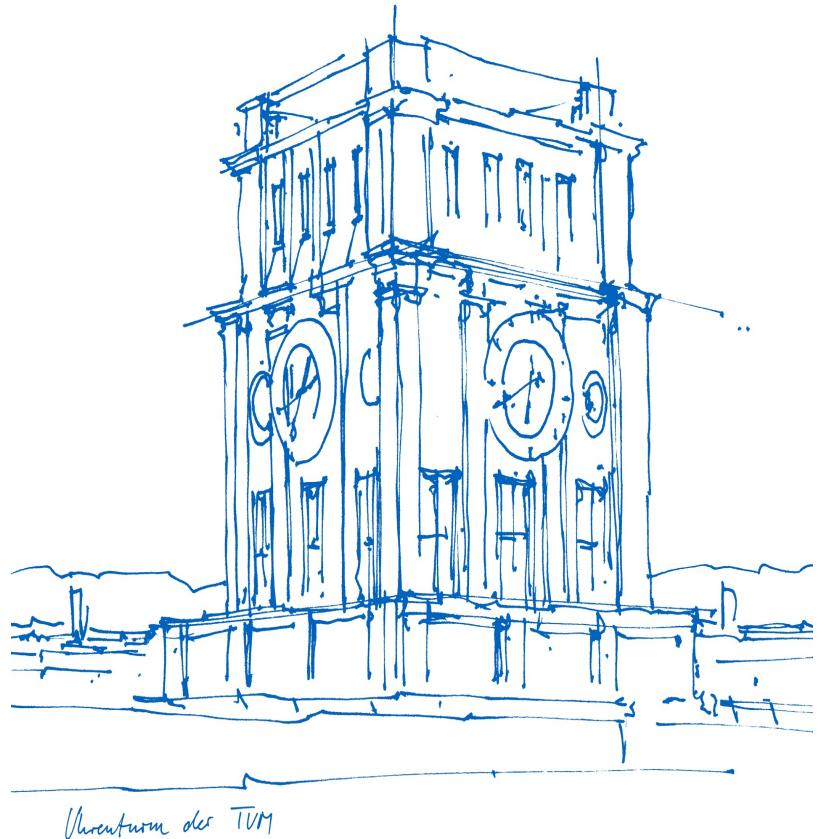


# Geoinformation

Prof. Dr.-Ing. Liqiu Meng

Chair of Cartography and Visual Analytics

WS 24/25



# List of Lectures

**L1: Introduction**

**L2: Spatiotemporal representations and databases**

**L3: Spatial data analysis I**

**L4: Spatial data analysis II**

**L5: Selected cartographic techniques**

# L1: Introduction

- I. An overview of geoinformatics**
- II. The nature of geoinformation**
- III. Different views of space and time**
- IV. Challenges of geoinformatics**

# I. An overview of geoinformatics

## Geoinformation in our daily life

Citizens and professionals typically want to know and reason about location, time, object, process etc.



## Geoinformatics

A discipline dealing with acquisition, storage, processing, presentation and dissemination of geoinformation incl. the infrastructure to secure efficient and ethical use of this information.

Technische Universität München  



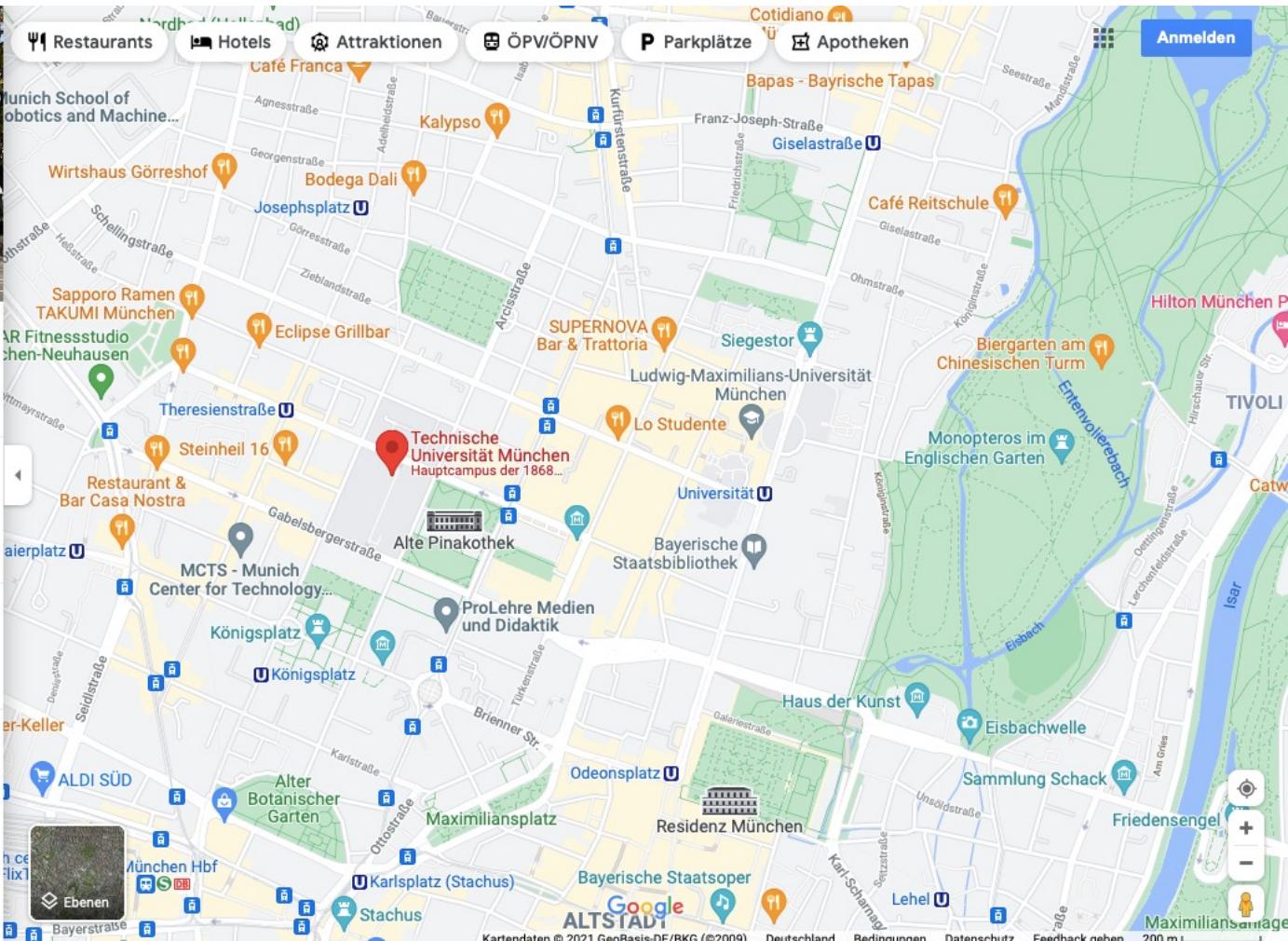
**Technische Universität München**

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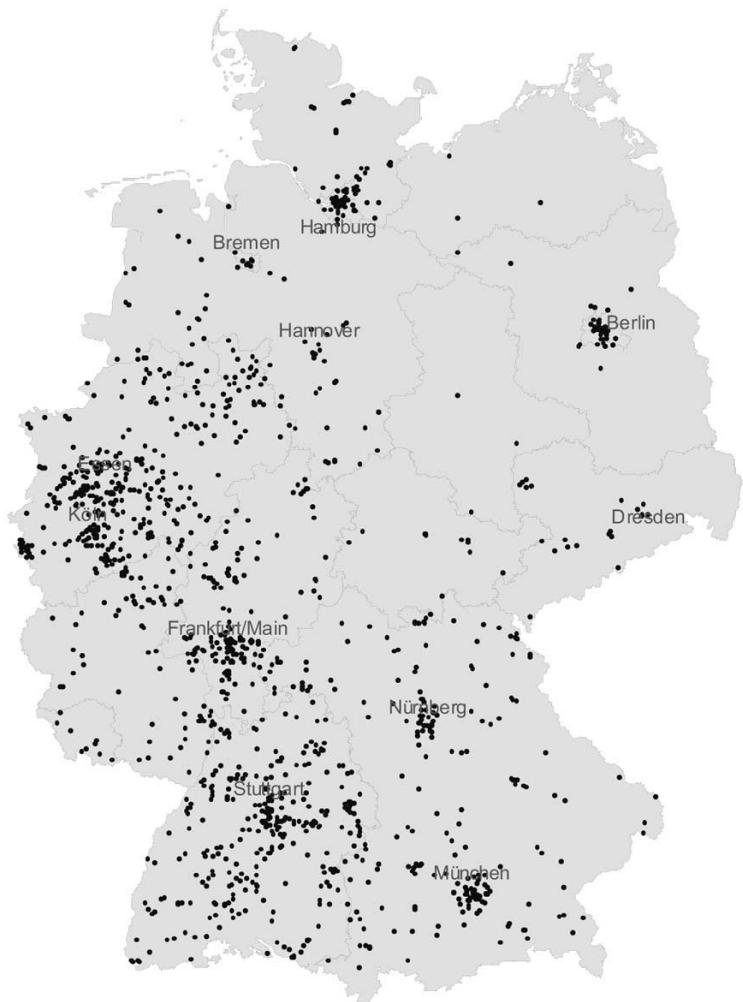


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Café Franca, Kalypso, Bodega Dali, Sapporo Ramen TAKUMI München, AR Fitnessstudio München-Neuhausen, Eclipse Grillbar, SUPERNOVA Bar & Trattoria, Siegestor, Ludwig-Maximilians-Universität München, Lo Studente, Restaurant & Bar Casa Nostra, Steinheil 16, MCTS - Munich Center for Technology, Alte Pinakothek, Bayerische Staatsbibliothek, ProLehre Medien und Didaktik, Königsplatz, Odeonsplatz, Residenz München, Alter Botanischer Garten, Stachus, Karlsplatz (Stachus), Bayerische Staatsoper, ALDI SÜD, München Hbf, Lehel U, Friedensengel, Maximiliansbrücke, Eisbachwelle, Sammlung Schack, Haus der Kunst, Monopteros im Englischen Garten, Entenvollerbach, Biergarten am Chinesischen Turm, Hilton München P, Catwalk, TIVOLI, Isar.

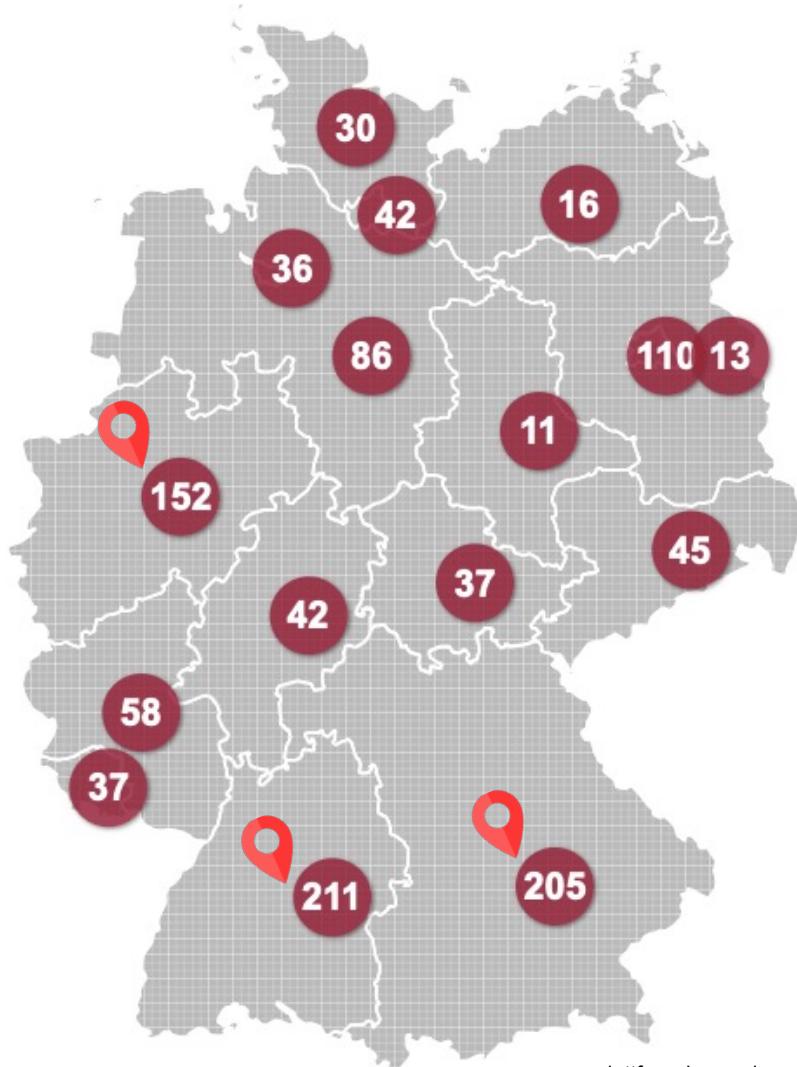
Kartendaten © 2021 GeoBasis-DE/BKG (©2009) Deutschland Bedingungen Datenschutz Feedback geben 200 m

## Hidden champions

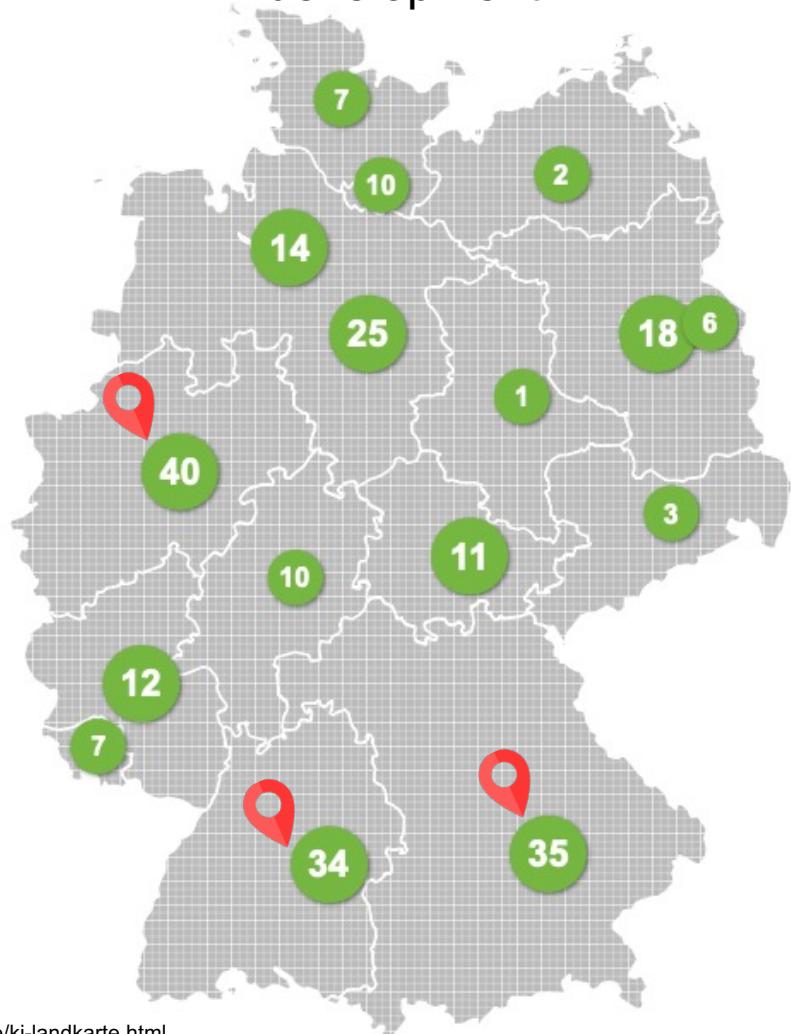


Handelsblatt

## AI projects

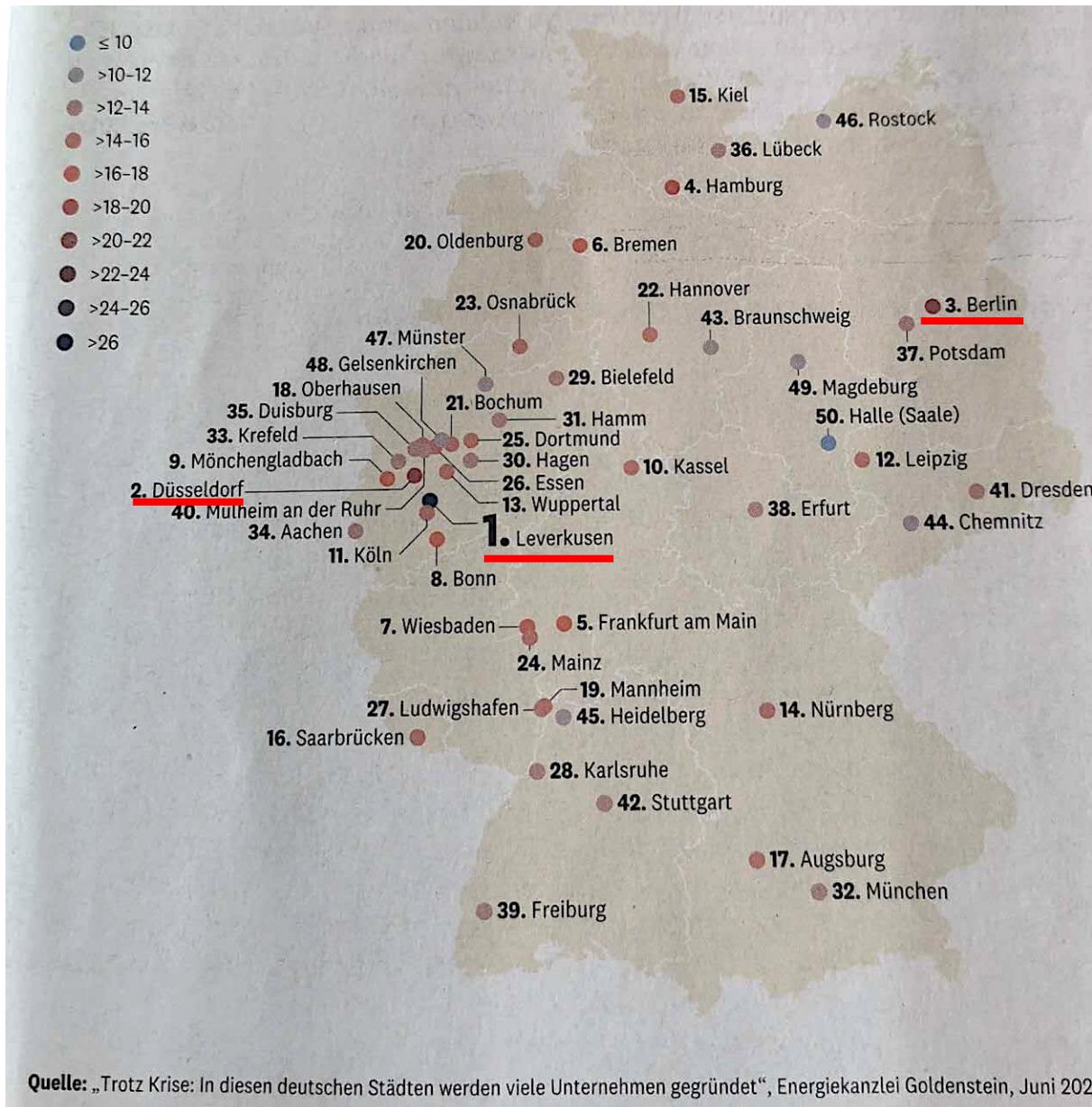


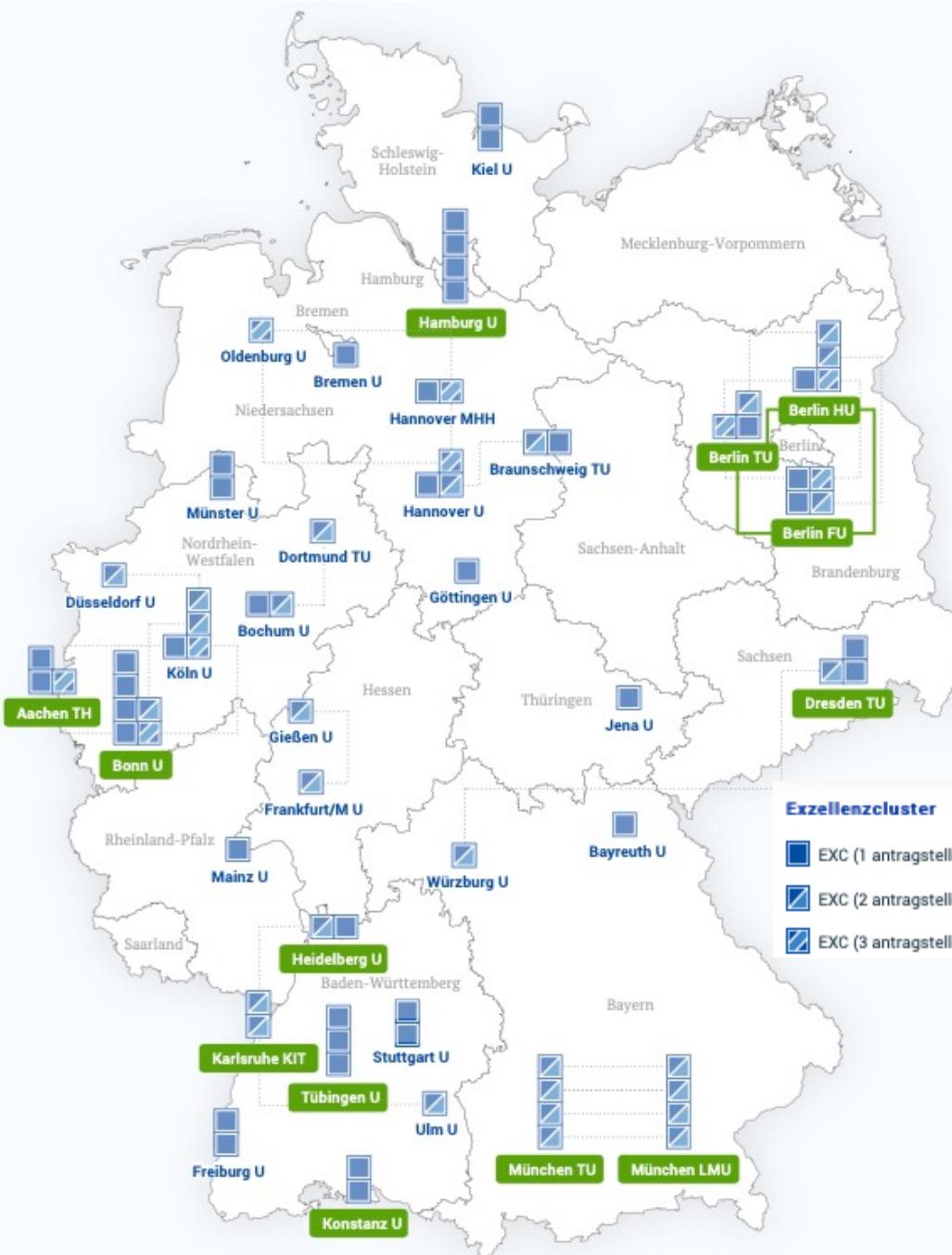
## AI projects for sustainable development



[www.plattform-lernende-systeme.de/ki-landkarte.html](http://www.plattform-lernende-systeme.de/ki-landkarte.html)

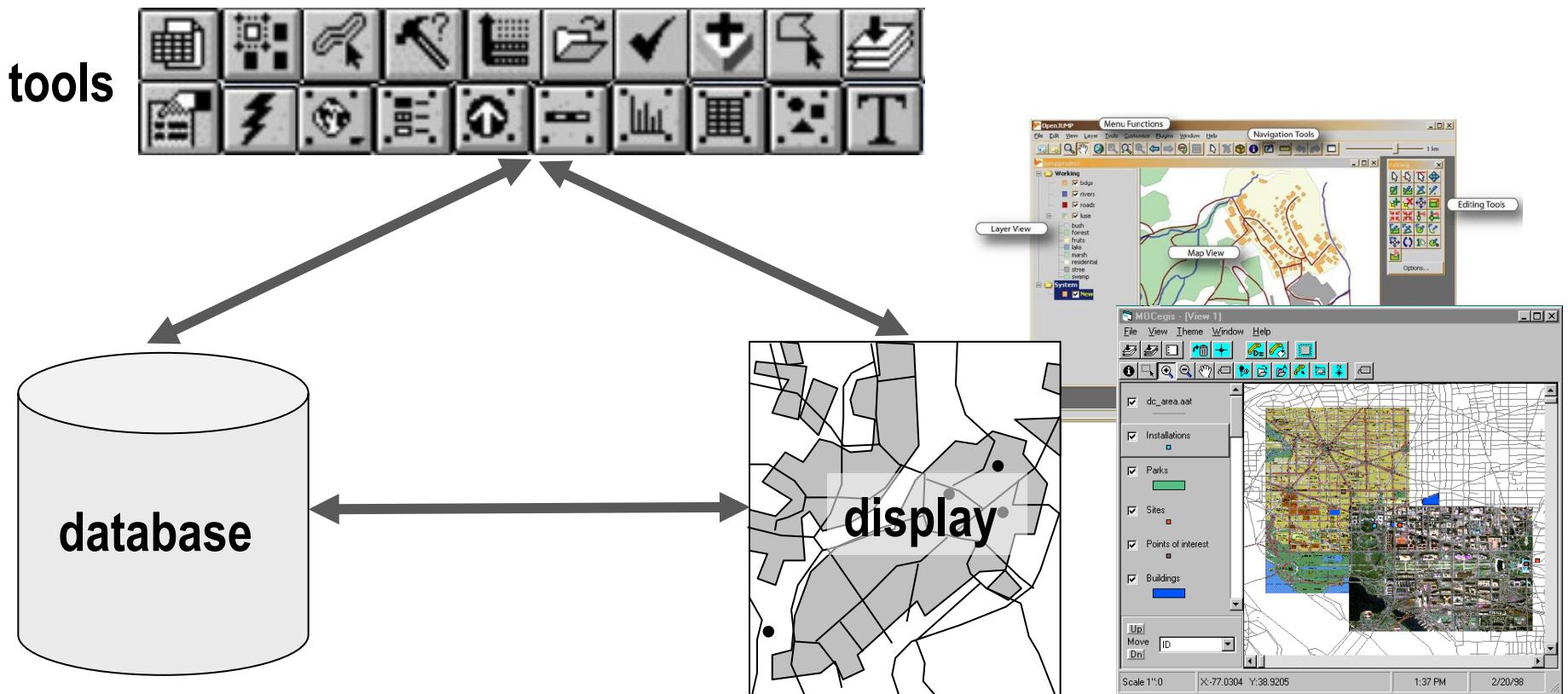
# Number of start-ups per 1000 inhabitants



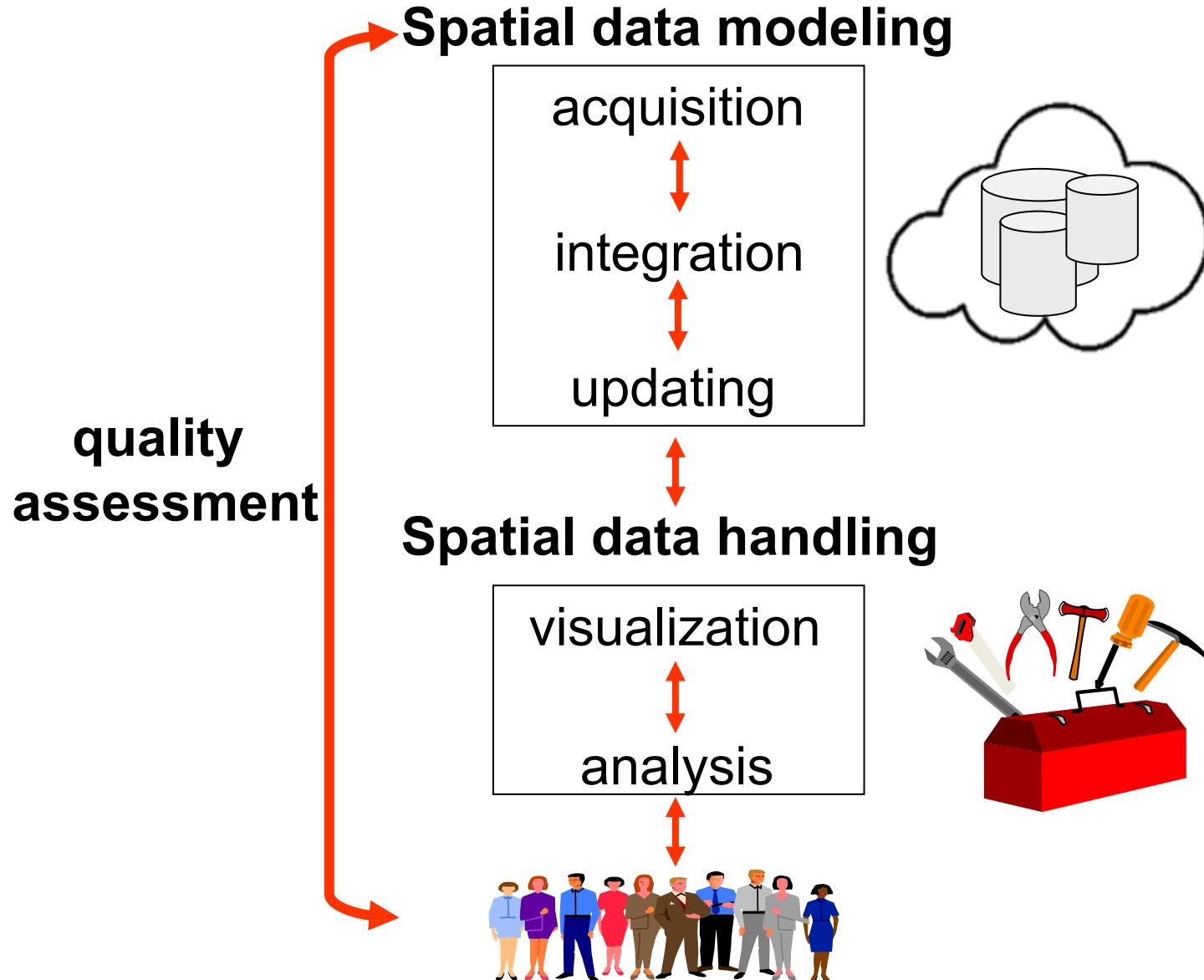


## Landscape of Excellent Universities

# Essential components of a GIS



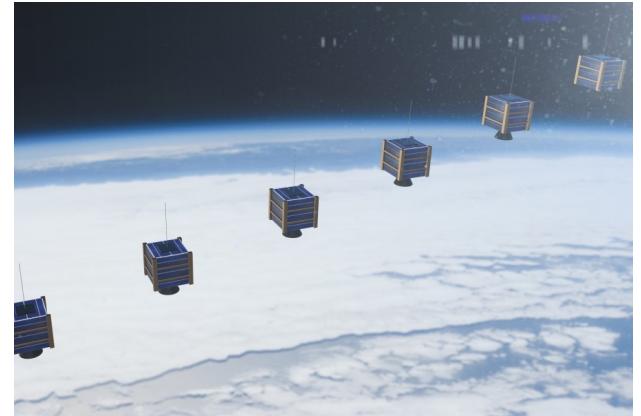
# The typical workflow of a GIS



# Major sources of geodata

## 1. Remote sensing with structured Earth observation

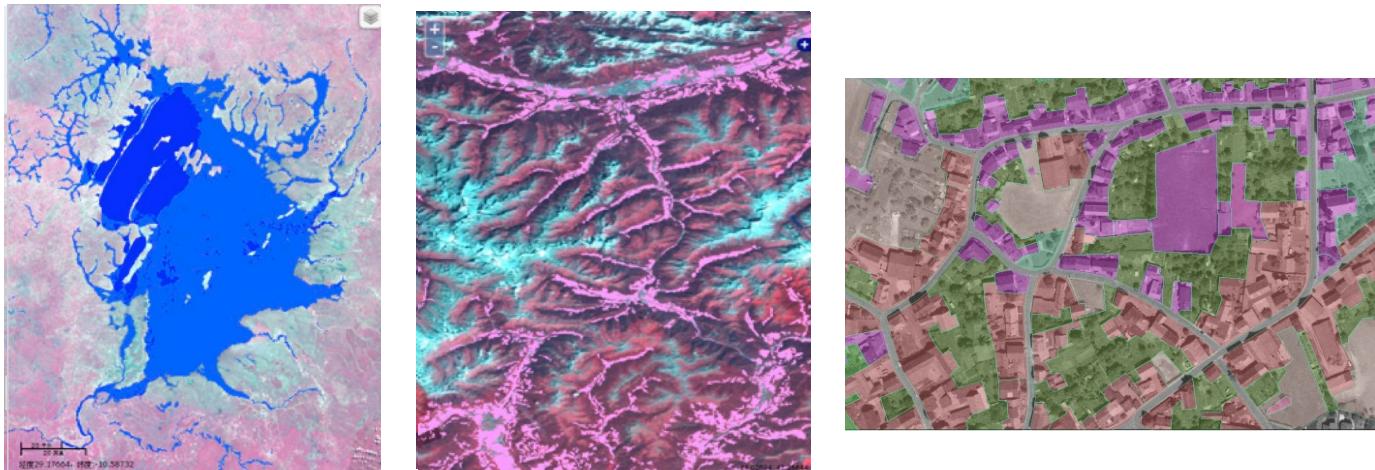
Earth Observation Satellites



## Aerial Photogrammetry

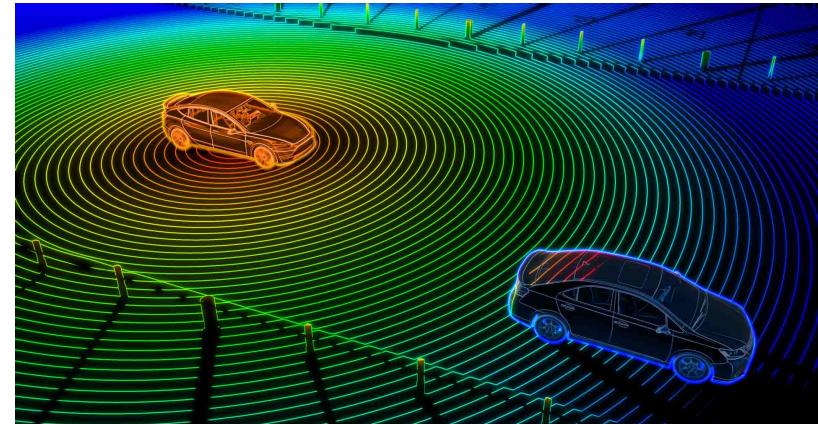


Terrestrial laser scanning



Multispectral images and their interpretation

Interpretation of terrestrial  
laser scanning data



## Learning and deep learning in remote sensing

- Segmentation, classification, recognition
- Change detection
- Quality assurance of geodata
- ...

## 2. Social sensing based on less structured crowd-sourcing

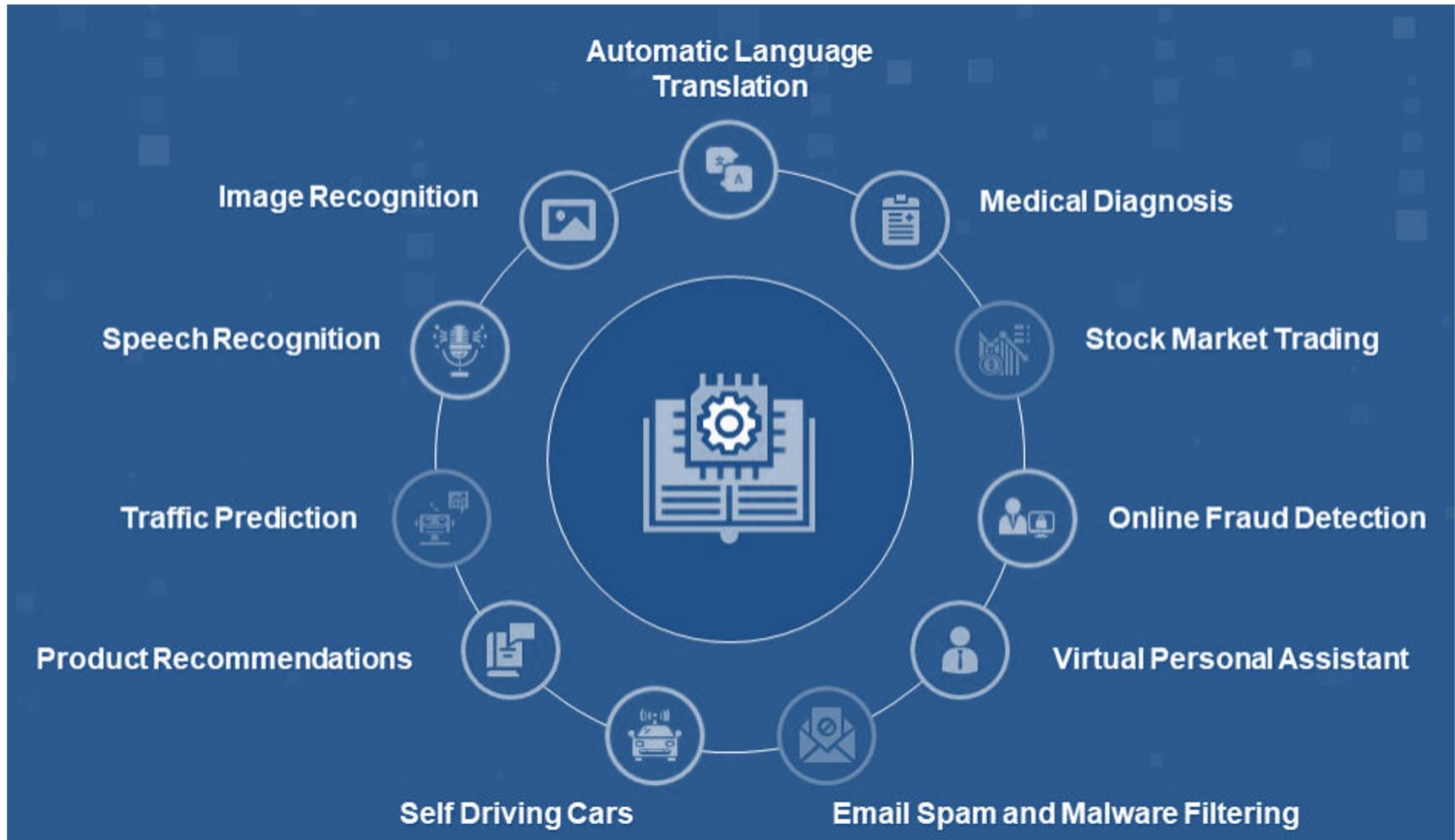


## Deep learning in social sensing

Understanding of natural languages, trajectories, and street views



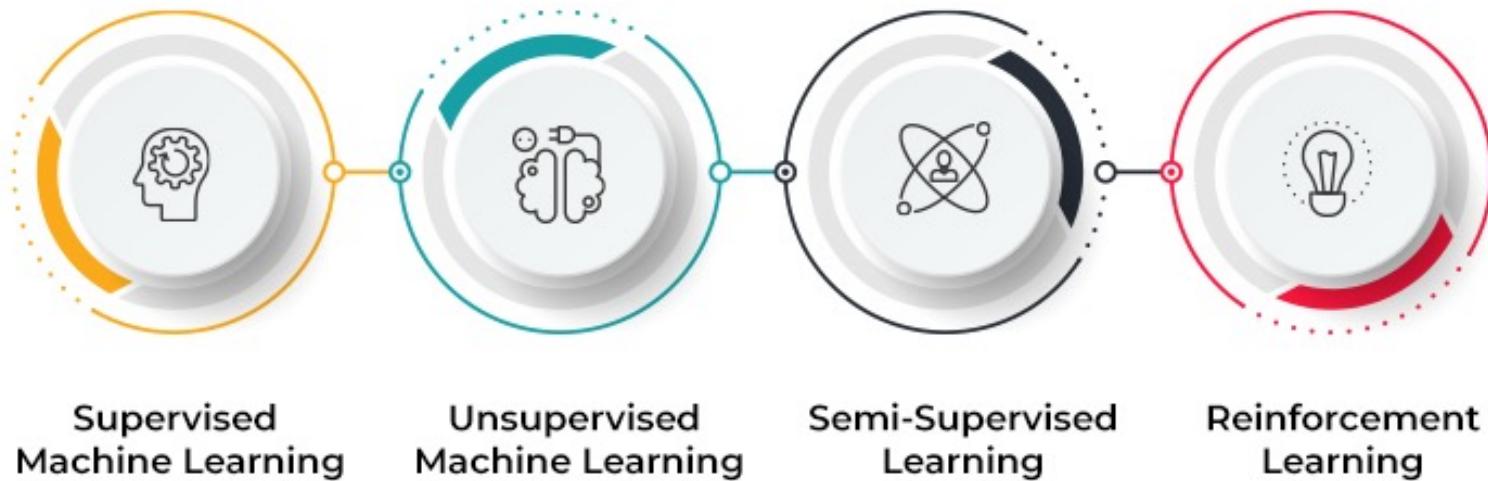
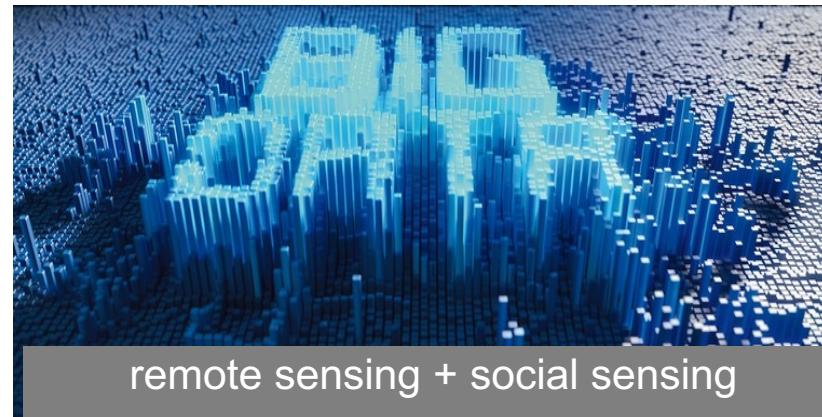
- Natural Language Processing for improved search
- Sentiment analysis for improving user experience and engagement
- Predictive analytics for targeted advertising
- Trajectory analysis and geotargeting for safety and health measures
- Detection of privacy violation
- ...



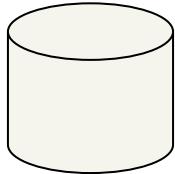
[www.analyticsvidhya.com/blog/2023/04/machine-learning-for-social-media/#:~:text=It%20utilizes%20artificial%20neural%20networks,\(RNNs\)%20for%20sequence%20analysis.](http://www.analyticsvidhya.com/blog/2023/04/machine-learning-for-social-media/#:~:text=It%20utilizes%20artificial%20neural%20networks,(RNNs)%20for%20sequence%20analysis.)

## Typical ML applications of social media data

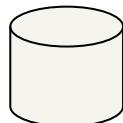
# Big geospatial data



# A value cycle from geodata to intelligence



Data - neutral



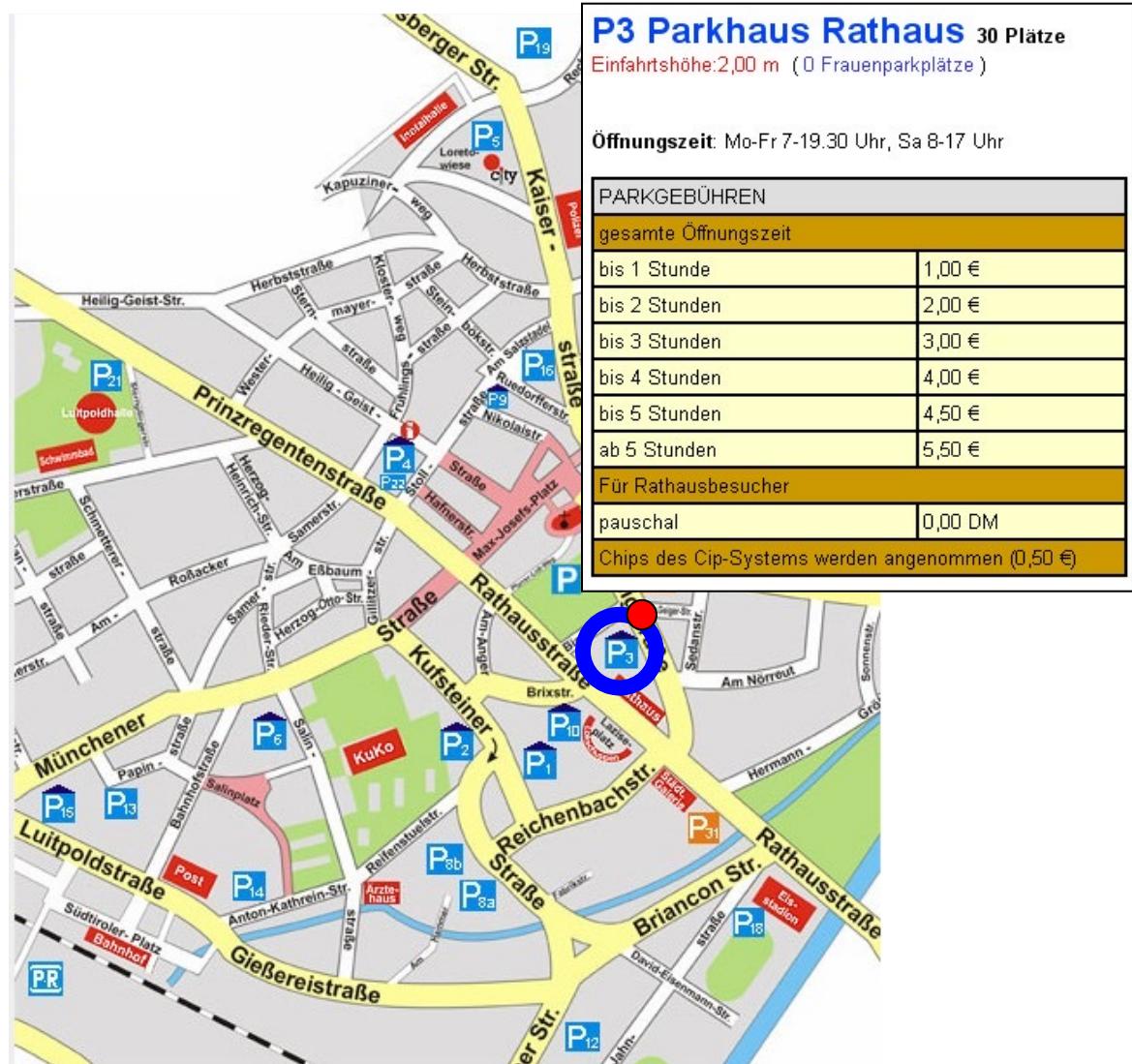
Information - relevant



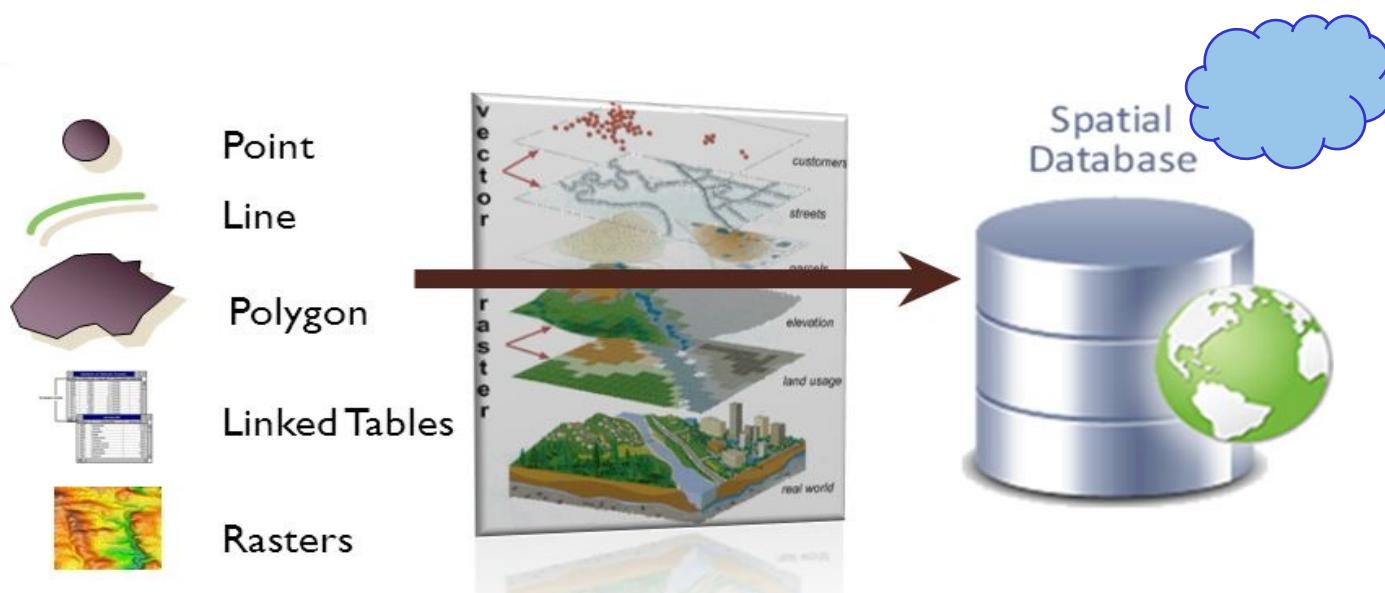
Service - useful



Intelligence – beneficial/profitable



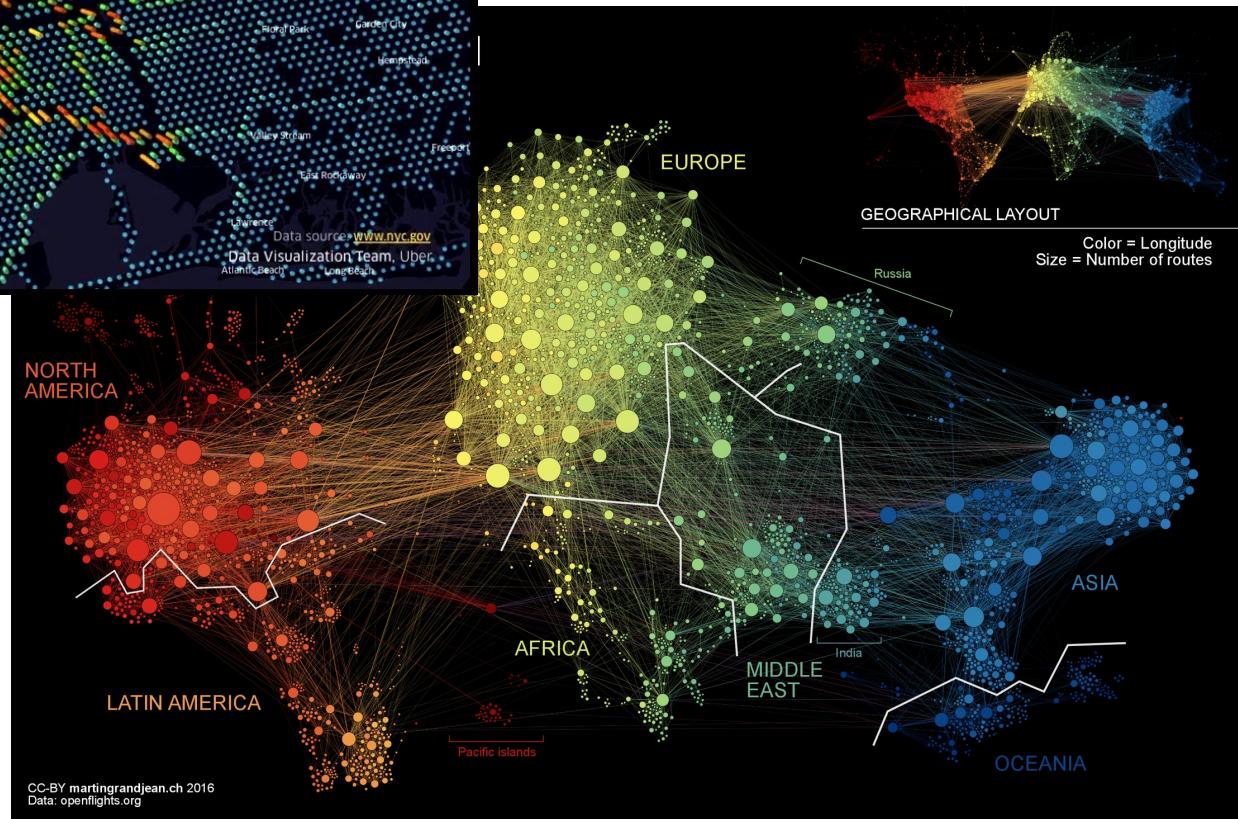
# Possibilities of your future career

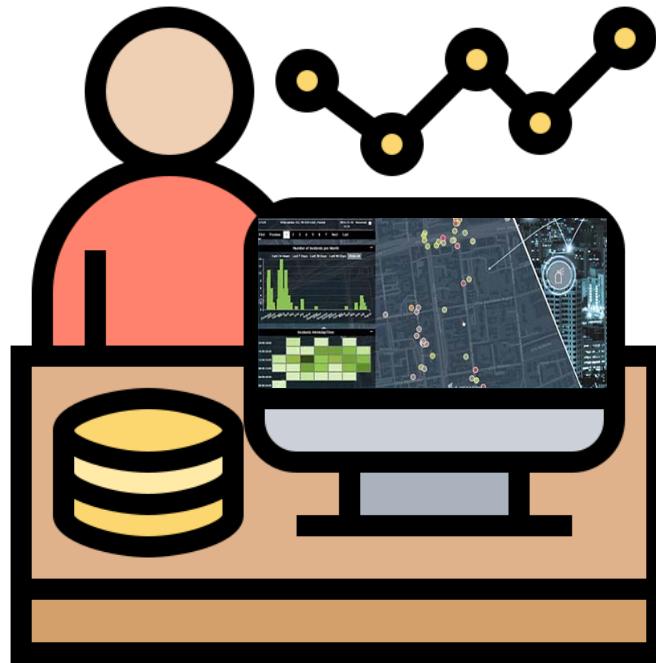


Geodata management



## Geodata visualization





domain knowledge  
+  
machine learning

## Geodata science / Geovisual analytics

# Milestones in the history of GIS

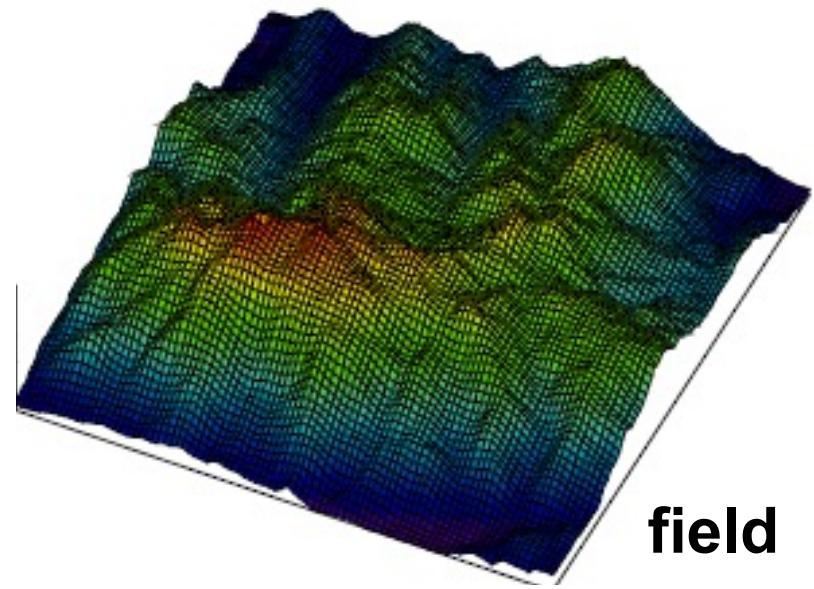
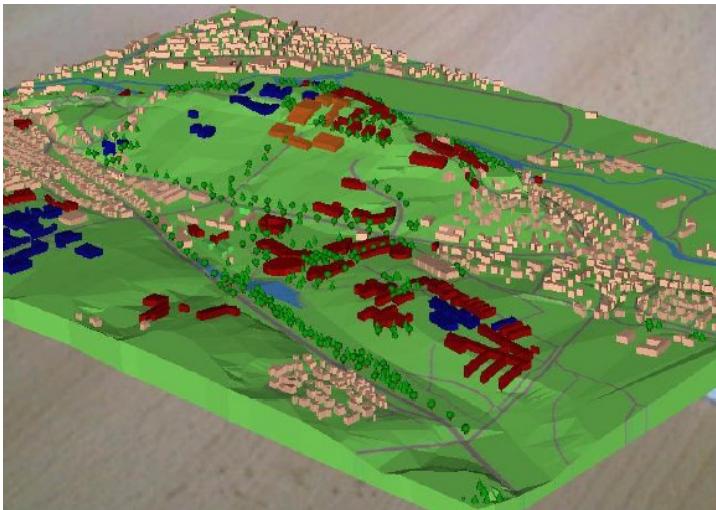
- ❖ Data analysis and display tools (1950s)
- ❖ Mapping tools (1960s)
- ❖ Emergence of the term “GIS” (1970s)
- ❖ Image processing functions and Graphical User Interfaces (1980s)
- ❖ Distributed GIS and peer-to-peer geo-computing (1990s)
- ❖ Mobile GIS (2000s)
- ❖ Big geodata, cloud computing (2010s)
- ❖ Deep learning, GeoAI (2020s)

## II. The nature of geoinformation

### Categories of geoinformation

1. Entities – spatially discrete objects that statically litter in space (e.g. cities, roads)
2. Fields – spatially continuous functions with a unique value everywhere (e.g. terrain height, temperature, moisture)
3. Phenomena – temporally continuous functions that happen dynamically (e.g. brush fires, epidemic, urban growth)

**entities**



**field**



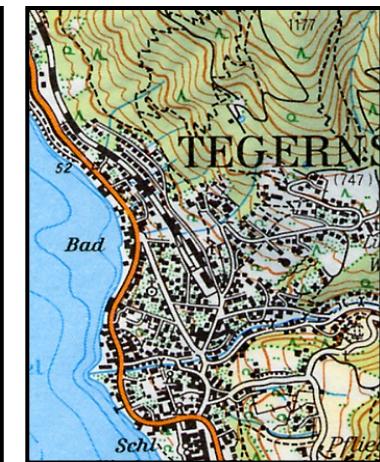
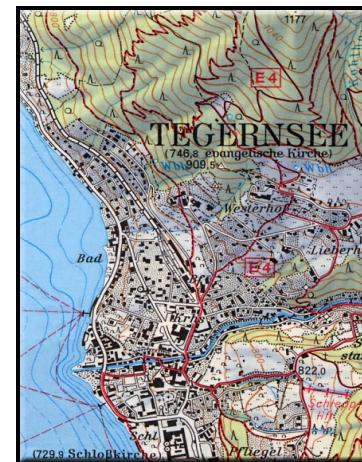
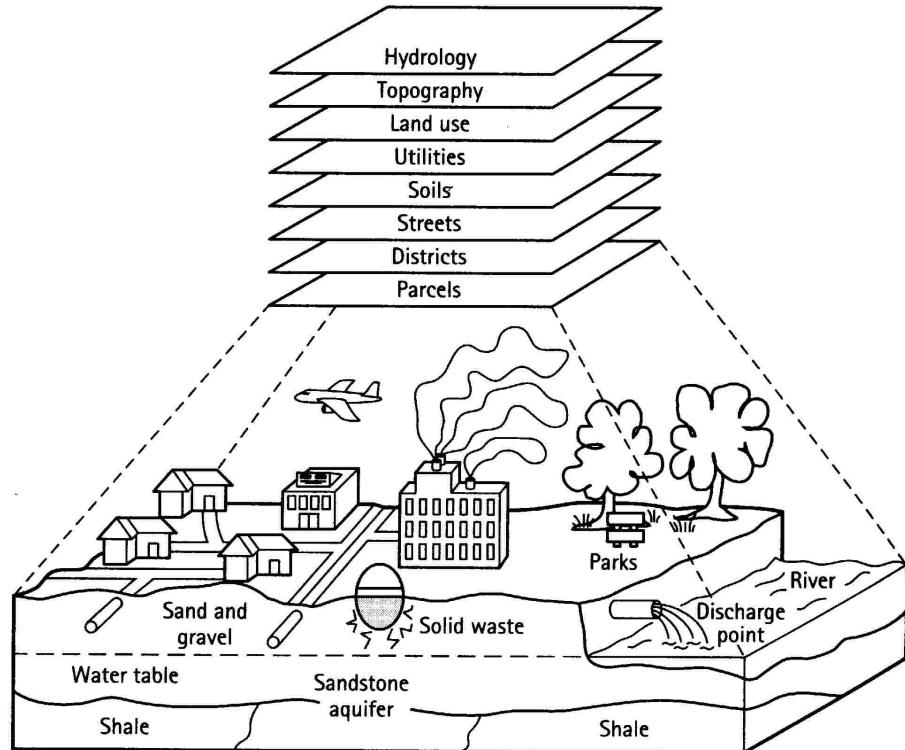
**phenomena**

## Dimensions of geoinformation

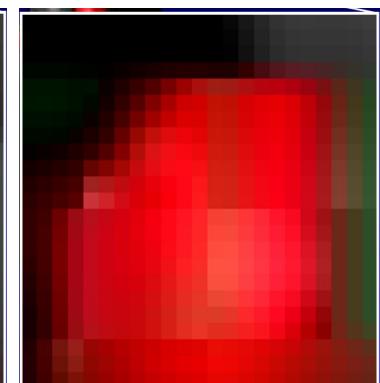
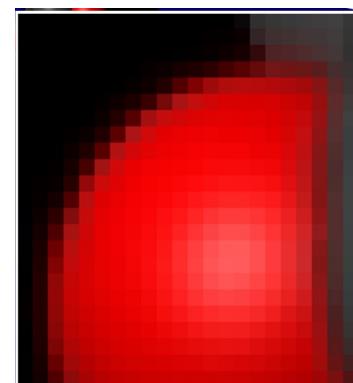
- 3D space – coordinates, address, orientation, distance
- Time – clock time and date, change, cause, effect
- Theme – spatial related topics
- Scale – level of detail, resolution, map scale
- Quality – discrepancy between model and reality

## scales

### themes



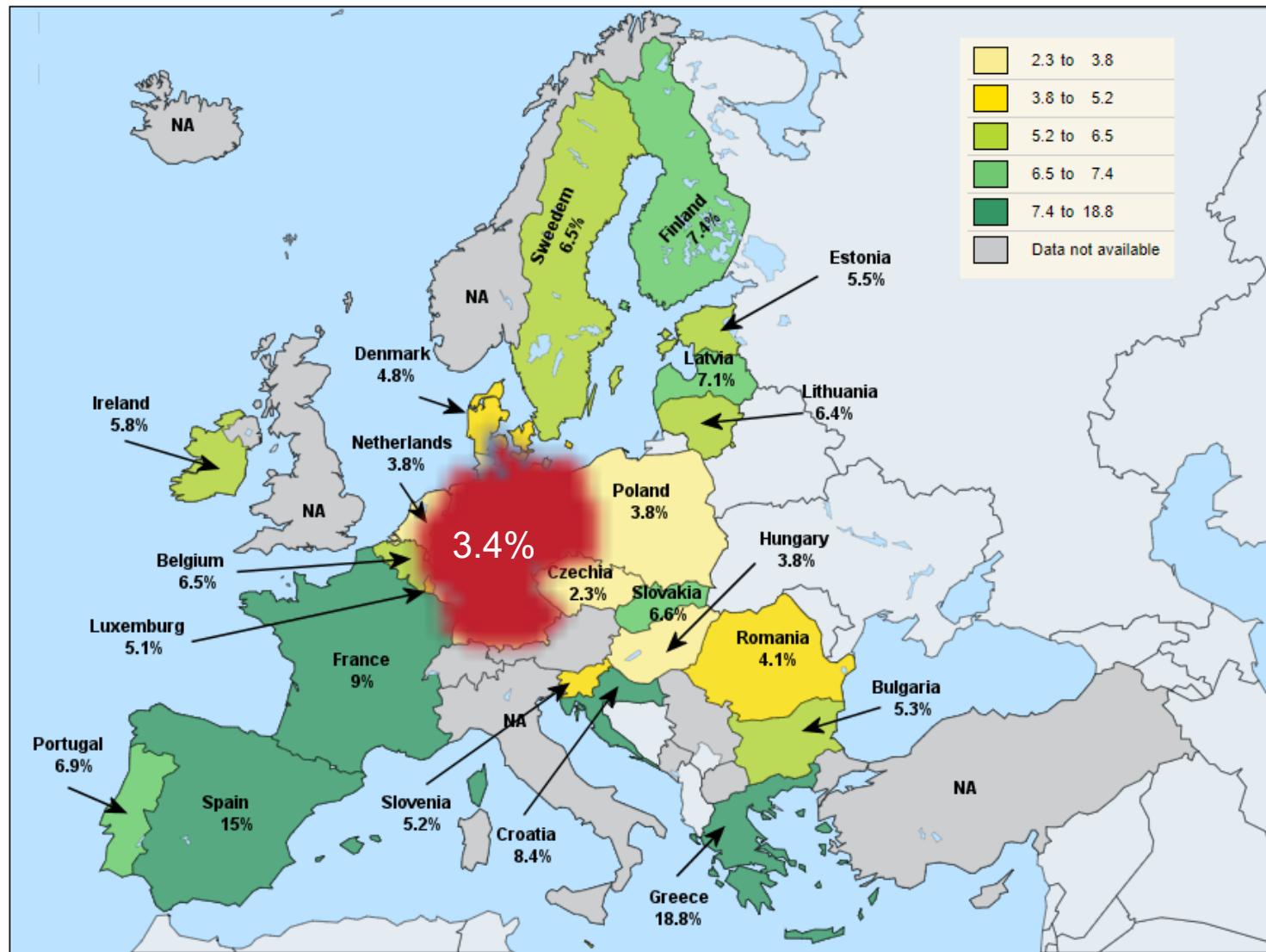
### resolutions



# What makes geoinformation special?

- Spatial and temporal dependence – geographic objects are interrelated.
- Spatial heterogeneity - Conditions at different places are different.
- User interest is place-sensitive – Information of a place is of greater importance to users living in that place than it is to users elsewhere.

## European Unemployment Rates Q3 2018



© EuroGeographics Association for the administrative boundaries

Data courtesy of eurostat

# III. Different views of space and time

## Mathematical view

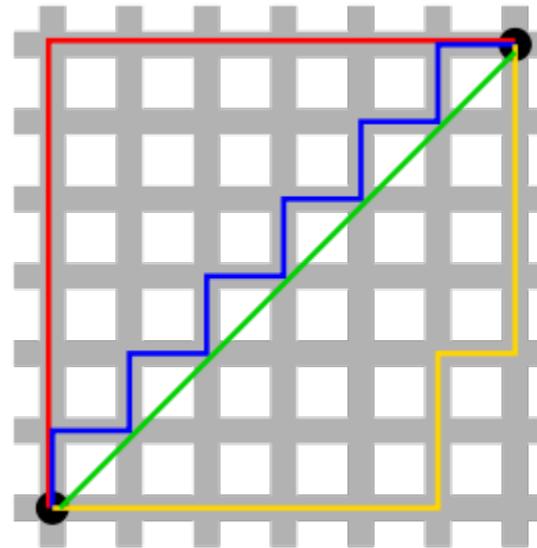
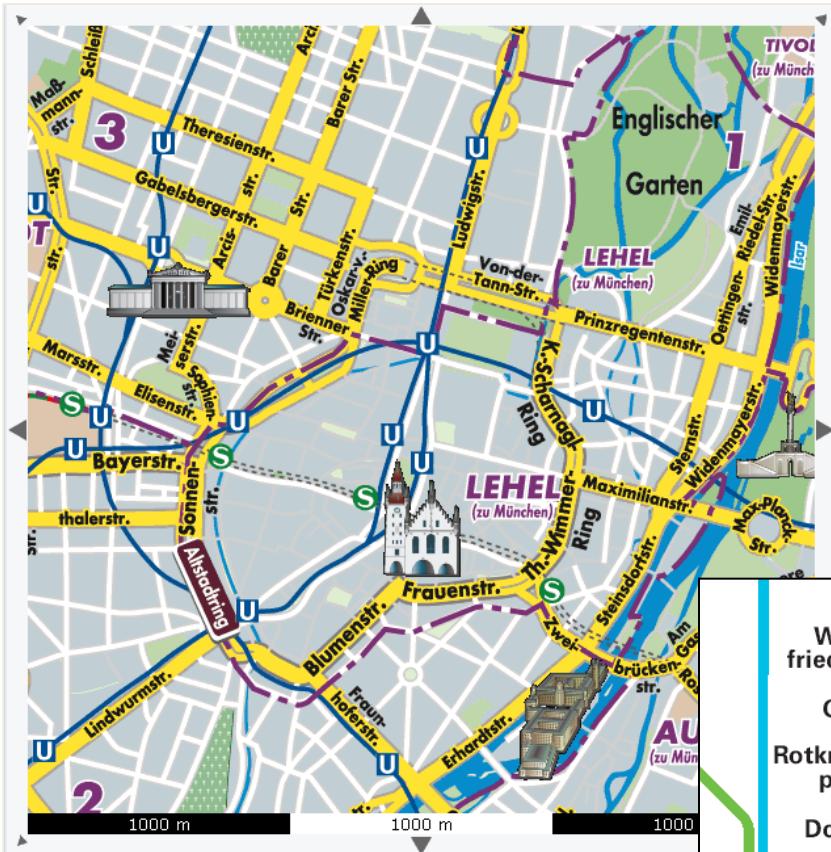
- Euclidean space (e.g. the Euclidean distance):

$$d_{i,j} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}$$

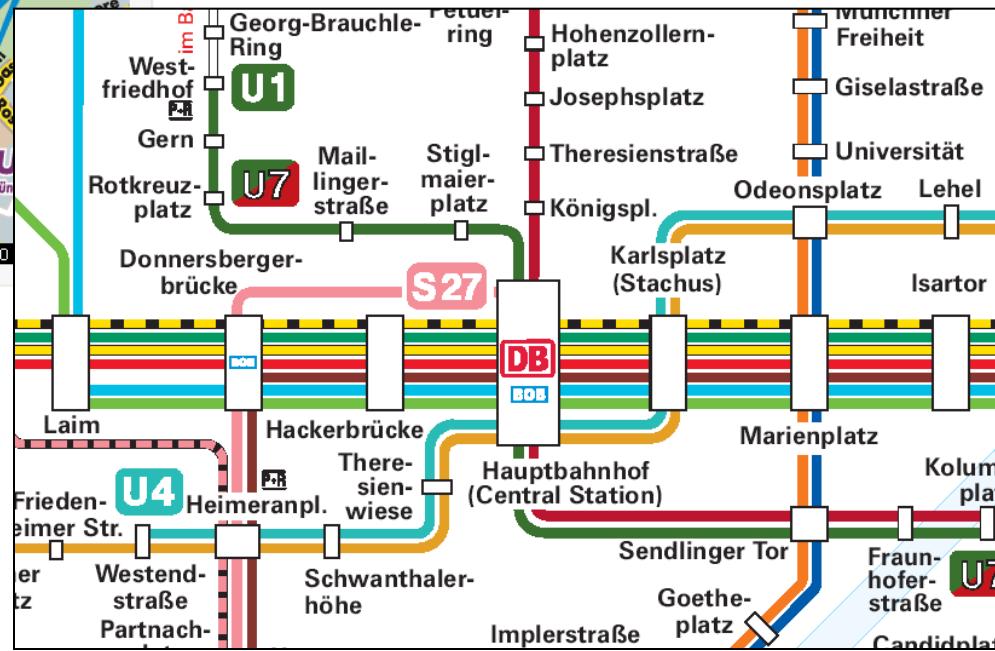
- Gridded space, i.e. ‘Manhattan’ or ‘taxicab’ metric:

$$d_{i,j} = |x_i - x_j| + |y_i - y_j|$$

- Topological space: invariant properties under some transformations, e.g. inside and outside, touching, overlapping, connection.

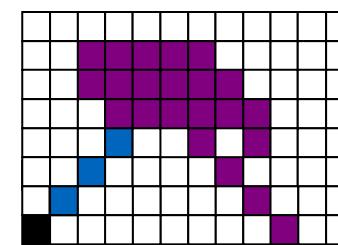
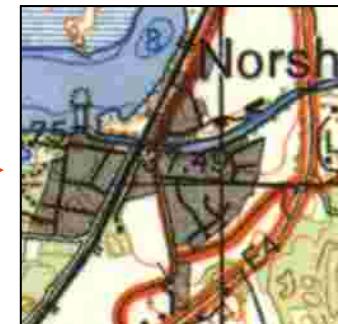


Topological



## Physical view

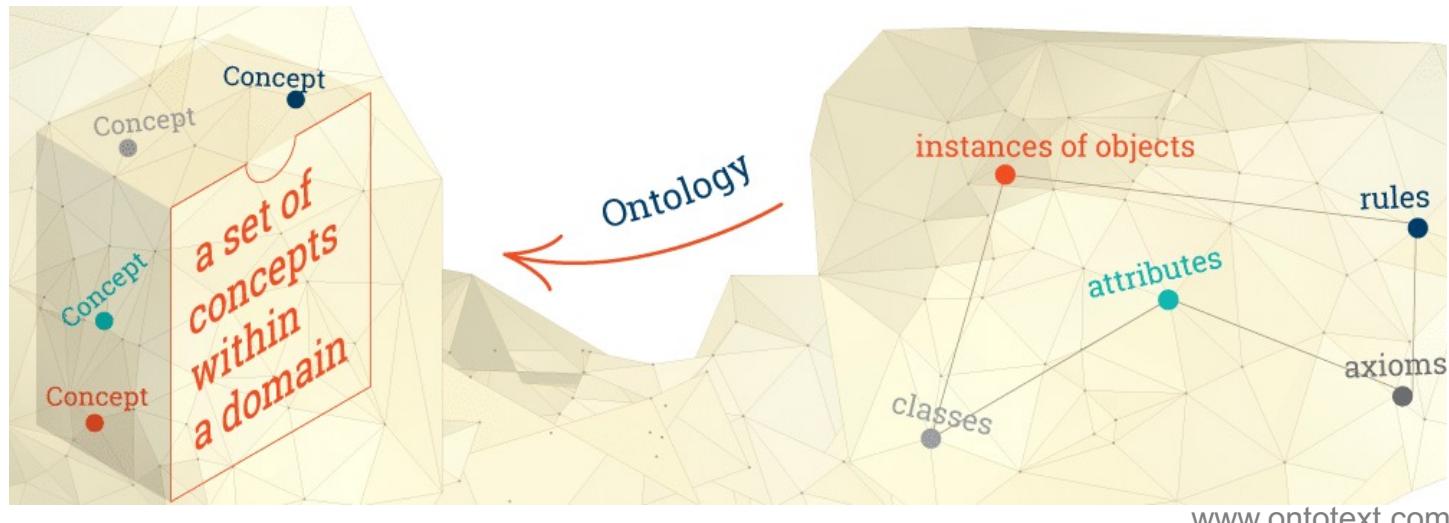
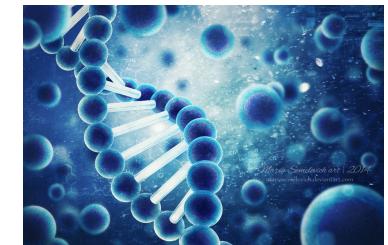
Real-world objects can be represented by geometric primitives, e.g. a road is treated as a line, or a lake is treated as a polygon or a connect set of grid cells.



## Philosophical view

Ontology studies concepts, categories and relationships within a domain and across domains in space and time.

The concepts may be within or beyond the direct experience of human beings.



## Cognitive and socio-cultural views

- There is no single reality that is the same for all.  
Different realities exist in different minds and different application domains.
- Cognitive factors often influence behaviour more than objective properties of the world may do.
- Social phenomena vary across geographical space.  
It is not clear what are the fundamental spatial units to which they relate.

# The world of a child

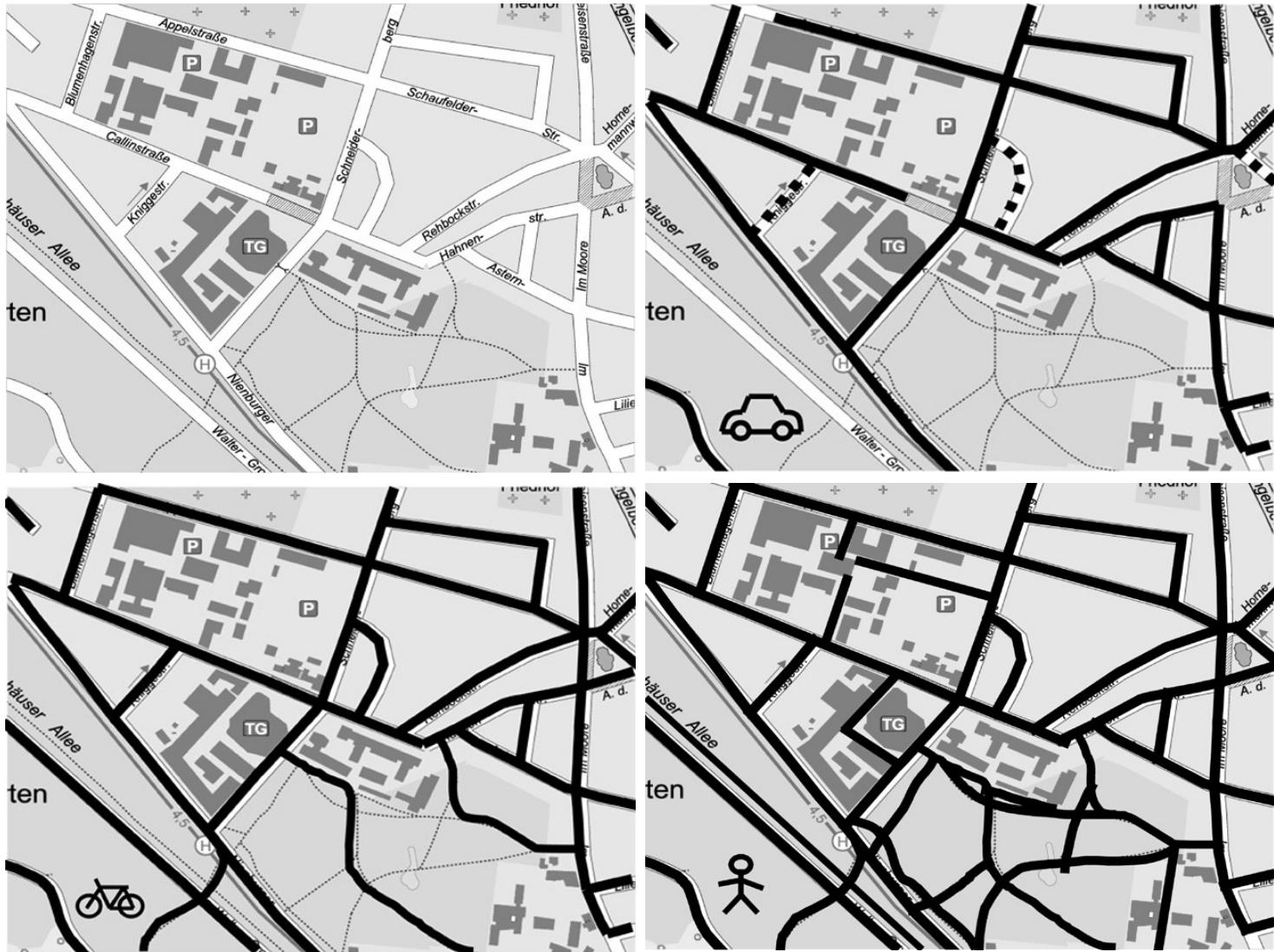


Bulgarien - Sofia - Aleksandar V. Cerovski - *The children draw and make a better world*

# THE WORLD AS WE KNOW

O. Hajjai (Jordan)





## IV. Challenges of geoinformatics

### Modeling and handling of time

- A lot of information is missing for measurements with different time stamps.

### Modeling and handling of non-metric space

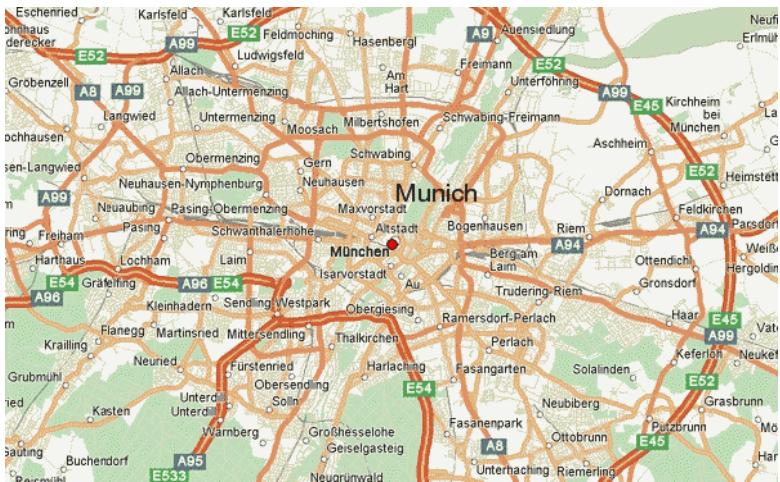
- It is difficult to compare and represent non-metric relationships such as proximity in terms of distance.

## Modeling and handling of uncertain properties

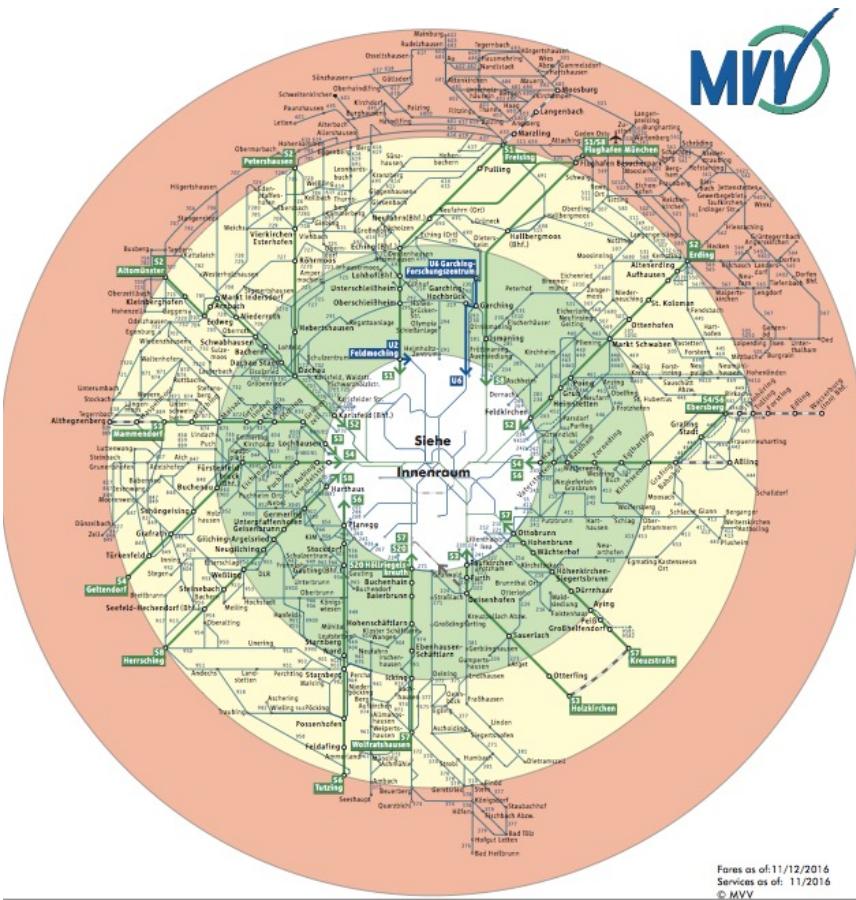
- The measured properties describing entities, fields and phenomena are uncertain.

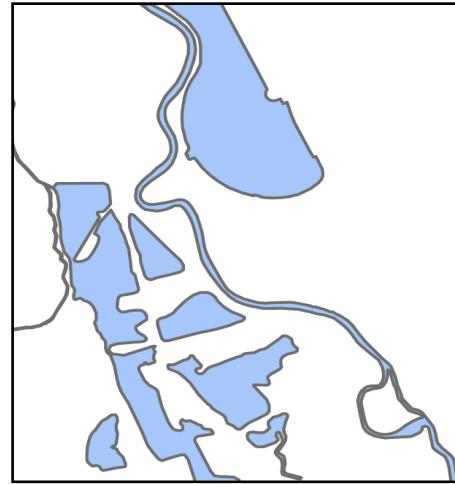
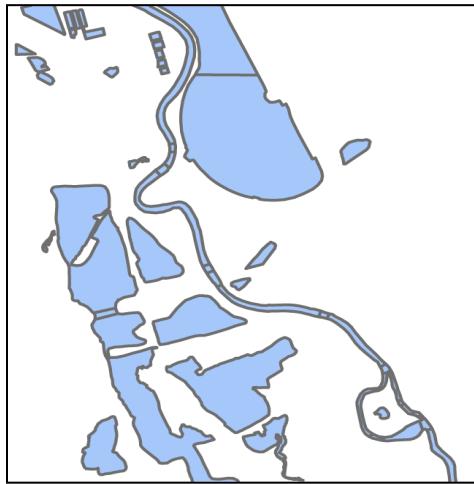
## Modeling and handling of multiple views of the world

- We see the world through our own eyes and minds.  
It is difficult to translating multiple and sometimes conflicting insights into a uniform data model.



Which one do you rely on?



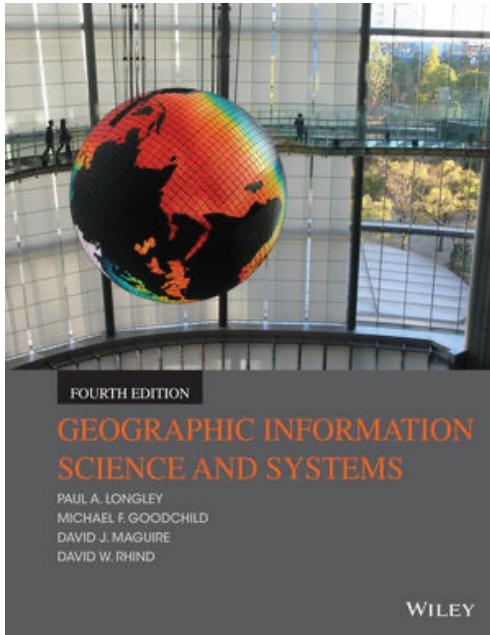


Datasets of the same region and scale

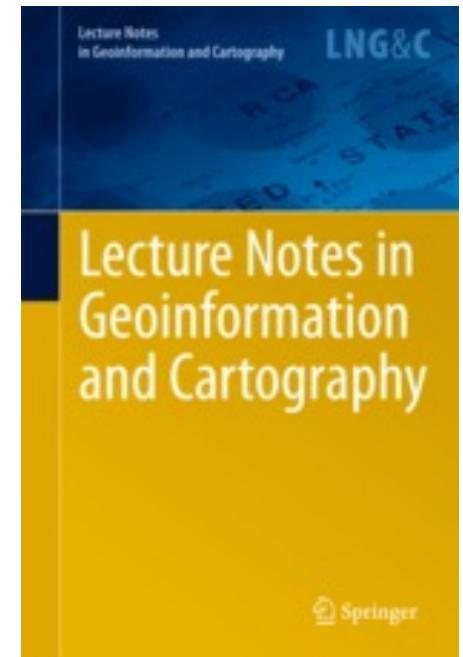


Datasets of the same region but different map scales

# Main references



- PA Longley, MF Goodchild, DJ Maguire & DW Rhind (2015): Geographical Information Science and Systems



- Lecture Notes in Geoinformation and Cartography since 2006  
Editors: W Cartwright, G Gartner, L Meng & MP Peterson



1. How do you understand geoinformatics and its development?
2. Explain the essential components and typical workflow of a GIS.
3. What is your opinion about big geospatial data and its development?
4. What is your understanding of value cycle from data to intelligence?
5. What makes geoinformation special?
6. Use examples to explain the terms - entities, fields and phenomena.
7. What is the difference between Euclidean distance and Manhattan (taxicab) distance?
8. How do you understand the dimensions of geoinformation?
9. How do you understand the ontology in space time?
10. What are the main research challenges of geoinformatics?