Universität Stuttgart

GeoVis
– From Terrain to Tweets and Movements

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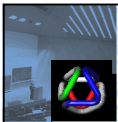
University of Stuttgart, Germany

PhoWo 2015

Institut für Visualisierung
und Interaktive Systeme



51. Photogrammetrische Woche 2007

Univ. Stuttgart, Visualization and Interactive Systems Institute

Towards Gigapixel Displays for Data Visualization

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Conclusions

- Large displays offer new opportunities for
  - science, development, education, entertainment
  - to deal with the increasing amount of visual information
  - by visualization, interaction, and collaboration
- Large displays need
  - wide screens AND high resolution
  - enormous graphics power (GPU clusters)
  - new rendering and visualization algorithms
- GPU-based visualization techniques
  - allow for interactive exploration of huge data sets
  - are a fun research area

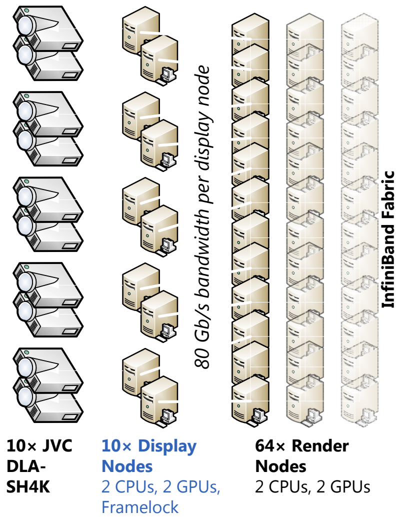
The Stuttgart PowerWall Project

- Visualization Research Center of the Univ. of Stuttgart (VISUS)
- Moved into remodeled „exotic" building in 2010
- Funding for new "immersive visualization lab"

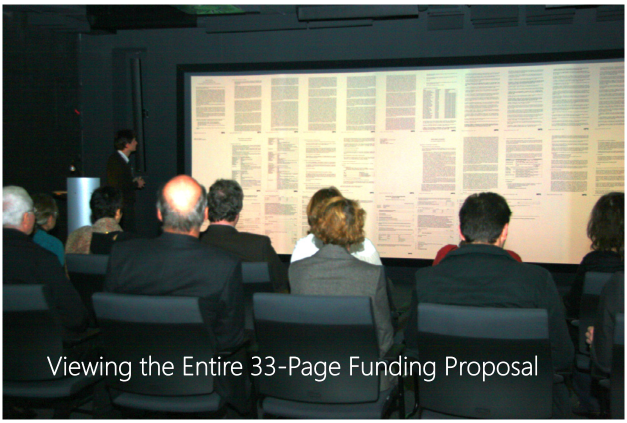
- Decision for high-res back projection stereo wall
- Visualization should benefit more
  from highres than from immersion
- Large Screen (display full car model): 6.0 m x 2.2 m
- Stereo for larger groups, no bevels
- Higher resolution than usual
  - (typical PowerWall pixel >2 mm)
- Goal: monitor resolution - pixel size 0.5 mm (50 dpi)
  - requires close to 2 x 50 Megapixels (50 HD projectors)

Projection System

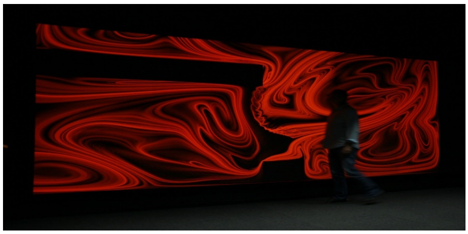
- Use as few projectors as possible and minimize seams
- 4K projectors (9 Megapixels via 4 video-in) in 5 vertical stripes
- 10x 4K projectors require 40 video-in and at least 20 Gbyte/s
- Gross 100 Megapixels must be generated
- 2-tier GPU cluster architecture
  - Only display nodes are connected to projectors
  - Render nodes perform off-screen rendering
  - 600 CPU cores
  - 150 GPUs



Applications



Viewing the Entire 33-Page Funding Proposal



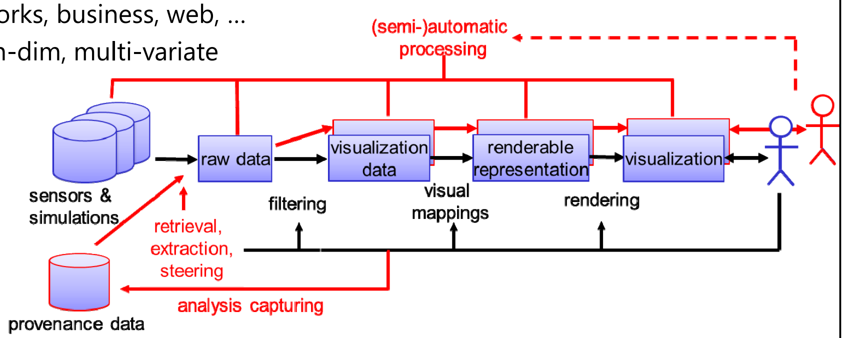
TRR 161
Transregional Collaborative Research Center
Quantitative Methods for Visual Computing

Visualization – Diversity after 25 Years

- Scientific Visualization
  - Science and engineering, medical imaging, …
  - Spatial data, fields, particles, underlying physics
- Information Visualization
  - Databases, networks, business, web, …
  - Non-spatial, high-dim, multi-variate
- Visual Analytics
  - Data analysis, interaction, visualization

National Science Foundation ViSC Report 1987:

Visualization is a method of computing. It transforms the symbolic into the geometric, enabling researchers to observe their simulations and computations. Visualization offers a method for seeing the unseen.



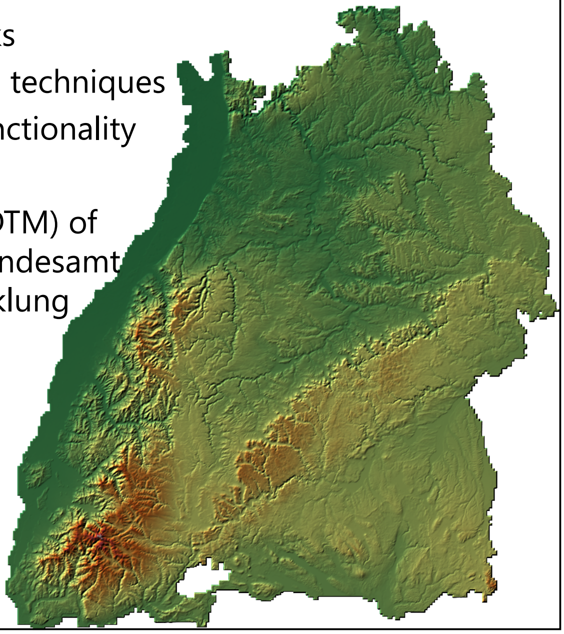
GeoVis – An Obvious Combination

- Spatial data exhibits an outstanding value in visualization: "Everything is related to everything, but near things are more related than distant things." [Tobler, 1970]

- If any feature can be visualized spatially, visualization will implement a map view for finding patterns, trends, and outliers in the data
- Three examples for visualization approaches for spatial data
  - Terrain visualization
  - Geo-referenced social media
  - E-bikes trajectories

Terrain Visualization

- Is this still interesting with Google Earth being available?
- Yes, for large and high-resolution data
- Yes, for advanced visual analysis tasks
- Yes, for advanced rendering/shading techniques
- Yes, for exploiting advanced GPU functionality

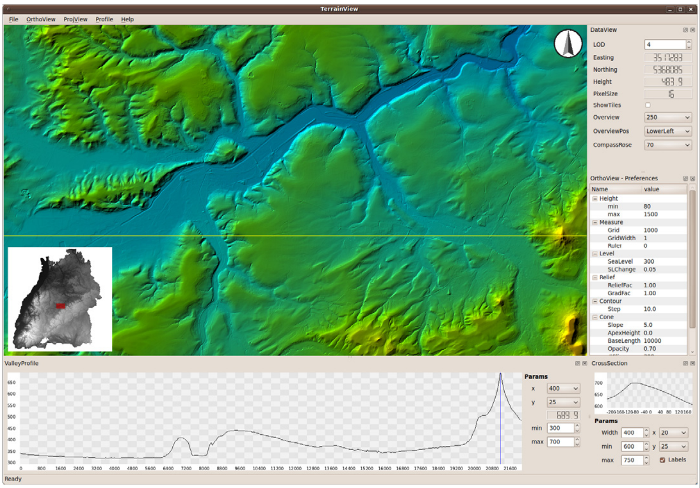


- LiDAR-based digital terrain model (DTM) of Baden-Württemberg provided by Landesamt für Geoinformation und Landentwicklung
  - covers about 360 00 km2
  - horizontal resolution: 1 m
  - vertical resolution: 15 cm
  - raw dataset:
    about 37 000 tiles
    à 1001 m x 1001 m => 1 TB

TerrainView

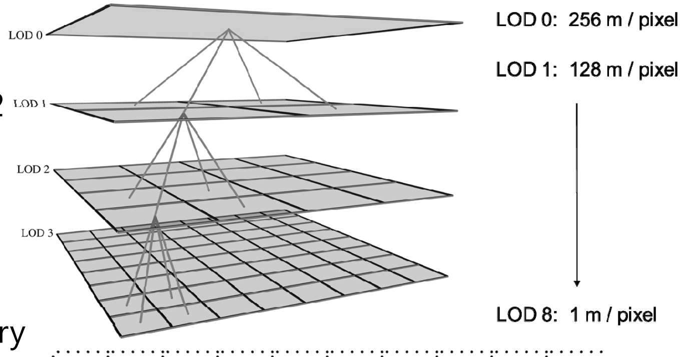
Thomas Müller, et al.

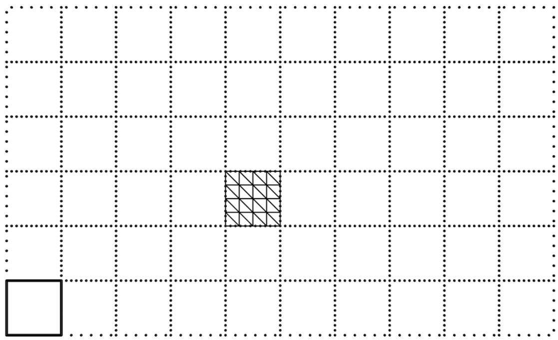
- Project collaboration with Prof. Hartmut Seyfried on identification and interpretation of young (Würmian) glacial geomorphology
- Commercial tools can handle only a subset of the data at once
- Goal: interactive visualization of entire dataset on desktop PC
- TerrainView functionality – all in "real-time"
  - Terrain visualization orthographic/perspective
  - coloring, relief shading (variable light directions), gradient representation, sea level, contours
  - calculate valley profiles along polylines for geo-morphological investigs.
  - new cone model to estimate glacial loads



TerrainView Techniques

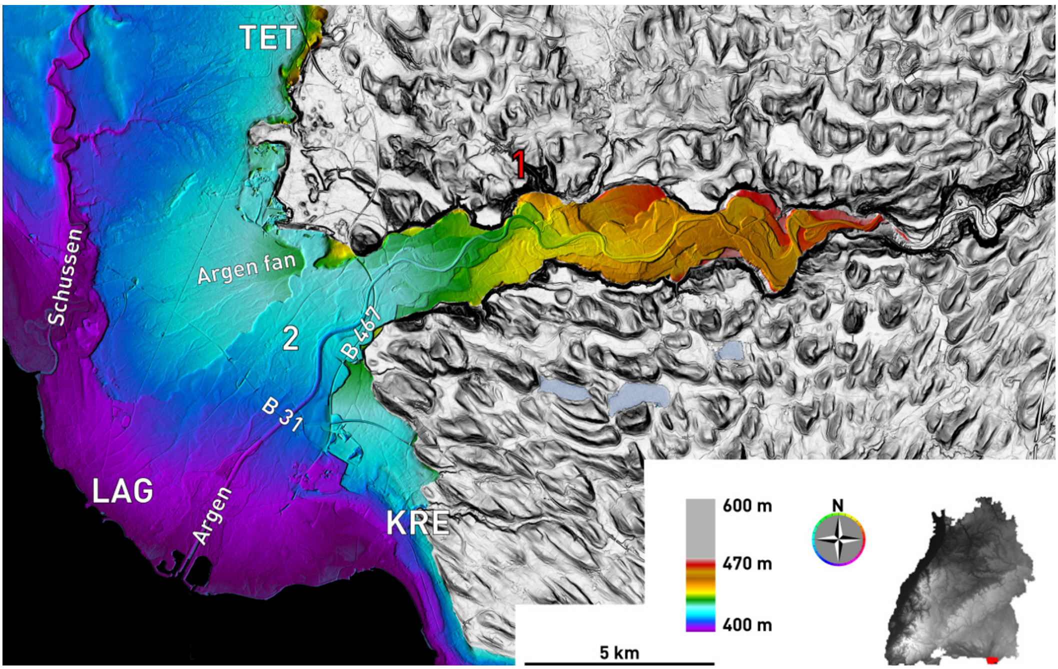
- Preprocessing step: resample into quadtree structure: 1024 x 1024 m^2
- Heavy use of GPU features
- New shaders change the way how we do graphics
- Instead of sending geometry to the graphics card, let the GPU generate the triangles
  - Send one quad to GPU
  - Replicate into 112x80 quads by instancing
  - Tessellation control shader -> triangle mesh
  - Tessellation eval. shader -> adjust height



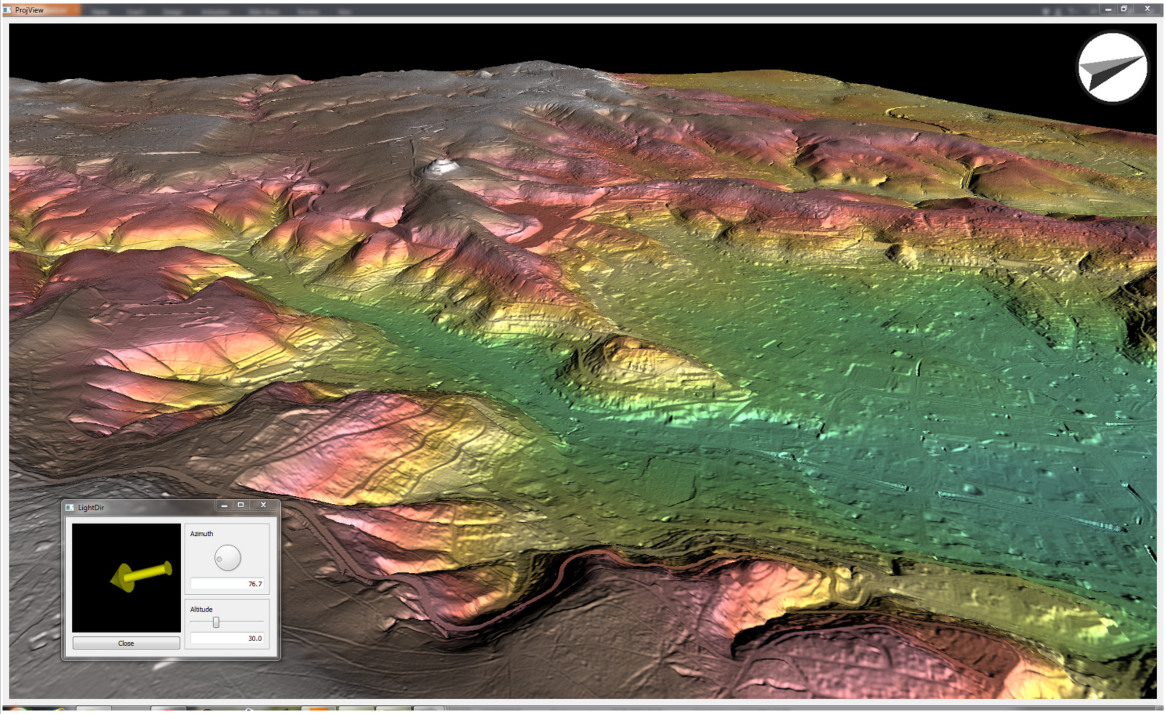


TerrainView - applications

- Post-glacial recessional terraces in the Argen valley

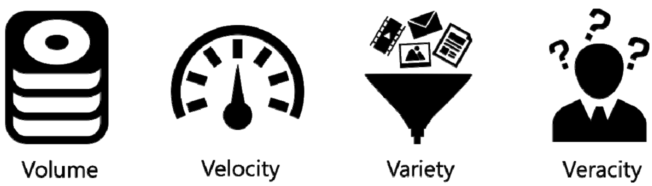


TerrainView - applications



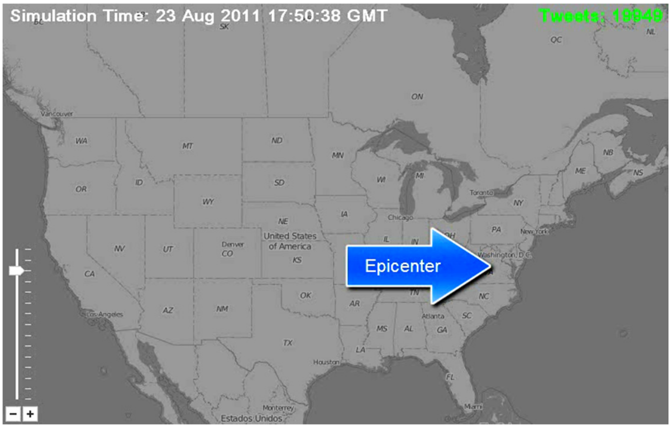
GeoData for Situation Awareness

- We live in a world where cybersocial and cyberphysical systems produce billions of geo-related data records on a daily basis:
  - Twitter Posts
  - Instagram Photos
  - Facebook Posts
  - Flight Records
  - Hotel Check-Ins
  - Passenger Info
  - Traffic Data
  - Crime Records
  - Census
  - Weather data
  - Public Webcams
  - etc ...
- Accessing, extracting, and combining this information would significantly help to inform situation awareness, intelligence, and decision-making -> a typical Visual Analytics task
- Technical challenges in utilizing the information are commonly referred to as the four V's of Big Data:



Twitter for Situation Awareness

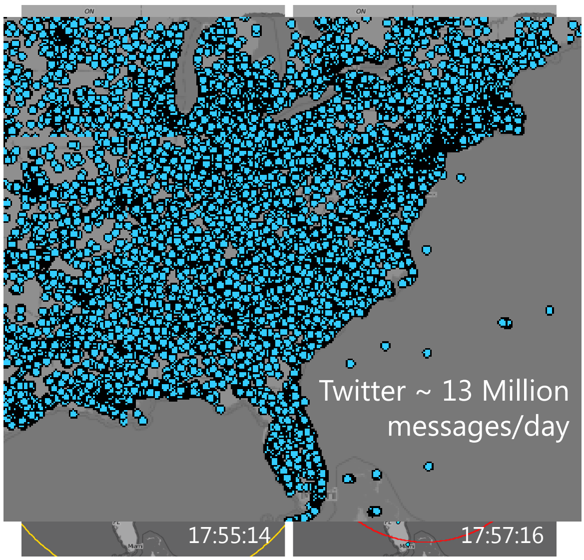
- Simulation of Virginia Earthquake 2011
  - Yellow = P-Wave
  - Red = S-Wave
  - Blue = Tweets
- Event demonstrates the high timeliness and distribution of social media reactions



Twitter for Situation Awareness

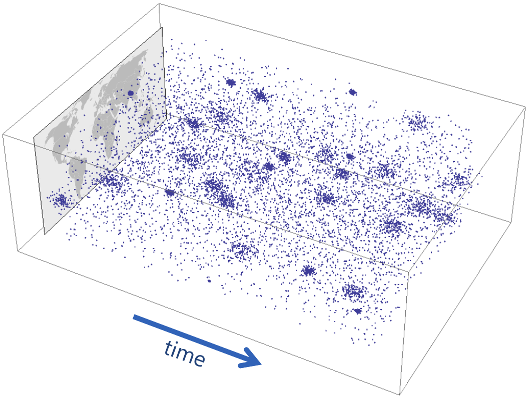
- Information extracted from the data could be of great value for decision makers in
  - Disaster Management
  - Public Safety
  - Disease Control
- Research question
  How to identify relevant information and produce meaningful situation overviews from millions of data items in real-time?

Dennis Thom, et al.



Spatiotemporal Anomalies

- Assumption 1: Event is the most central entity in situation awareness
- Assumption 2: Events generate spatiotemporal clusters of similar tweets

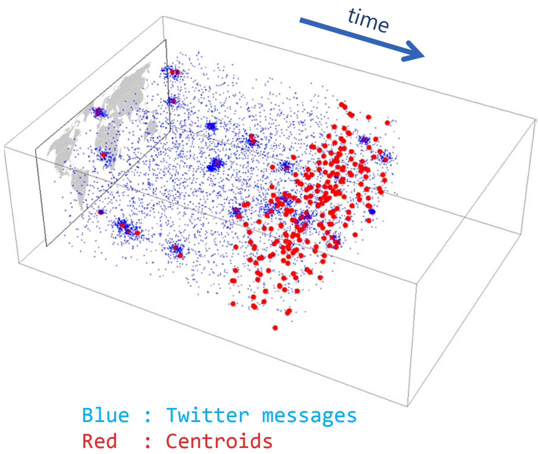


Spatiotemporal Anomalies

- Traditionally, analysts would enter keyword queries to find this kind of clusters
- Idea: Revert the process by detecting such clusters in the data and use them to generate a visual overview of what should be searched for

Anomaly Discovery

- Streaming-enabled cluster analysis based on K-Means
  - Instead of a fixed number of centroids (means), a splitting mechanism is employed
  - A sliding window is used to evaluate/discard clusters once they turn stale



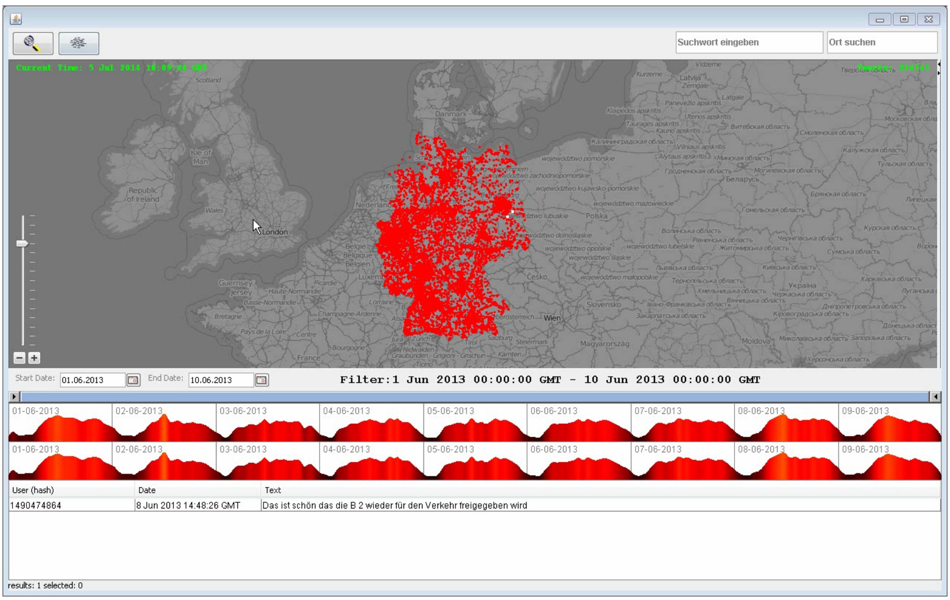
Anomaly Discovery

- Clustering performed seperately for any observed topic to account for „clusters within clusters“
- Each new message is assigned to topics and only the corresponding cluster branches are updated

Anomaly Visualization

- Detected clusters are placed as labels on the map – collision resolution produces tagcloud layout
- Similar overlapping labels are aggregated to counteract overfitting and allow adaptive semantic zoom

ScatterBlogs Visual Analytics



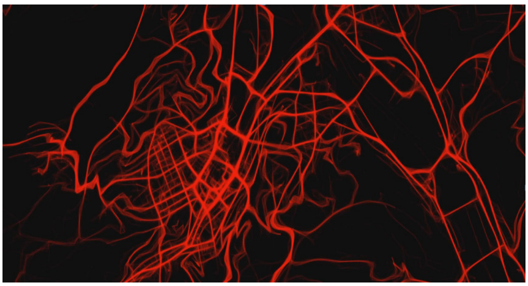
Data Enrichment

- In services like Twitter and Foursquare, users also provide information about relevant Points of Interest (POI) in an environment.
- Traditional geographic data can be interactively enriched with such knowledge from Web 2.0 data sources.
- For example: To better understand urban dynamics, but also to enable consumer acceptance analysis, there is an increasing interest to look into movement reasons.

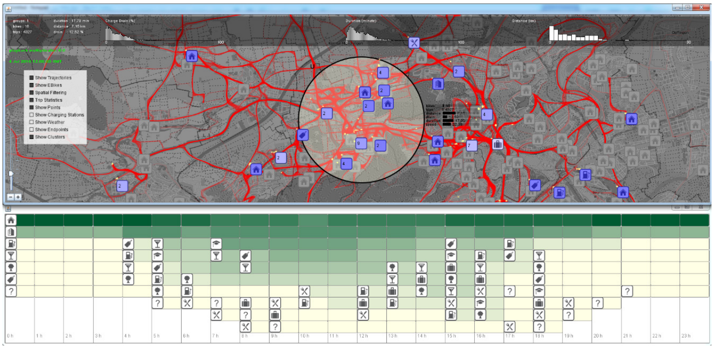
Data and Task

- Data: Large electric mobility dataset
  - 500 electric scooters, 155.000 trips, 8 mio measurements
- Task: Usage analysis
  - *Can e-mobility find its way into everday's life?*
  - *When, where, what for ...*

    ... do costumers use their scooters?



Find Reasons of Movement



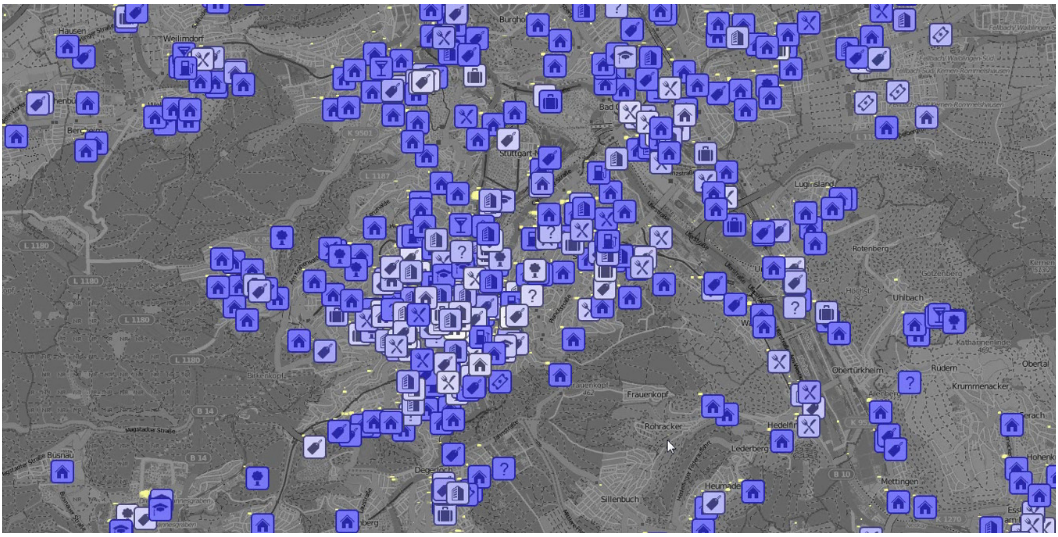
- Use data from Foursquare to annotate areas of interest with reasons of movement

foursquare

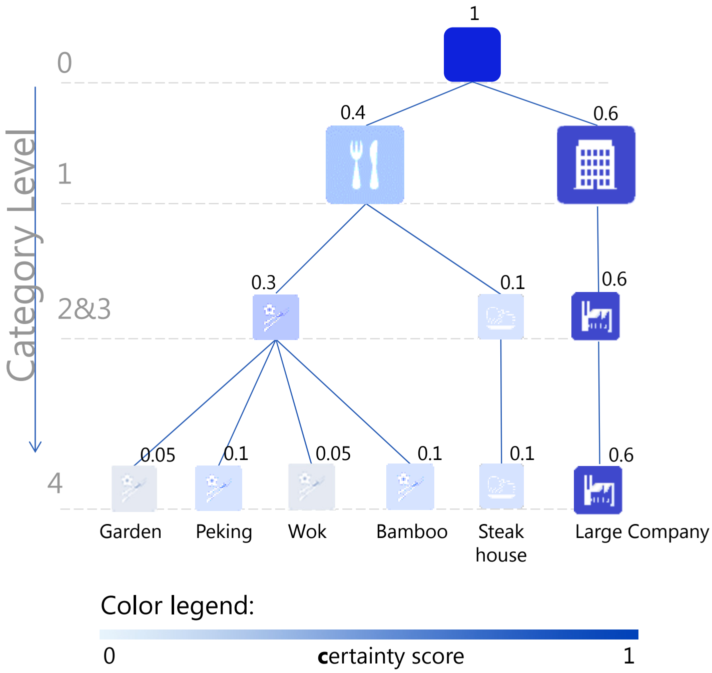
Visual Analysis of Movement Behavior using Web Data for Context Enrichment [Krueger et al. 2014]

Interactive Map

- Plotting POIs near clusters -> information overload and visual clutter

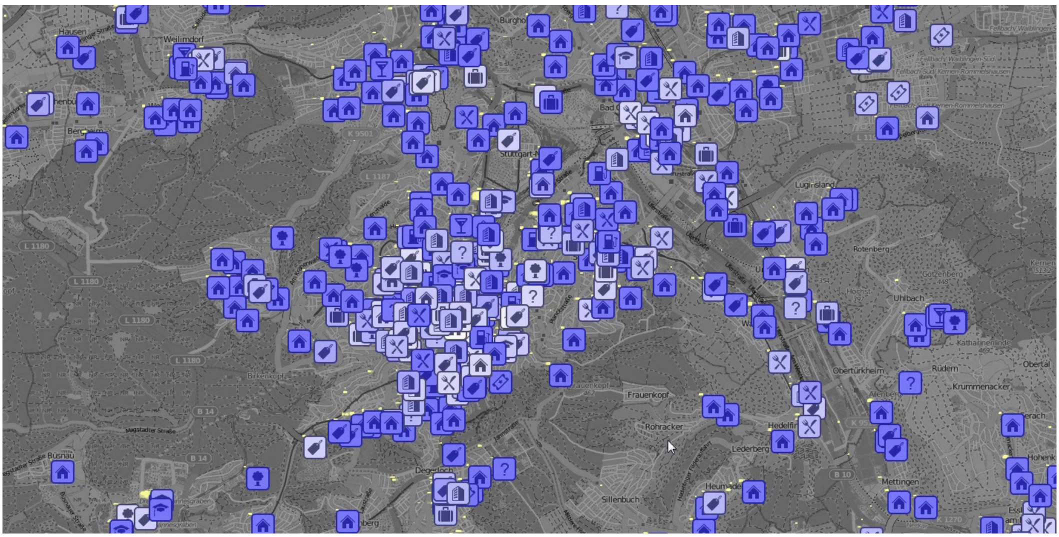


Certainty Aggregation



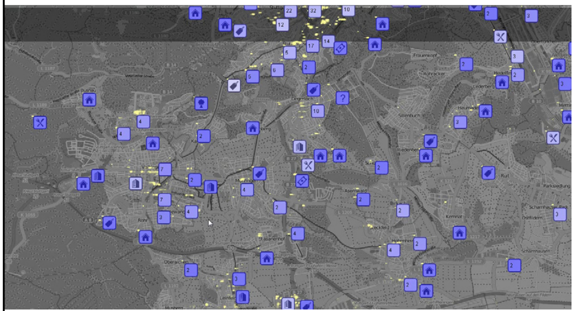
- Certainty Criteria:
  - Distance
  - Checkins
  - Users
  - Combination

Certainty Aggregation



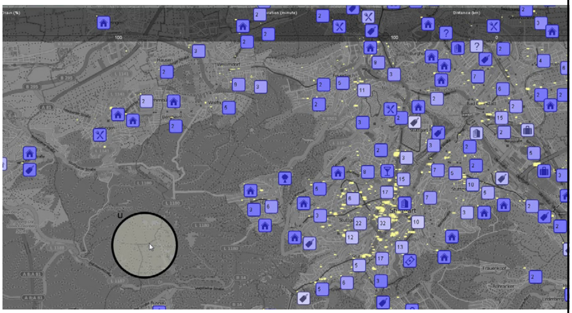
Use Case

- Single Instance Filtering



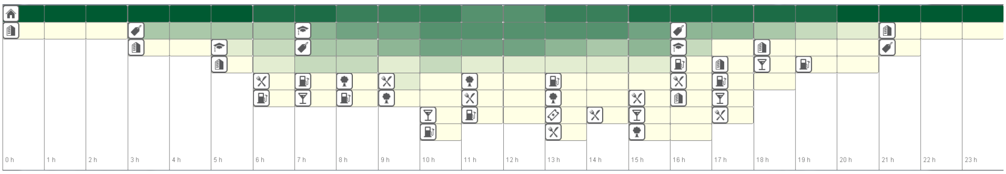
- Explore visited POIs and routes from a single user

- Area Filtering



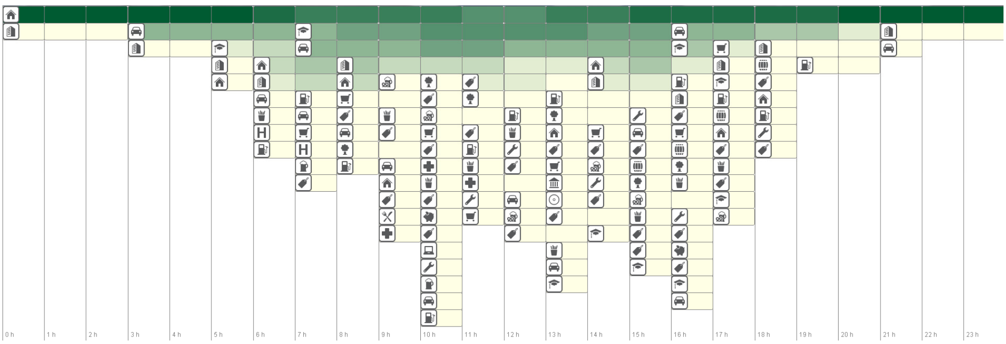
- Explore POIs and routes from users living in a certain area

Temporal Analysis



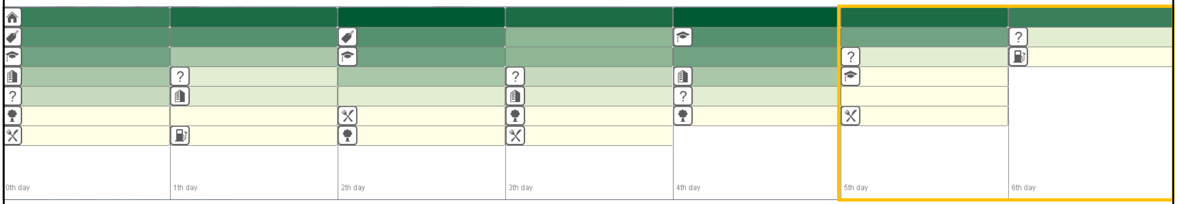
drill down

aggregate



Temporal Analysis

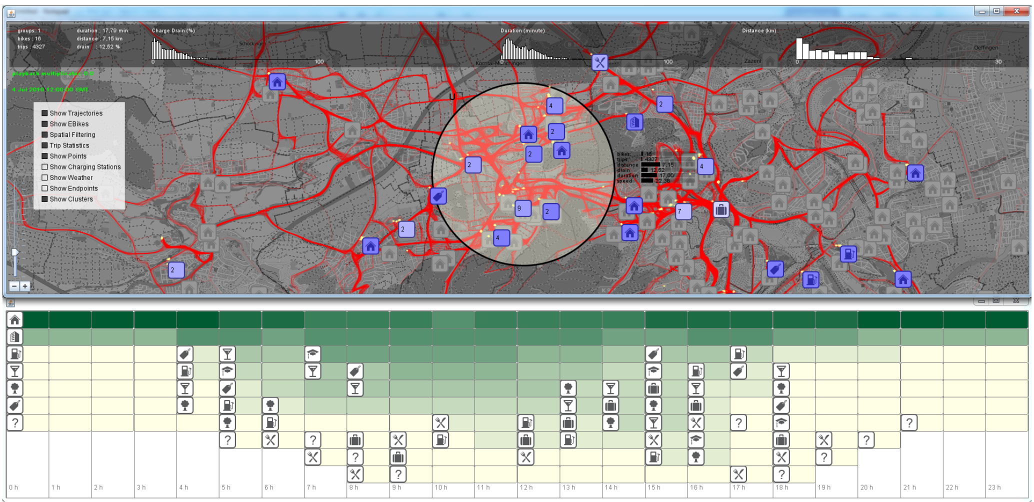
- Evaluation of cyclic behavior (week: Monday to Sunday)



weekend

Analysis Examples

- Use Case: Area related usage



Conclusion

- Cybersocial and cyberphysical systems will continue generate enormous amounts of data, many of which will have a spatial relation
- Visualization plays an important role in the exploitation of this data
  - Terrain visualization continues to provide research challenges like correlations of geologic and geomomorphic phenomena.
  - Spatial properties of data can be used to enable new visualization forms of abstract data, such as events in social media.
  - Context knowledge in Web 2.0 sources can be employed to enrich traditional geographic data.
- Visualization research can help to enable space-time indexed data exploration, the discovery of unknown correlations, and deep insights about the semantic realm entangled with our geospatial environment.