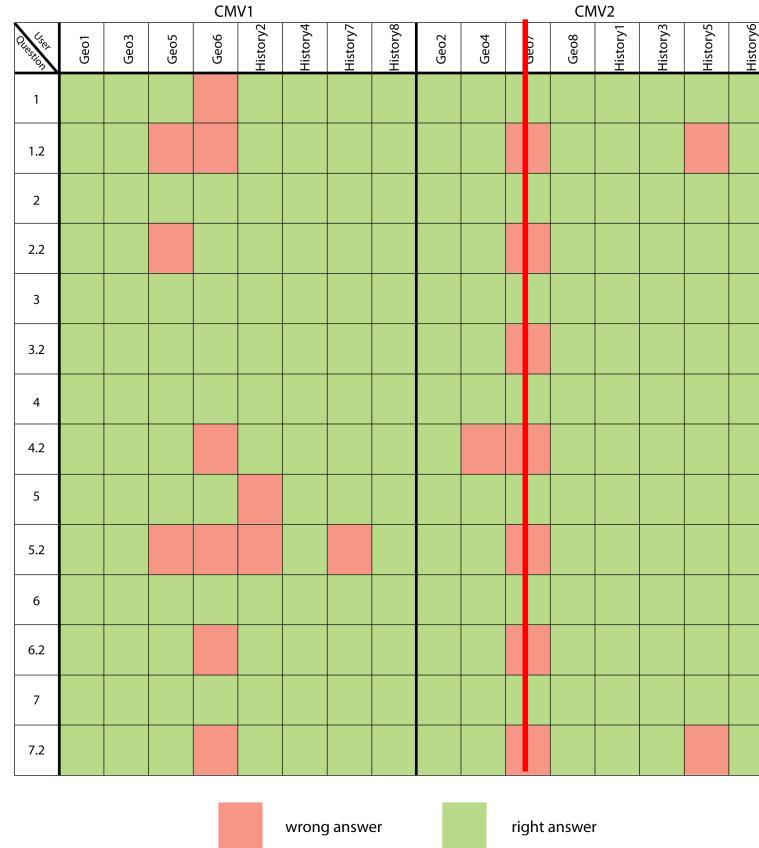
10,7%

8,9%

4 Evaluation

4.2 Results

Effectiveness



Wrong answers:

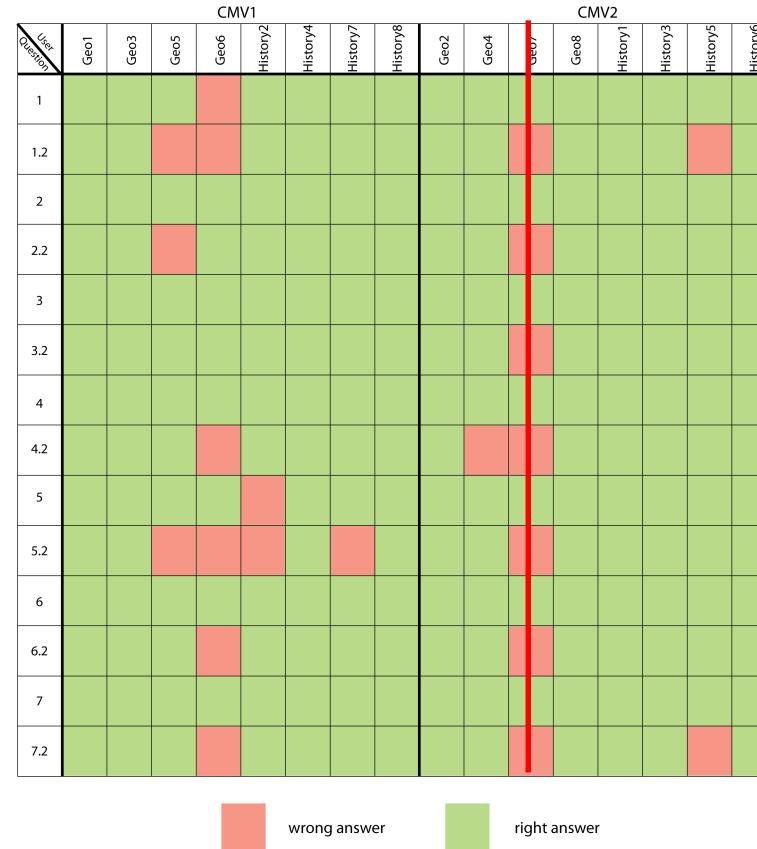
10,7%

8,9%

4 Evaluation

4.2 Results

Effectiveness



Wrong answers:

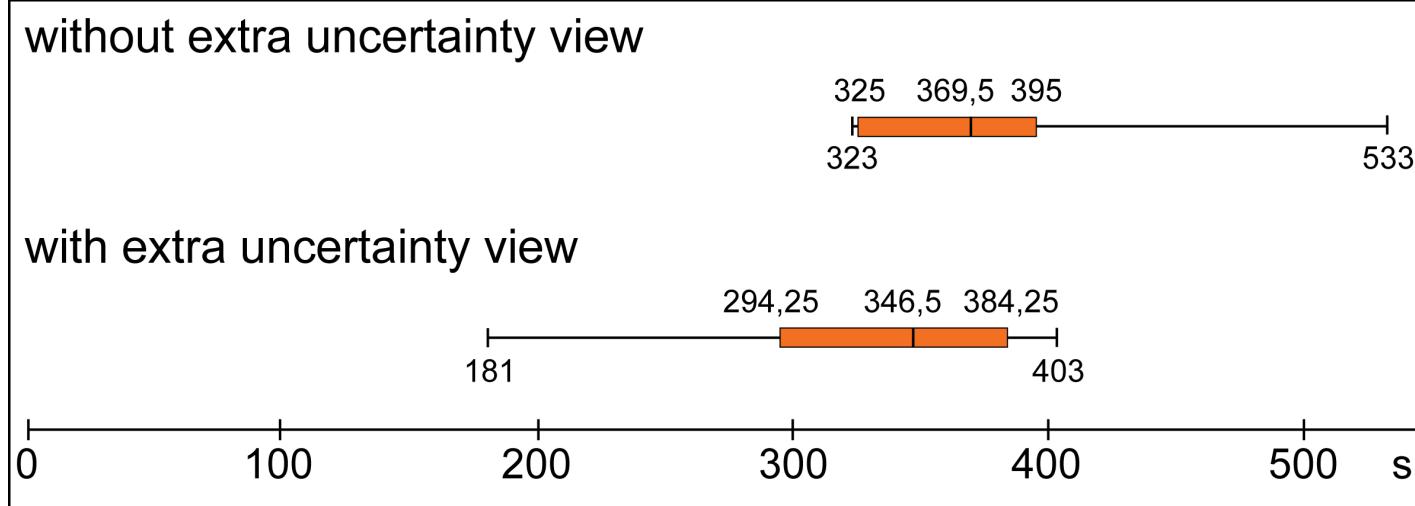
10,7%

3,0%

4 Evaluation

4.2 Results

Efficiency



3 views: $\emptyset 332,5\text{s}$

4 views: $\emptyset 281,5\text{s}$

→ Hypothesis refuted, 4 views more effective and efficient

4 Evaluation

4.2 Results

Mouse Interaction Density Map



a) uncertainty integrated

b) extra uncertainty view

5 Discussion

Summary

- Additional uncertainty view more effective and efficient
- Integrated uncertainty confuses user

Further research

- Higher number of test persons
- Different case study dataset(s)
- Different uncertainty visualization methods
- 3 views vs. 4 views

Sources

- J. C. Roberts. (2007). 'State of the Art: Coordinated & Multiple Views in Exploratory Visualization'. In 'Fifth International Conference on Coordinated and Multiple Views in Exploratory Visualization (CMV 2007)', pp. 61-71, IEEE Computer Society Washington, DC, USA, [ISBN:0-7695-2903-8].
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- [1] A. M. MacEachren. (1992). 'VISUALIZING UNCERTAIN INFORMATION'. *Cartographic Perspective*, Volume 13, pp. 10-19. (modified)
- [2] [http://understandinggraphics.com/wp-content/uploads/ 2010/01/retinal-variables.png](http://understandinggraphics.com/wp-content/uploads/2010/01/retinal-variables.png) (modified)
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