# Analyzing Effectiveness of Spatio-temporal Data Visualization Techniques

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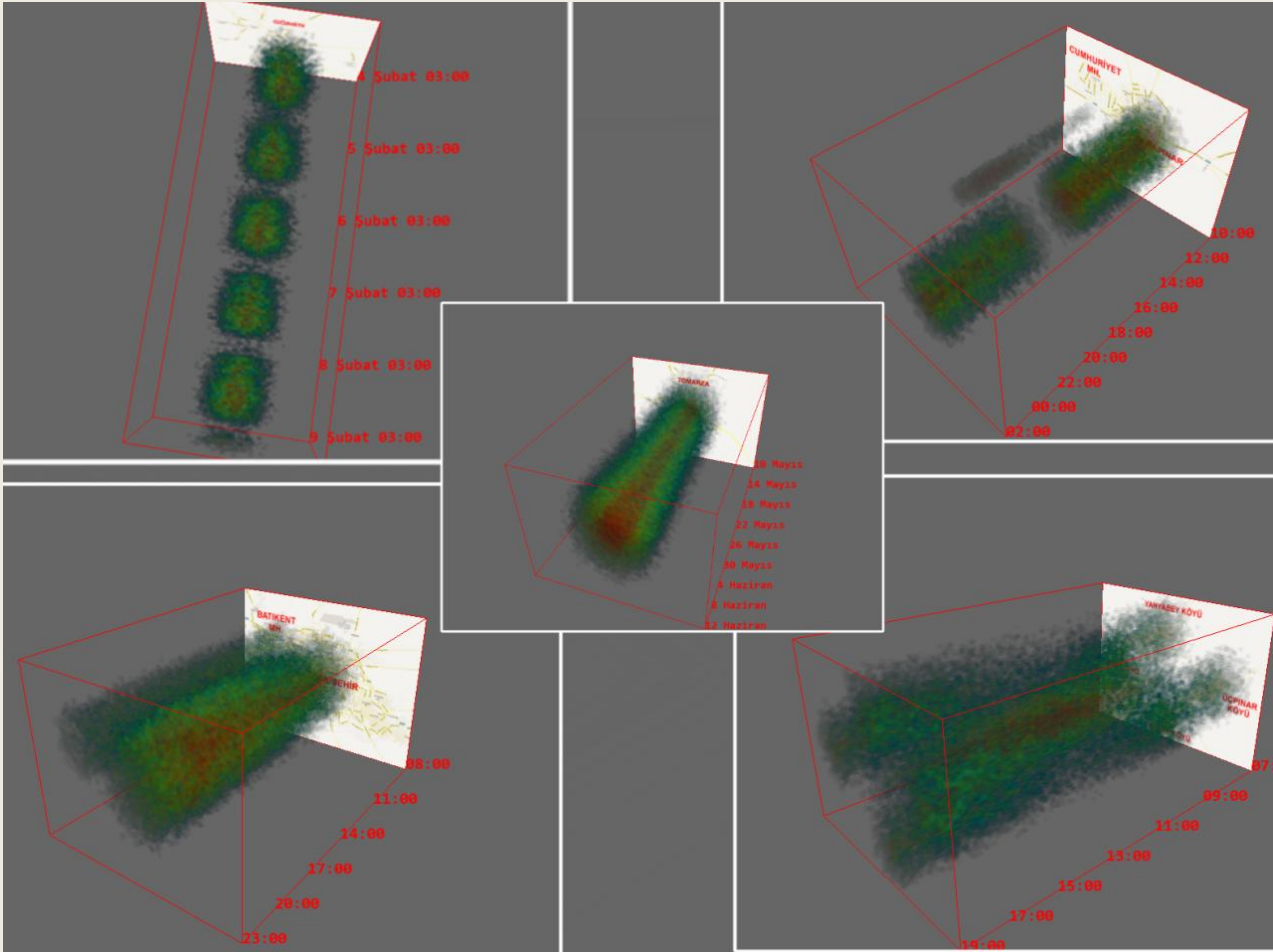
Introduction & Motivation

- Usability study of two competing methods.
- We are interested in two analyses
  - Analysis that requires users to inspect a <u>specific time and place</u> for anomaly detection
  - Analysis that requires users to inspect <u>general trends</u> over a time span
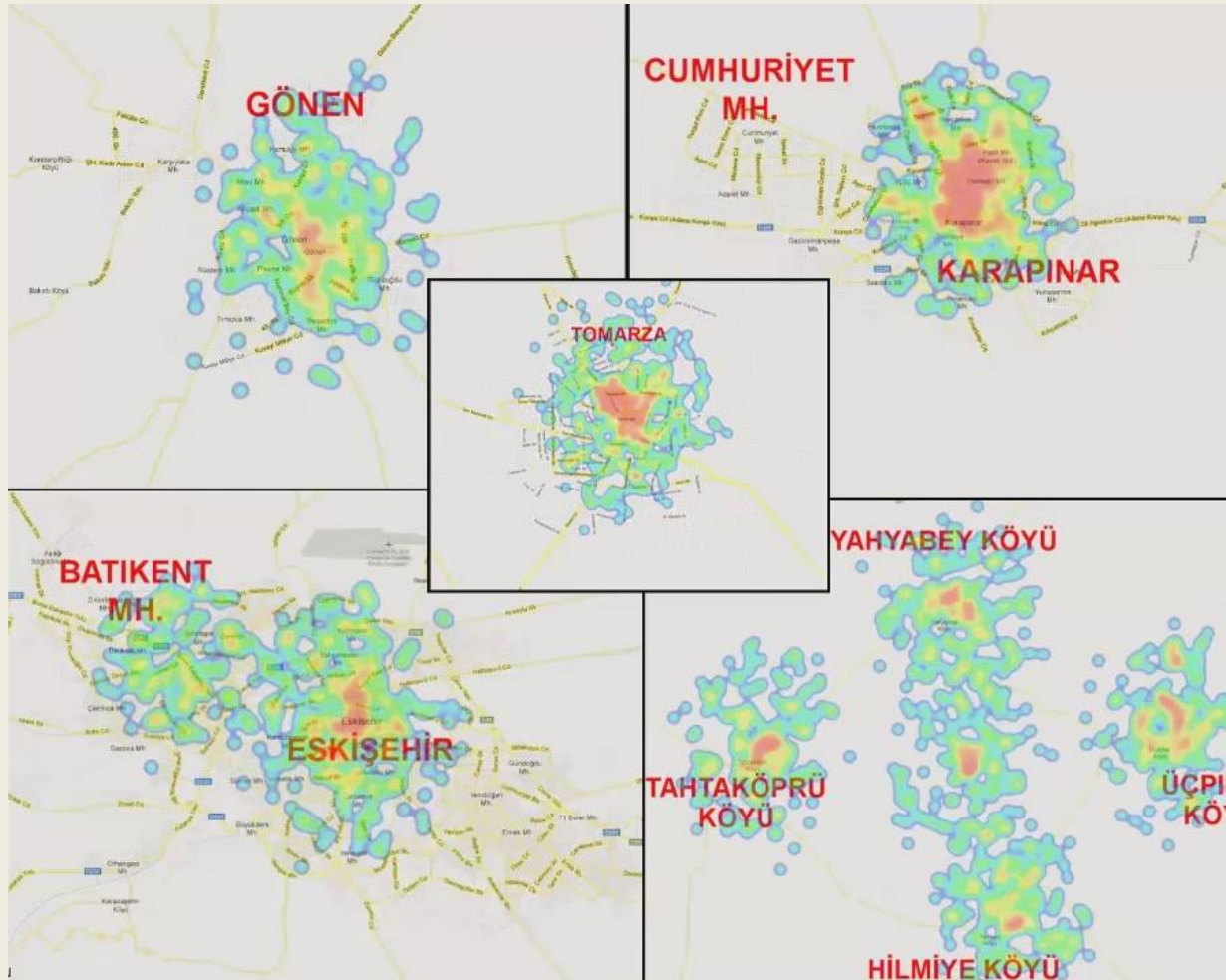
Heatmap Animation
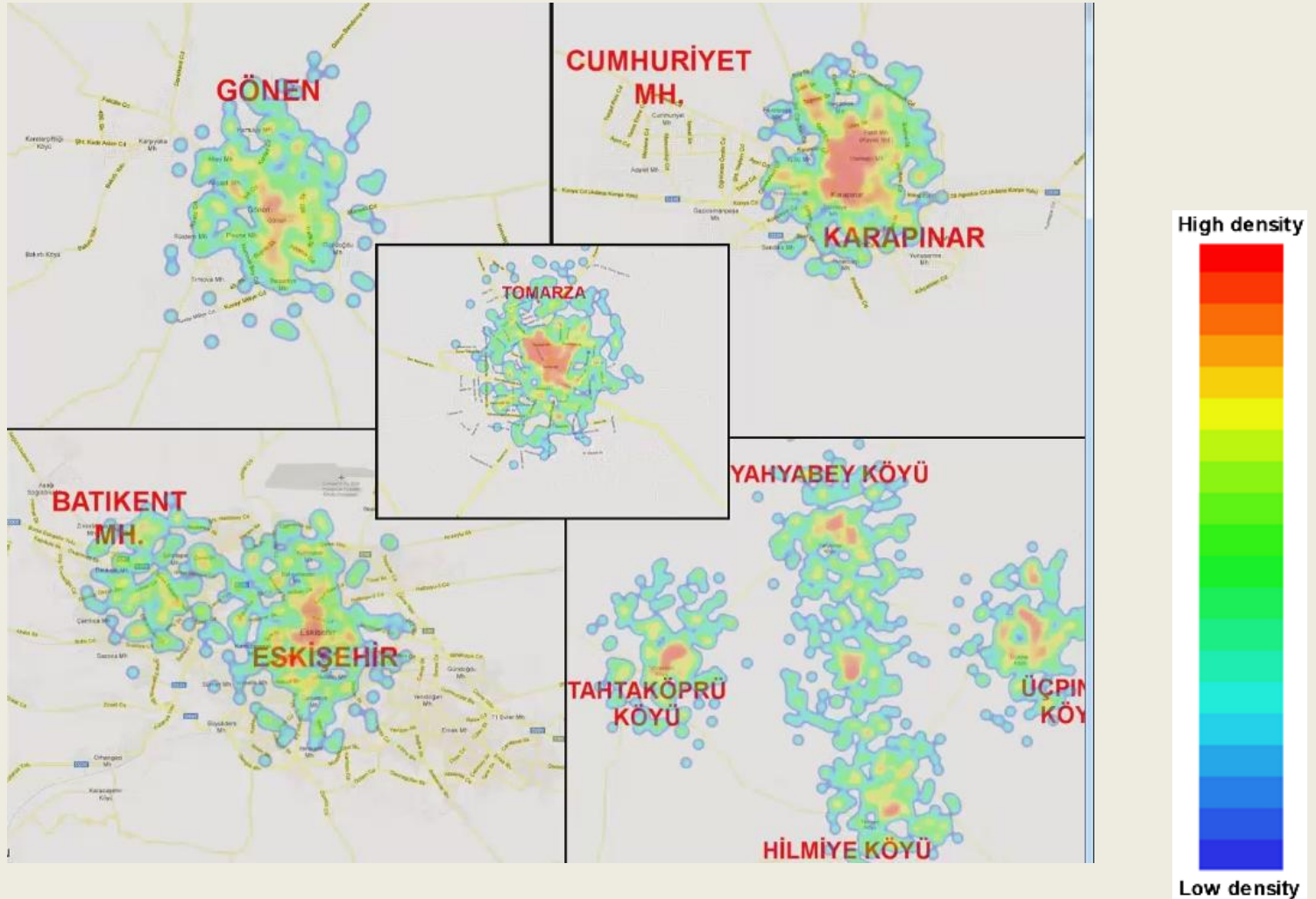
Heat-cube

Hypothesis
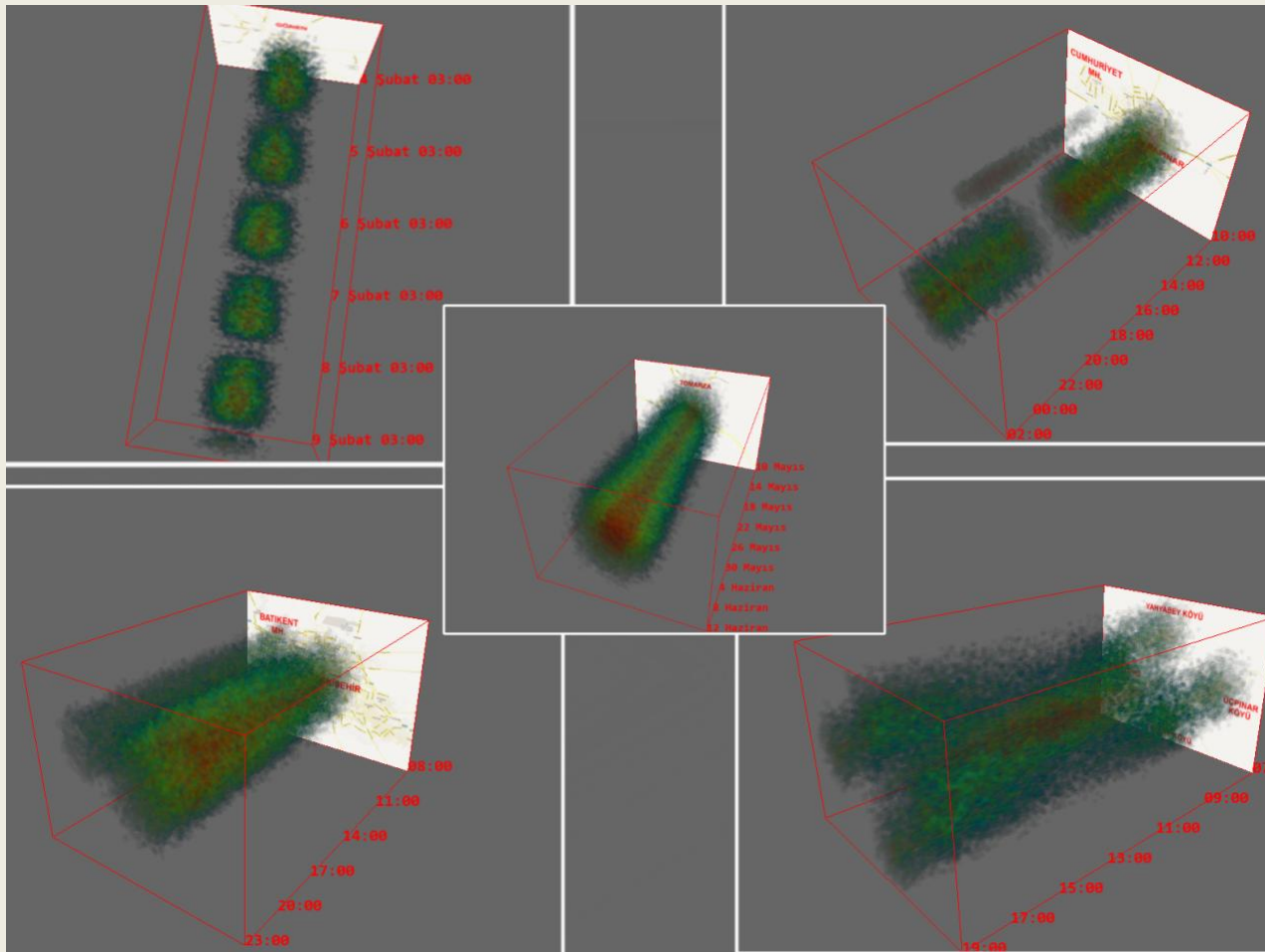
- ## Novice users will

  - Locate general trends faster and with fewer errors with Heat-cube

  - Complete time specific tasks faster and with fewer errors with Heatmap

Service Usage Scenarios

Service Usage Scenarios

Example Question

- When is the service usage minimum ?
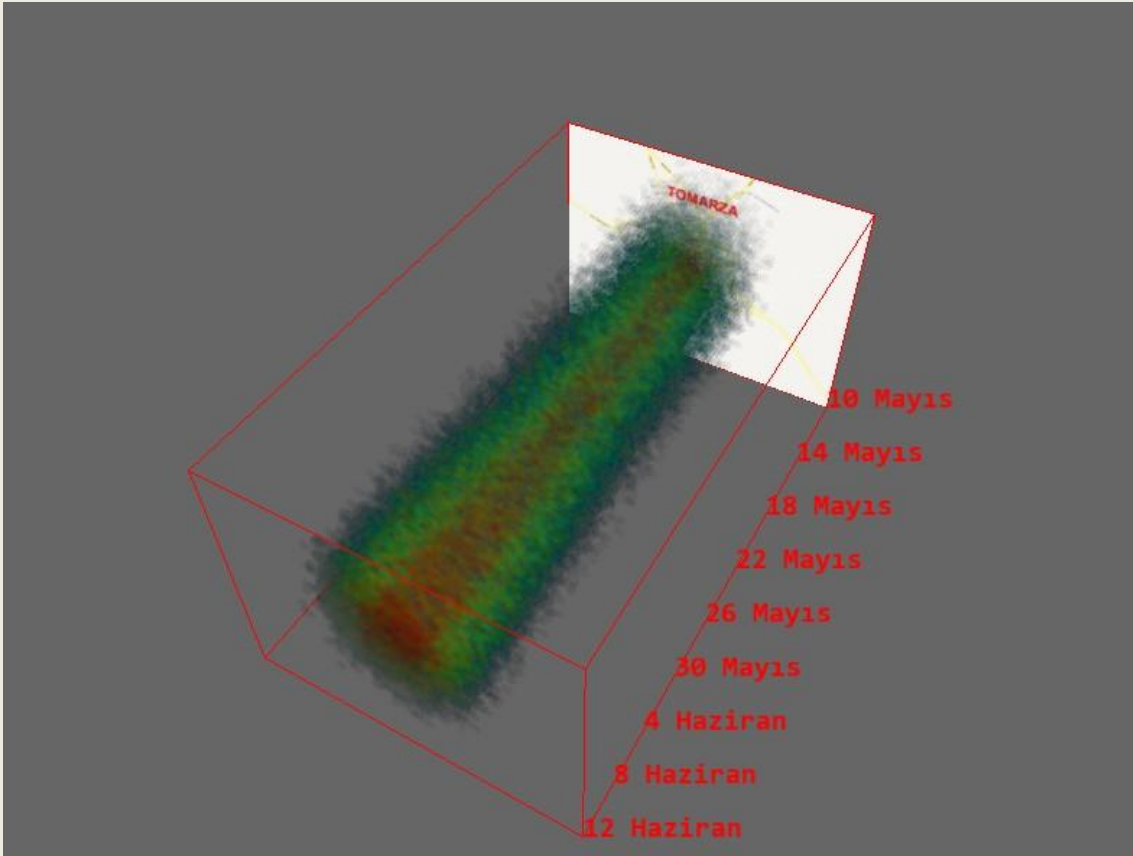
a) 10 – 14 May
b) 22 – 26 May
c) 26 – 30 May
d) 4 – 8 June
e) Visual does not provide enough information

Evaluation
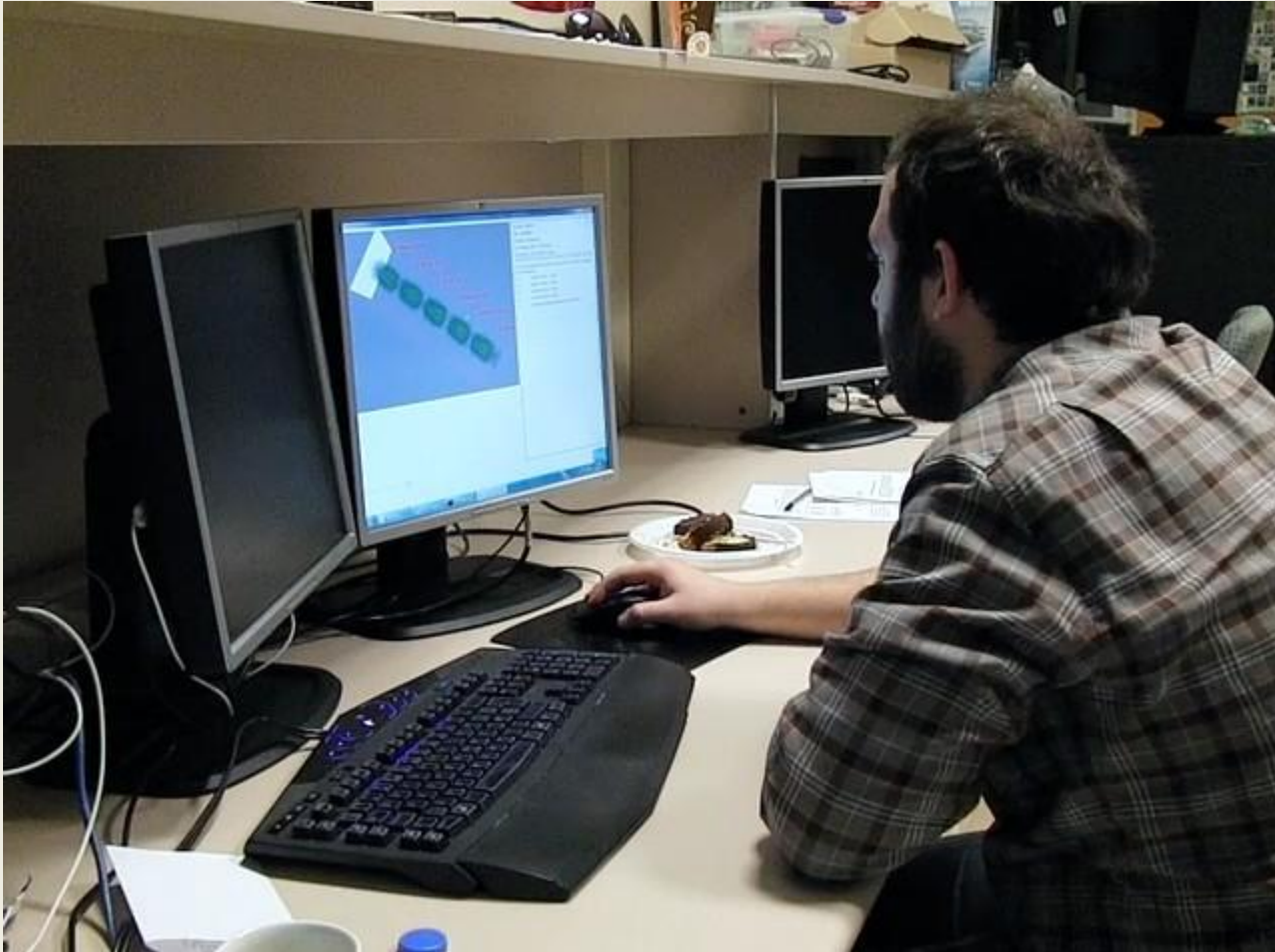
Experimental Design

- With two dependent measures:
  - Time
  - Correctness

- Self-reported measures (USE questionnaire, Lund 2001).

- 3D Visual Capability as covariate

Results

Random Variable Effects

No significant effect was observed.

3D Visual Capability Effects

No significant effect was observed.

Time to Complete

Scenarios	Heatmap	Heat-cube	T-test
1	M= 226, SD= 115	M= 218, SD= 107	t(12) = .207, p <= .84
2	M= 201, SD= 47.1	M= 172, SD= 62.1	t(12) = 1.998, p <= .07
3	M= 210, SD= 67.0	M= 190, SD=95.1	t(12) = .79, p <= .45
4	M= 197, SD= 62.1	M= 228, SD= 97.3	t(12) = -1.219, p <= .25
5	M= 163, SD= 44.5	M= 177, SD= 97.6	t(12) = -.566, p <= .58
Overall	M= 999, SD=280	M= 987, SD= 417	t(12) = .112, p <= .91

Marginal effect of time was observed in second scenario.

Time is in seconds.

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Time to complete

Error Bars: +/- 1 SD
Time is in seconds.
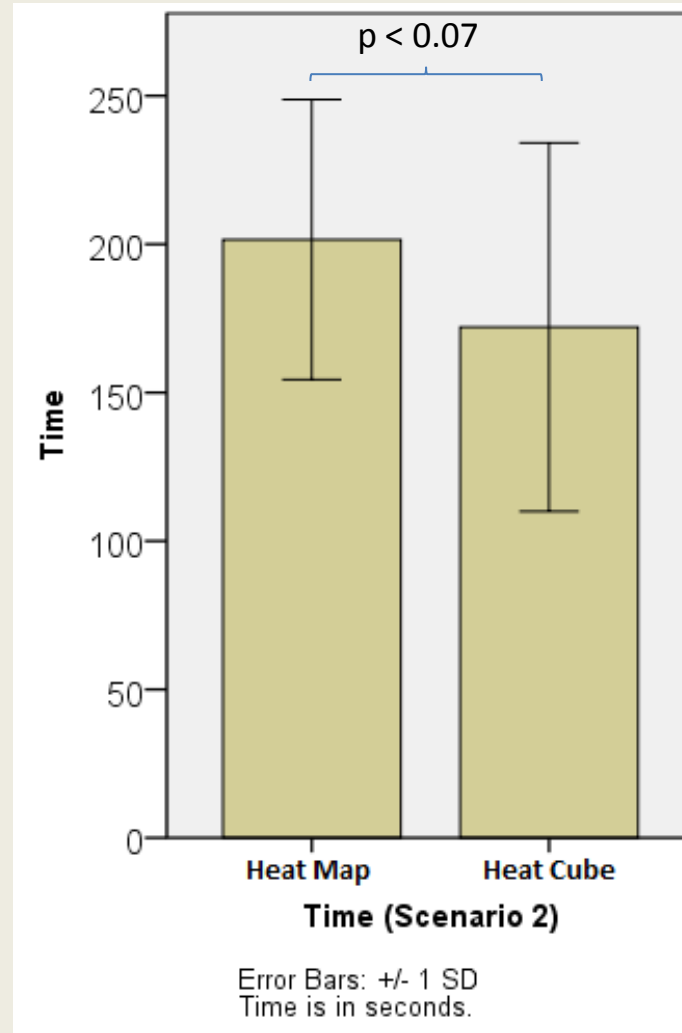
Correctness

Scenarios	Heatmap	Heat-cube	T-test
1	M= .75, SD= .12	M= .75, SD= .19	t(12) = 0, p <= 1
2	M= .69, SD= .23	M= .52, SD= .31	t(12) = 1.612, p <= .13
3	M= .66, SD= .15	M= .59, SD= .19	t(12) = 1.237, p <= .24
4	M= .91, SD= .16	M= .66, SD= .32	t(12) = 2.792, p <= .016
5	M= .60, SD= .28	M= .44, SD= .33	t(12) = 1.055, p <= .31
Overall	M= .73, SD= .11	M= .60, SD= .17	t(12) = 2.14, p <= .054

Significant effect observed on the correctness measure in the fourth scenario.

Correctness in the fourth scenario

Self-reported Measures

Discussions & Future Work

- Visual Analytics Tool / Workflow
  - How to combine Heatmap, Heat-cube into a single tool ?
  - Integrated workflow
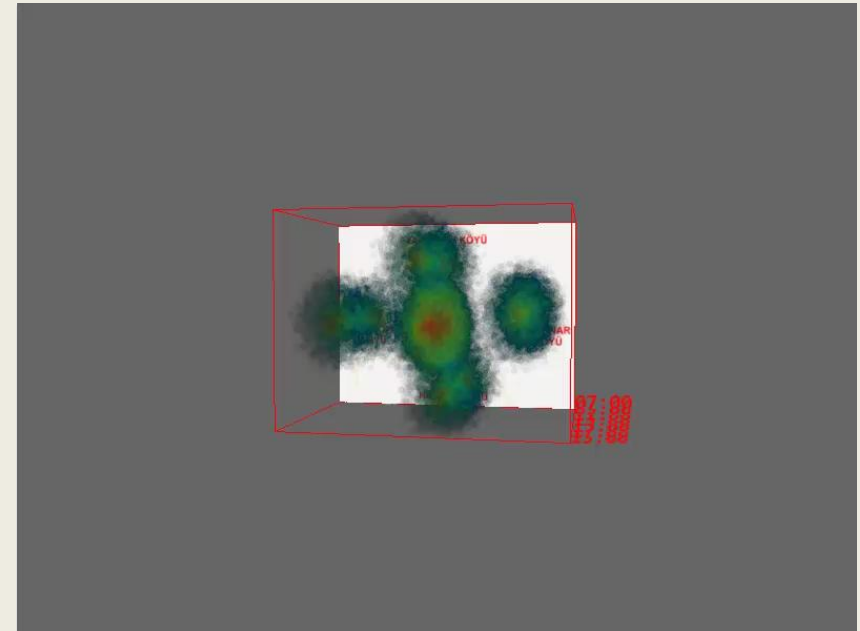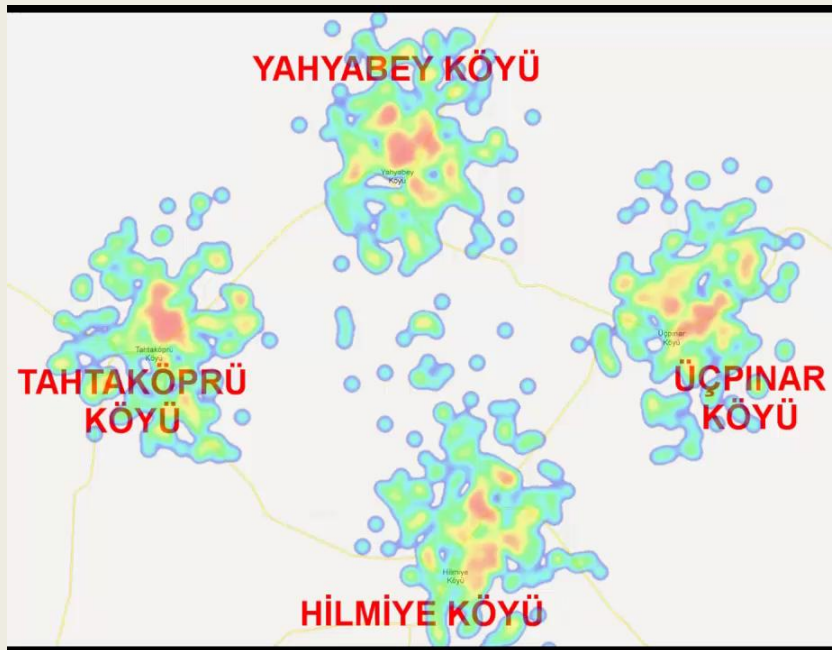
- Surface-cube
  - Composition of several layers of isosurface geometries
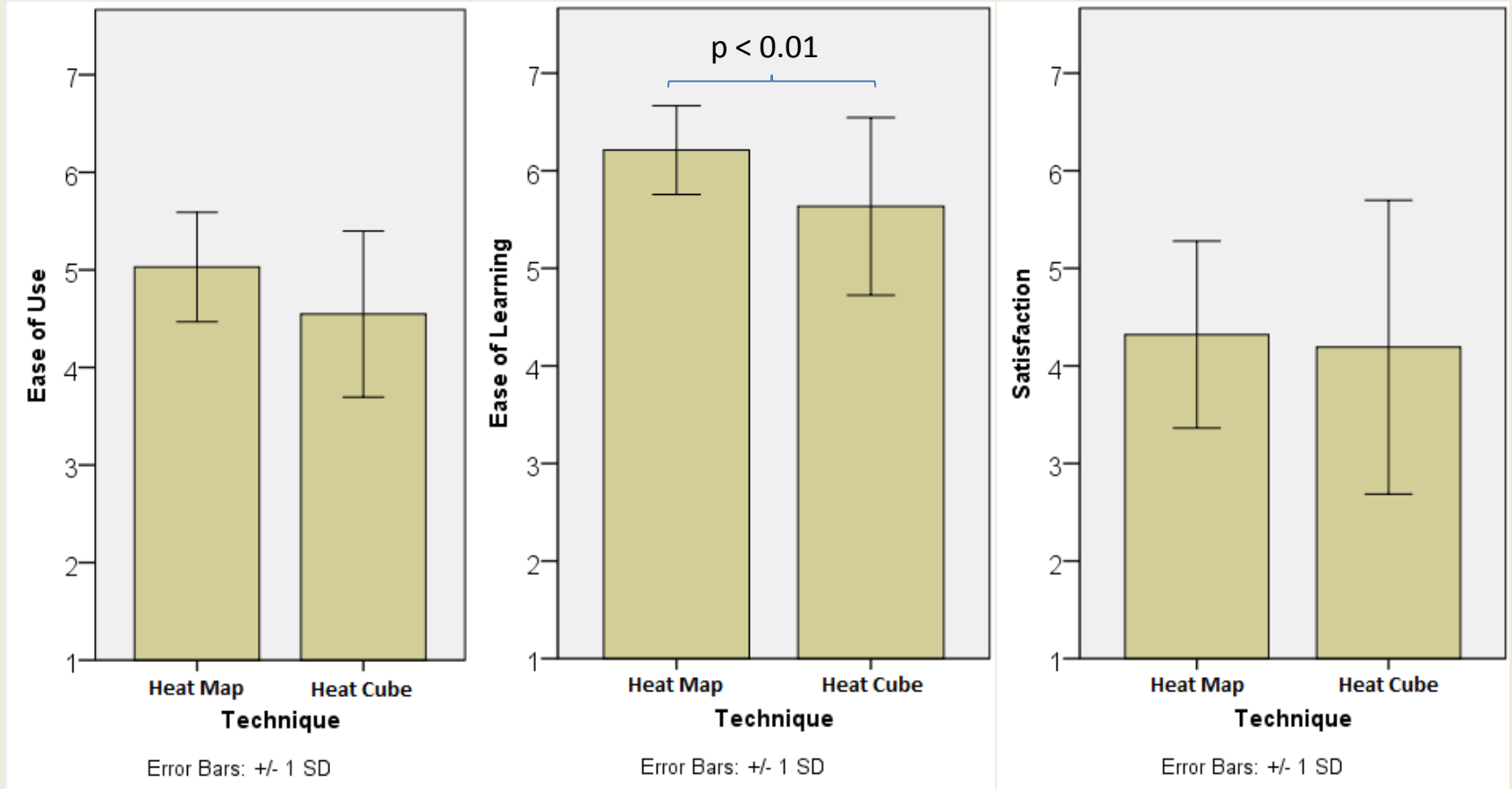
Data

- Some tasks are not easy to demonstrate with real-life data

- Minimal data-generation tool
  - Reproducible experiments
  - Variables
    - Center (latitude, longitude pair)
    - Radius
    - Starting and finishing data amount
    - Time variables (step size, starting date, number of steps)
    - Randomness control (Gaussian-like distribution)

Task Design

- Data Generation

Evaluation

- We have designed our user study to evaluate effectiveness of the implemented techniques
  - 10 tasks per user
  - 5 scenarios
  - Within subject design
  - 13 participants

- 4 Groups
  - 2 datasets
  - 2 techniques

Evaluation

Our evaluation process benefited much from Munzner's Nested Model (Munzner, 2009).

threat: wrong problem
validate: observe and interview target users
  threat: bad data/operation abstraction
    threat: ineffective encoding/interaction technique
    validate: justify encoding/interaction design
      threat: slow algorithm
      validate: analyze computational complexity
        implement system
      validate: measure system time/memory
    validate: qualitative/quantitative result image analysis
    [test on any users, informal usability study]
    validate: lab study, measure human time/errors for operation
  validate: test on target users, collect anecdotal evidence of utility
  validate: field study, document human usage of deployed system
validate: observe adoption rates

Contribution on visual encoding and interaction design
Evaluation: Lab Study + Expert Review

Previous Work

- Heat Maps (Wilkonson, 2009)

- Space-time Cube (Kraak, 2003)

Results

Random Variable Effects

No significant effect was observed.

Random Variable	Time	Correctness
Sex	F(1,6) = 2.74, p<= .14	F(1,6) = .088, p<= .77
Experience	F(1,6) = .006, p<= .94	F(1,6) = .672, p<= .43
Computer Usage	F(1,6) = .074, p<= .80	F(1,6) = .001, p<= .97

3D Visual Capability Effects

No significant effect was observed.

Covariate	Time	Correctness
3D Visual Capability	F(1,6) = 1.82, p<= .23	F(1,6) = 4.652, p<= .1

Vandenberg Kuse Mental Rotation Test (Peters, 1995)