GEOProcessing 2013 International Expert Panel

Geosciences in the Age of Knowledge:

Tackling the Complex and Challenging World of Future Geo-application Scenarios

February 26, 2013, Nice, France

International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing 2013)

IARIA

GEOProcessing/DigitalWorld
February 24 – March 1, 2013 - Nice, France

GEOProcessing Expert Panel: Geosciences in the Age of Knowledge

Panelists

- *Claus-Peter Rückemann* (Moderator), Leibniz Universität Hannover / Westfälische Wilhelms-Universität Münster (WWU) / North-German Supercomputing Alliance (HLRN), Germany
- *Yerach Doytsher*, Technion - Israel Institute of Technology - Haifa, Israel
- *Mikhail Kanevski*, University of Lausanne, Switzerland
- *Małgorzata Hanzl*, Lodz University of Technology, Poland
- *Claus-Peter Rückemann*, Leibniz Universität Hannover / WWU / HLRN, Germany
- *Jiyeong Lee*, University of Seoul, South Korea

GEOProcessing / DigitalWorld 2013:
`http://www.iaria.org/conferences2013/GEOProcessing13.html`

GEOProcessing Expert Panel: Geosciences in the Age of Knowledge

Related Topics:

- Scientific and technical issues and advanced applications,
- Knowledge discovery in geosciences and natural sciences,
- Intriguing multi-disciplinary application scenarios and collaboration,
- Long-term issues,
- Geo-data in social context,
- Legal aspects of geo-data use,
- Human-GIS interaction,
- High End Computing and storage aspects,
- Geo-data in learning and education environments,
- Integrating geo-data, medical data, and social data,
- Isolated or integrated information systems (geosciences, spatial sciences, archaeology, ...)
- ...

GEOProcessing Expert Panel: Geosciences in the Age of Knowledge

Wrapup:

- **Infrastructures, frameworks, applications:** What do we need?
- **Integration:** Which challenges do we encounter?
- **System and architectures:** What is long-term?
- **Recycling components:** What are the suggested benefits?
- **Big data and knowledge:** Challenges ahead?
- **Knowledge discovery and information:** Status, next steps?
- **Knowledge resources requirements:** Key issues?
- **Computing and storage requirements:** Key issues?
- **Multi-disciplinary collaboration:** Is there an integration breaktrough?
- **Your ideas:** Who and what are we creating and operating geo-applications for? Why does general progress take so long?

GEOProcessing Expert Panel: Geosciences in the Age of Knowledge

Panel Statements:

- **Key-terms:** Socio-spatial networks, knowledge discovery, urban plannung, long-term, navigation, geographic entities, GPS, cellular phones, multi-disciplinary context, indoor-outdoor, ...
- **Long-term knowledge resources needed:** Natural sciences and humanities.
- **Integrated Information and Computing Systems needed:** Resources for computing and storage in natural sciences, geosciences, archaeology, ...
- **New Geomatics paridigm:** Integrated Socio-Spatial Networks.
- **Common multi-disciplinary platform needed for urban planning:** Geo-data in social context, multi-disciplinary application scenarios, collaboration.
- **Spatial is not outdoor only:** Indoor spatial awareness.

GEOProcessing Expert Panel: Post-Panel-Discussion Summary

Post-Panel-Discussion Summary:

- The panel showed a continuous spectrum from *large scale/satellite scenario* to *urban planning* to *indoor spatial* awareness applications.
- The different focus aspects are interwoven, even the more we get into details. The amount of data gathered by *automation* is increasing fastest.
- Some scenarios are *batch* applications, other near *real-time* with increasing micro-aspects.
- *Privacy and anonymity is considered to be the most important upcoming issue with the future geo-application scenarios.*
- Data being privacy relevant is already being available, *without any wider general protection possible*.
- *Data size, heterogeneity, and technological limitations* might currently still "protect" against near real-time privacy intrusion.
- It will be interesting to see the development of geo-data, especially regarding *privacy within the next years*.

GEOProcessing Expert Panel: Table of Presentations

Panelist Presentations:

- **Advanced Information Systems and Computing in Geosciences and Archaeology** (*Rückemann*)
- **The new Geomatics Paradigm: Integrated Socio-Spatial Networks** (*Doytsher*)
- **Environmental Data Modelling Using Machine Learning Algorithms** (*Kanevski*)
- **Geo-data in social context: Intriguing multidisciplinary application scenarios and collaboration** (*Hanzl*)
- **3D Indoor Space: Indoor Spatial Awareness** (*Lee*)

International Expert Panel GEOProcessing 2013

Geosciences in the Age of Knowledge:

Tackling the Complex and Challenging World of Future Geo-application Scenarios

Advanced Information Systems and Computing in Geosciences and Archaeology

The International Conference on Advanced Geographic Information Systems, Applications, and Services (GEOProcessing / DigitalWorld)
February 24 – March 1, 2013, Nice, France

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Dr. rer. nat. Claus-Peter Rückemann[1,2,3]

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Westfälische Wilhelms-Universität Münster

GEXI

ACTMAP

Knowledge

Where knowledge is ...

Knowledge is created from a subjective combination of different attainments as there are intuition, experience, information, education, decision, power of persuasion and so on, which are selected, compared and balanced against each other, which are transformed and interpreted.

And the consequences ...

Authentic knowledge therefore does not exist, it always has to be enlived again. Knowledge must not be confused with information or data which can be stored. Knowledge cannot be stored nor can it simply exist, neither in the Internet, nor in computers, databases, programs or books.

Status on Advanced Information and Computing Systems

Perception and solutions?

- Complementary needs and perception on research and business sides?
- Integrated collaboration frameworks and concepts?
- Validation, verification, error correction?
- Redundancy and criticality management?
- Knowledge, what?, where?
- Classification (Universal Decimal Classification, UDC)?
- Content and context?
- Georeferencing?
- Interactive communication requirements (quantity and quality).
- Data transfer to/from distributed resources (interactive and batch).
- Development of methods and applications depending on funding, physical resources, consulting, reliability, high availability, security.
- Is software a solution for every problem?
- Isolated user groups, no holistic view on context and content.
- Who will be the recipients of YOUR work/results?

Vision – Way to go: Cultural and Technological Development

Knowledge resources:

Knowledge transfer is essential.

Over generations of objects and subjects, this requires:

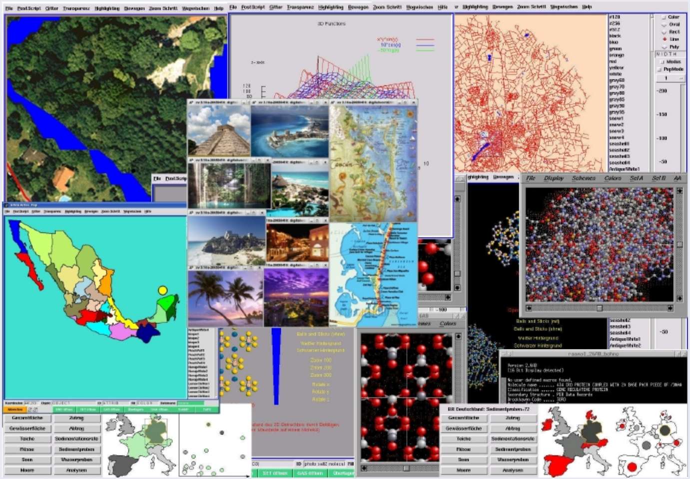
- Knowledge recognition (expertise).
- Knowledge documentation, for any aspect of nature and society (sciences, literature, technical descriptions, tools, cultural heritage, mythology, songs, media, ...).
- Long-term means.

Process targets

- Holistic knowledge resources creation,
- Knowledge resources transfer over generations,
- Documentation of requirements and context,
- Integrated information and computing systems development.

Challenges of disciplines-services-providers application scenarios

Integrated Information and Computing Systems (GEXI case study)



Data objects

- vector
- raster
- aerial
- photo
- spatial
- calculation
- measurement
- processing
- meta objects
- interactive
- commercial
- license
- ...

Universal Decimal Classification

Example excerpt of Universal Decimal Classification (UDC) codes:

UDC Code	Description (English)
UDC 55	Earth Sciences. Geological sciences
UDC 56	Palaeontology
UDC 911.2	Physical geography
UDC 902	Archaeology
UDC 903	Prehistory. Prehistoric remains, artefacts, antiquities
UDC 904	Cultural remains of historical times
UDC 25	Religions of antiquity. Minor cults and religions
UDC 930.85	History of civilization. Cultural history
UDC "63"	Archaeological, prehistoric, protohistoric periods and ages
UDC (7)	North and Central America
UDC (23)	Above sea level. Surface relief. Above ground generally. Mountains
UDC (24)	Below sea level. Underground. Subterranean
UDC =84/=88	Central and South American indigenous languages

Information systems and computed classified objects

Example: Region, Pyramid of Maya, Yucatán, México

Kukulkán

Nohoch Mul

El Meco

El Rey

- **Function:** SAMPLE objects from a group and / or location.
- **Content / context**: compute and storage:
  objects pyramids, Maya, Yucatán region.
- **Computation:** Selection of media photo objects.

Conclusions

Funding (and) Multi-disciplinary Work

Challenges and deficits:

(as identified in last years' GEOProcessing Panel on Large Data Volume)

- ((Sustainable funding)),
- Big data: Different disciplines different volume, velocity, variability,
- Common availability of integrated systems,
- Fast and massive I/O and communication solutions,
- Fast archiving, storage, retrieval, and file systems,
- Reliable and secure data and resources access (homomorphic not practical),
- Data staging with HW and SW,
- Architectures (storage, memory, cores) and energy efficiency.

Issues of future information systems and computing:

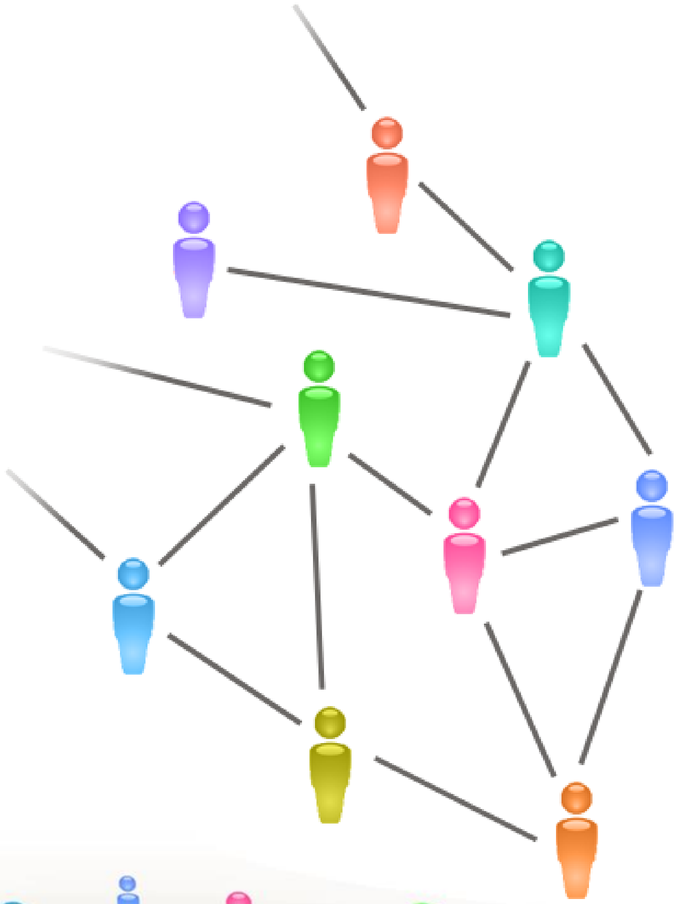
- **Multi-disciplinary work** (content, context, knowledge).
- **Sciences** (expertise in different disciplines).
- **Complexity** (holistic knowledge resources creation).
- **Long-term** (over generations).
- **Portability** (algorithms and solutions).
- **Hardware and software** (integration frameworks).

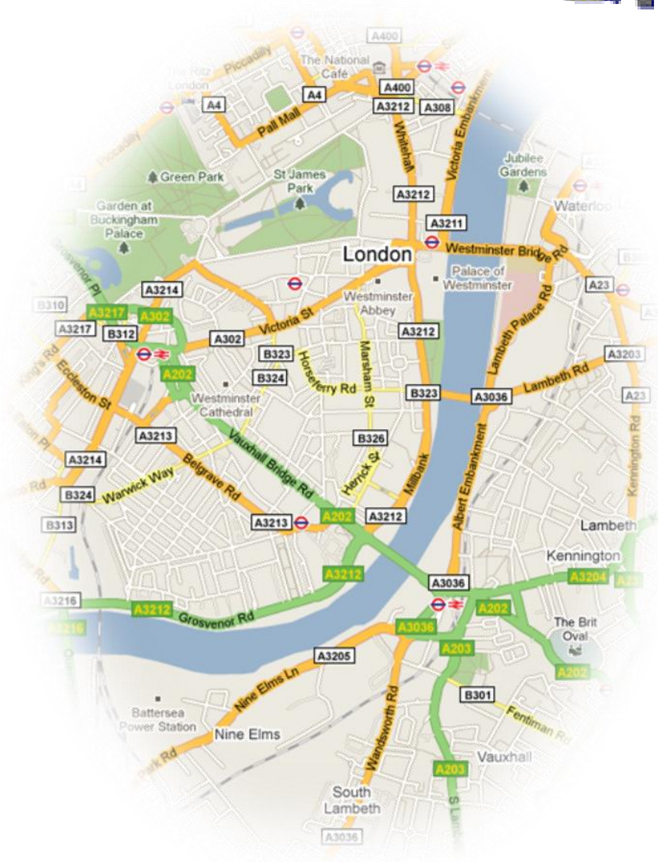
The new Geomatics Paradigm: Integrated Socio-Spatial Networks

Prof. Dr. Yerach Doytsher

Mapping and Geo-Information Engineering,
Technion, Israel

Socio-spatial Data





Socio-spatial Data

Motivation

- Efficient management of socio-spatial data has many applications, such as:
  - Disaster management
  - Urban planning
  - Researches in social sciences and economics
  - Location-based services

Life Patterns

- ***Life patterns* connect people and places**
- A life pattern is essentially a triple

  (user, geographic entity, time unit)
- For example,

  (Alice, Tower of London, Sundays)

  specifies that Alice visits the Tower of London, every Sunday
- Life patterns can be extracted from GPS logs.

Example

Alice jogs every morning, and she wants to find a partner for jogging

- A potential partner will be someone who:
  1. Is a friend of Alice or a friend of a friend
  2. Frequently jogs in the same area where Alice jogs and at the same time as she does

The life patterns will indicate presence in the same parks at similar times

Background – Data Integration Problems

- Different data models:
  Social network - graph
  Spatial data - relational
- Large amount of data:
  each user visits in many locations at different times
- Data have three dimensions:
  social, spatial and temporal

Background – Data Integration Problems

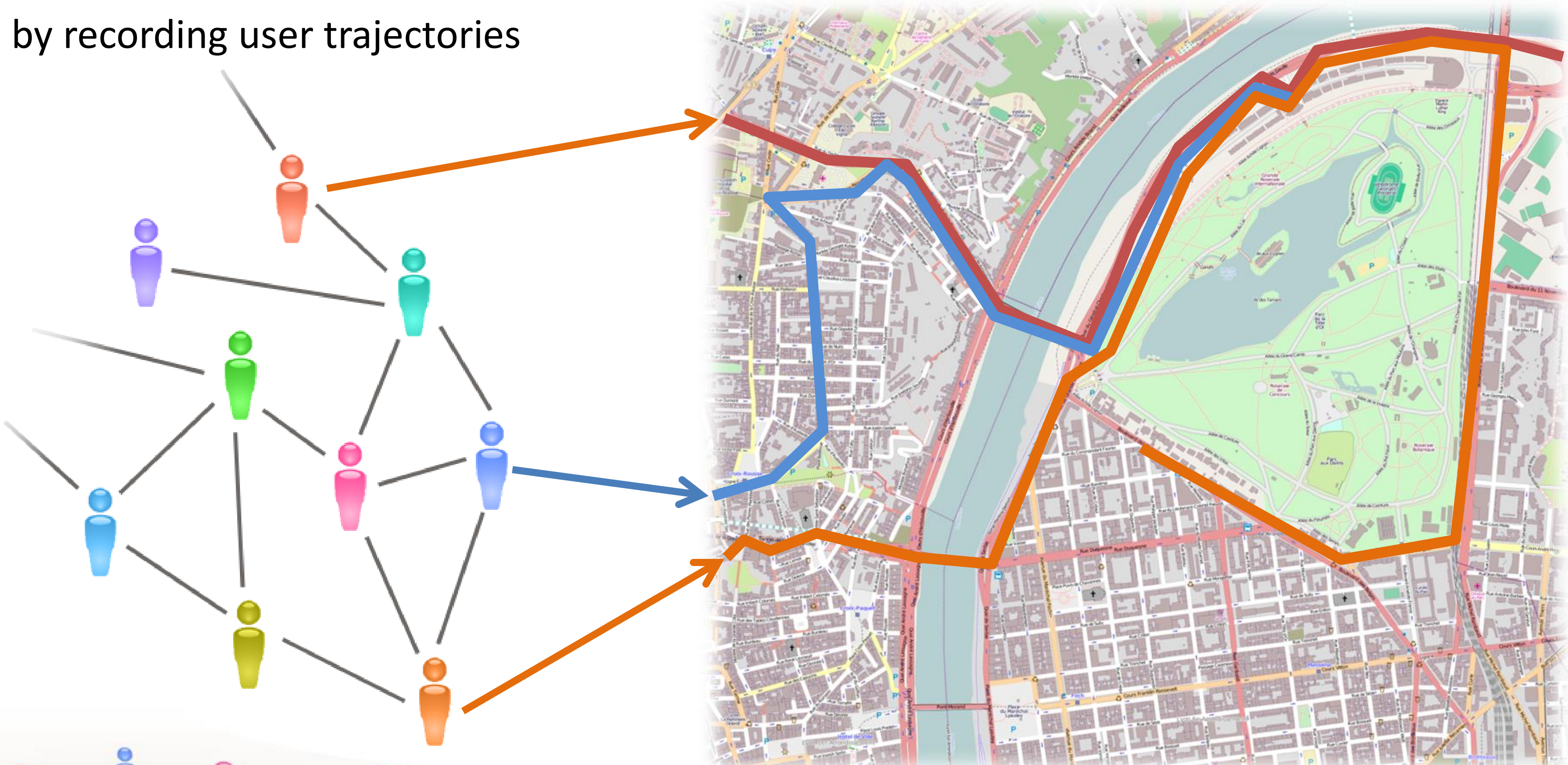
- Spatial entities form a hierarchy (e.g., city, neighborhood, building)

  Due to different sensors the accuracy of a visit can be changed

  How should queries use such hierarchy?

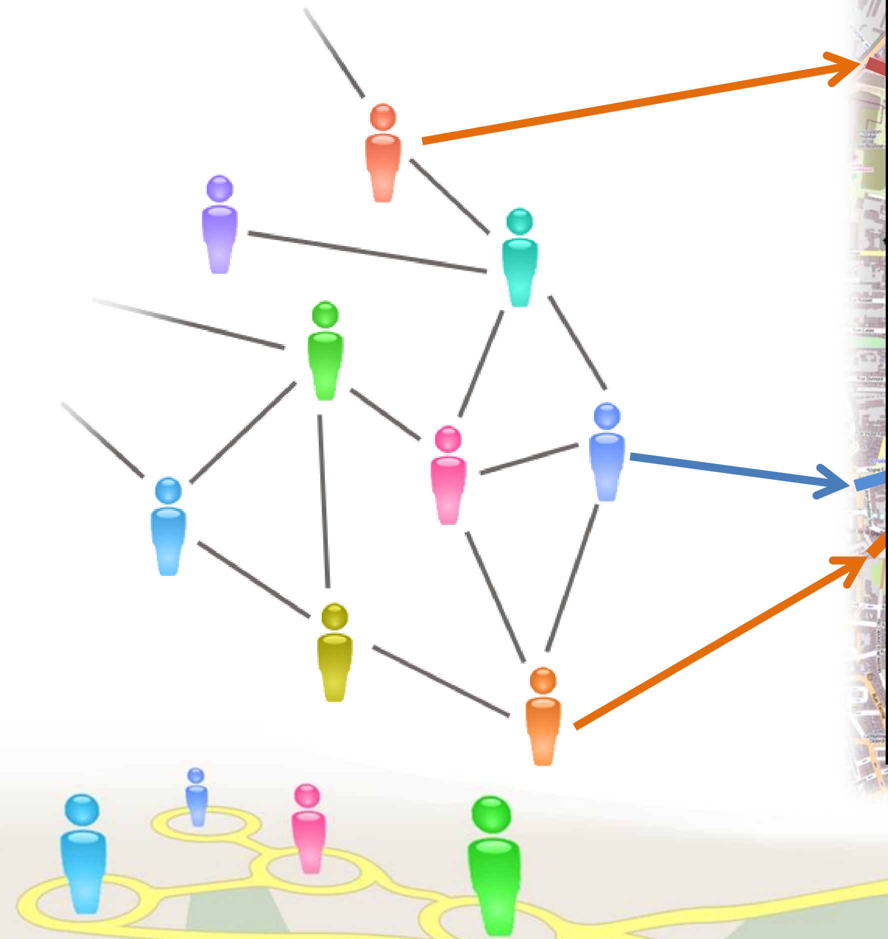
Background – Trajectories

The connection of users of the social network to locations is by recording user trajectories



Background – Trajectories

The trajectories are usually stored as a list of triples:
(latitude, longitude, time stamp)



Blue			Red			Orange		
lon	lat	time	lon	lat	time	lon	lat	time
4.824	45.774	12:02	4.831	45.784	15:34	4.822	45.773	08:45
4.834	45.775	12:03	4.836	45.783	15:35	4.824	45.773	08:46
4.835	45.775	12:04	4.838	45.783	15:36	4.827	45.772	08:47
4.835	45.781	12:05	4.841	45.779	15:37	4.832	45.773	08:48
4.833	45.782	12:06	4.845	45.778	15:38	4.832	45.773	08:49
4.836	45.782	12:07	4.847	45.783	15:39	4.838	45.773	08:50
4.838	45.783	12:08	4.852	45.785	15:40	4.841	45.772	08:51
4.841	45.779	12:09	4.852	45.785	15:41	4.842	45.775	08:52
4.845	45.778	12:10	4.853	45.786	15:42	4.844	45.778	08:53
4.848	45.783	12:11	4.857	45.786	15:43	4.845	45.778	08:54
4.852	45.785	12:12	4.860	45.786	15:44	4.848	45.783	08:55
4.852	45.784	12:13	4.865	45.785	15:45	4.851	45.785	08:56
			4.868	45.785	15:46	4.852	45.784	08:57
						4.853	45.785	08:58
						4.860	45.786	08:59
						4.860	45.781	09:00
						4.859	45.773	09:01
						4.854	45.772	09:02
						4.848	45.775	09:03

Model and Query Language

➢The model

A graph based model designed to store routes and a hierarchy of geographical entities

- A social network
- A spatial network
- Life patterns

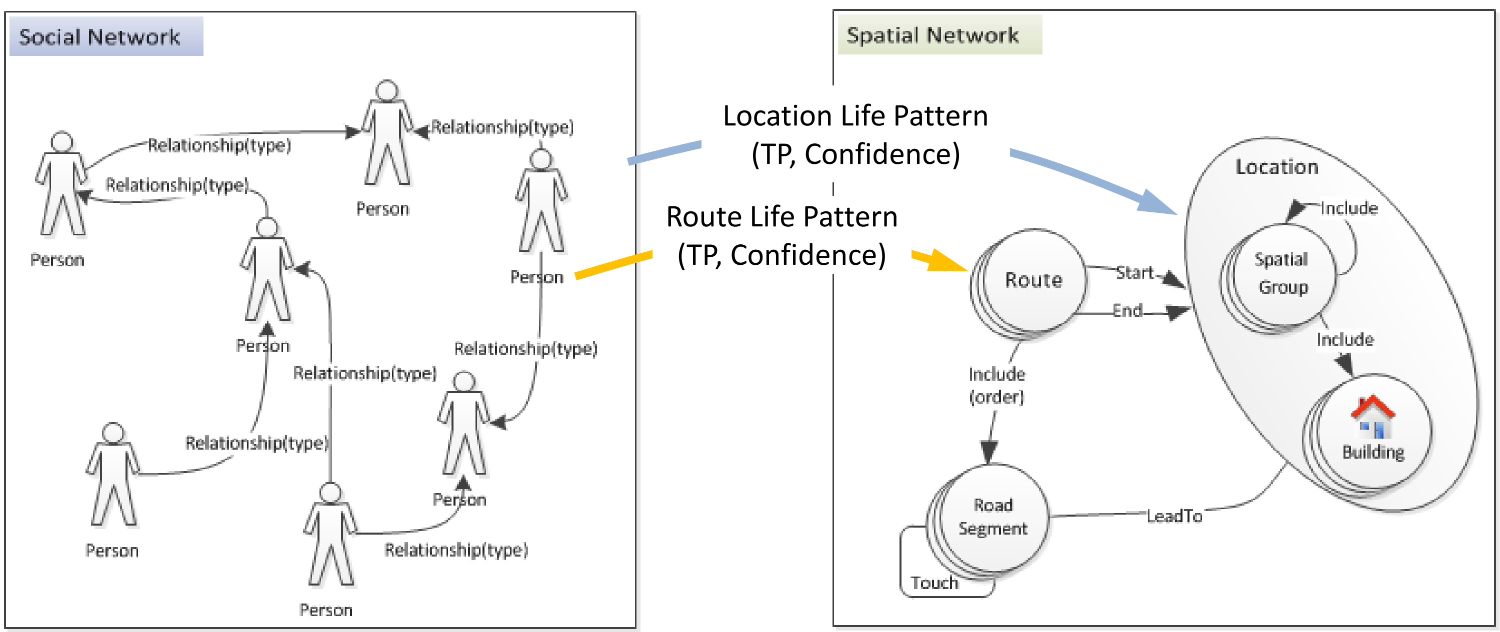
➢The query language

Designed to effectively retrieve data based on social, spatial and temporal conditions

- Select
- Move, HyperMove
- Join, Difference, Intersect

Data Model

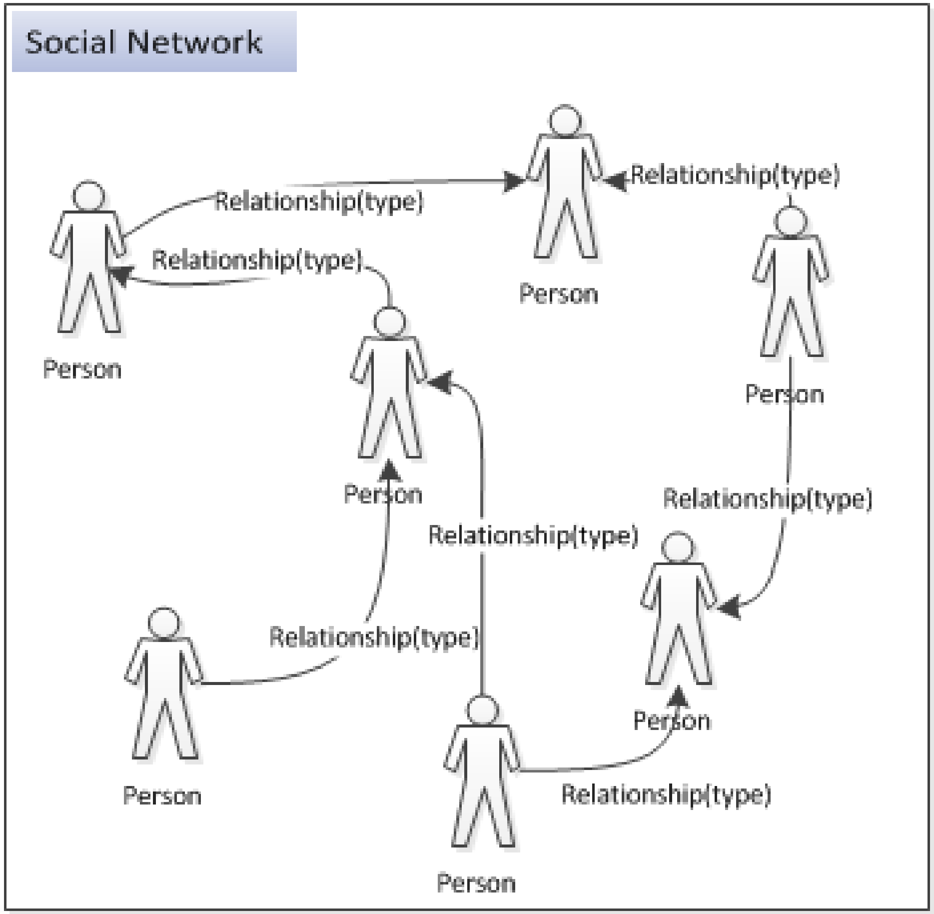
In a previous work we show that graph is a natural model for socio-spatial data and it is more effective than the relational model



Doytsher et al., Querying geo-social data by bridging spatial networks and social networks, LBSN 2010

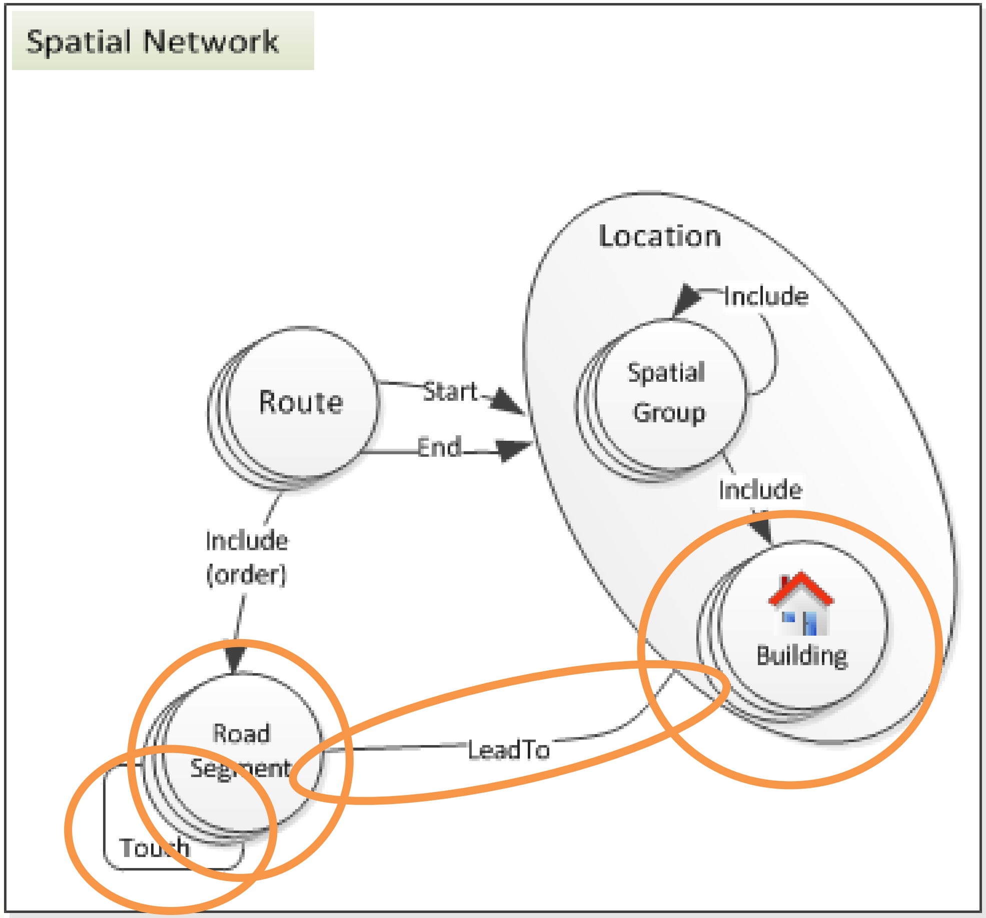
The Model: **Social Network**

- Nodes represent: users
- Labeled edges represent: different types of relationships



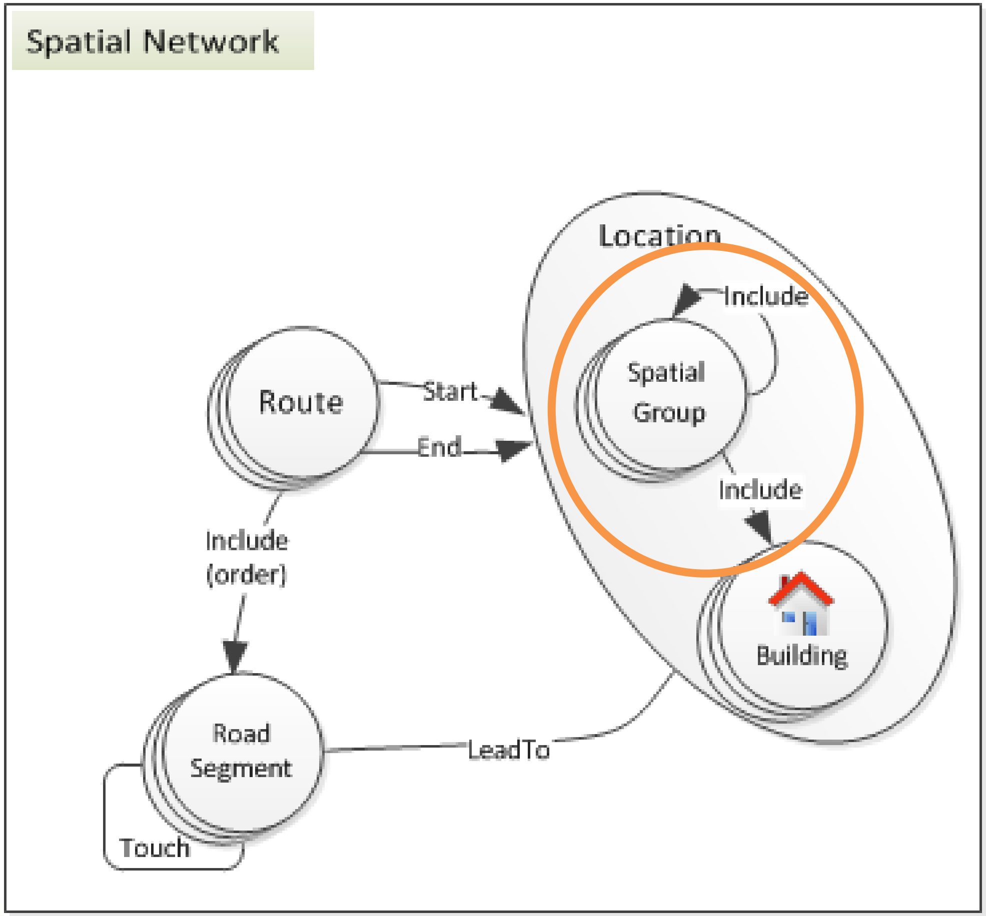
The Model: **Spatial Network**

- Nodes represent the basic spatial entities: buildings and road segments
- Labeled edges represent: the topological relationships between the nodes



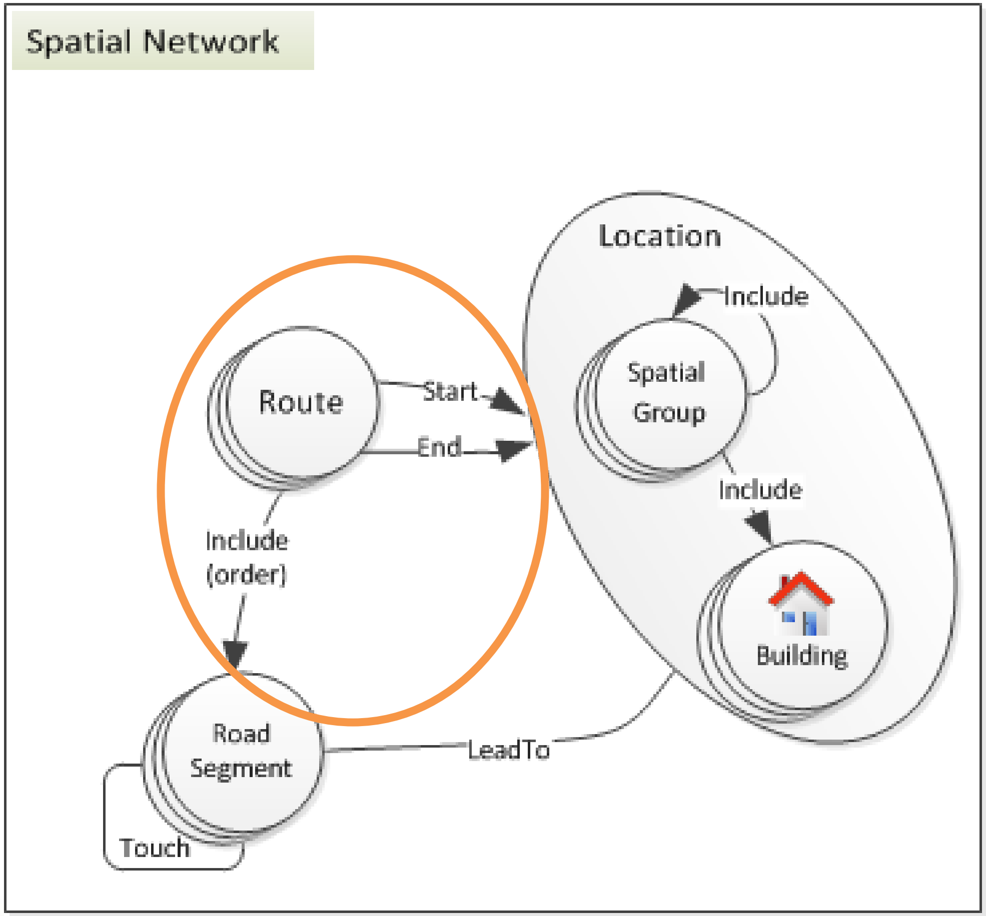
The Model: **Spatial Network**

- To represent a geographical hierarchy, there are nodes that represent spatial groups and edges that represent inclusion in spatial groups



The Model: **Spatial Network**

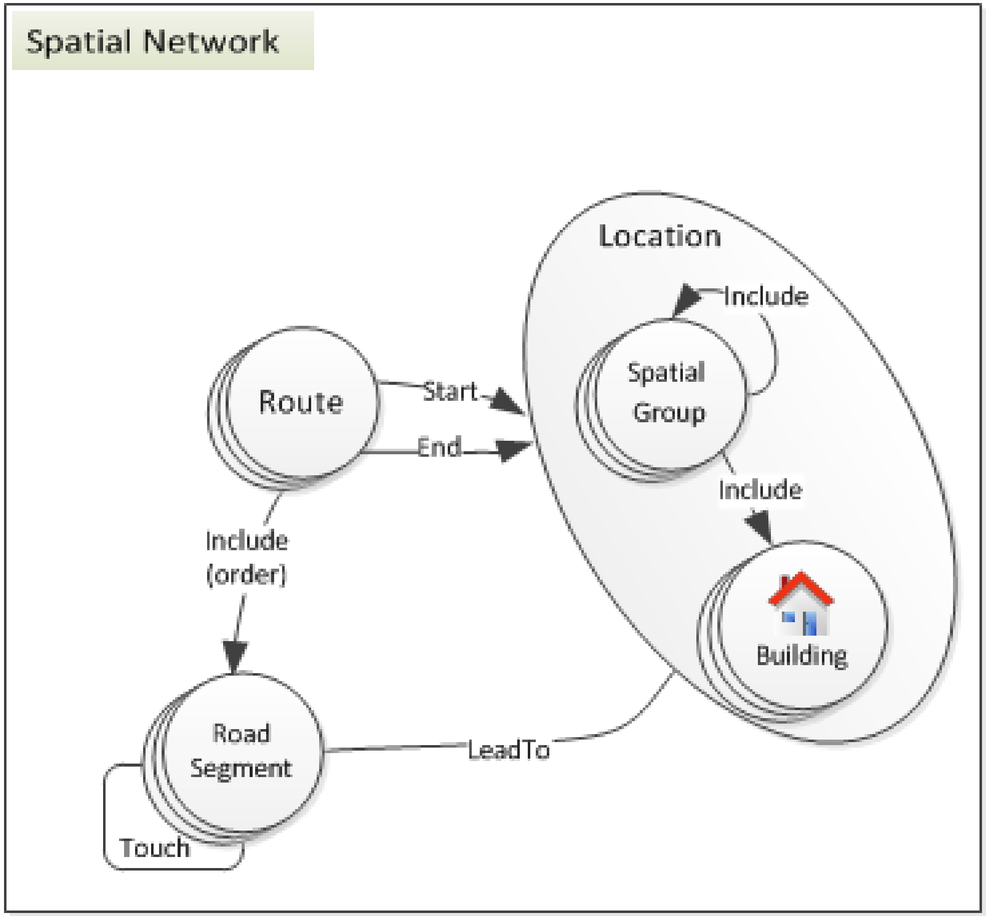
- Routes are represented by route nodes and ordered *include* edges
- *Start* and *end* edges connect routes to locations



The Model: **Spatial Network**

This model support representation of:

- Geographical entities and their hierarchy
- A road network and routes traveled by users



The Model: **Time Patterns**

- Time patterns represent repeated events:

  “every week”, “every day”, "every Sunday”, etc.
- There is a hierarchy of time patterns:
  - If an event happens at some level in the hierarchy, it also occurs in the higher levels
  - If Alice visits 10 Downing St. every workday, then Alice visits 10 Downing St. every week, every month, etc.
- **Time patterns significantly reduces the amount of data**

Zheng et al., Mining individual life pattern based on location history, MDM 2009

Query Language

- An algebra with six operators based on graph traversal and set theory
  - Select, Move, HyperMove, Join, Difference, Intersect
- Each operator returns a homogeneous set of nodes (nodes form the same type)

The Query Language

- Expressive but still efficient (e.g. no Cartesian product)
- Comprises graph operations and set operations
- Enables efficient and effective retrieval of users or of geographical entities based on social, spatial and temporal conditions (the three data dimensions)

Future Research

- Improve the storage system and the query language to support better **temporal questioning**
- Save and query **events** including **repeating events**
- Build and store location **socio-spatial patterns**
- Discover **socio-spatial trends**
- Socio-Spatial **data mining**

Thank You for Listening

Acknowledgments to my colleagues:
Dr. Yaron Kanza, Ben Galon - for their contributions on the subject

The Fifth International Conference on Advanced Geographic Information Systems, Applications, and Services: GEOProcessing 2013

PANEL Discussion

Environmental Data Modelling Using Machine Learning Algorithms

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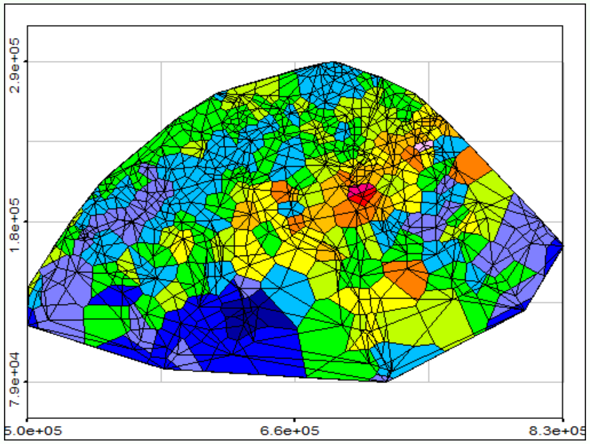
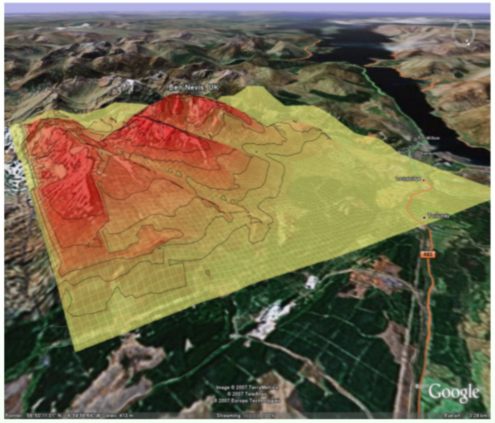
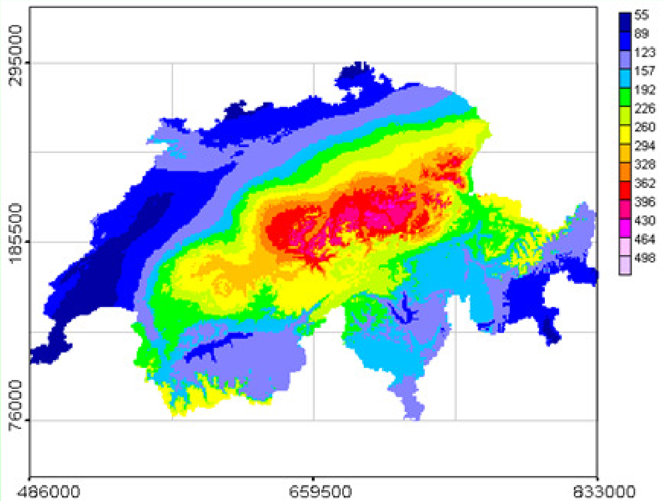
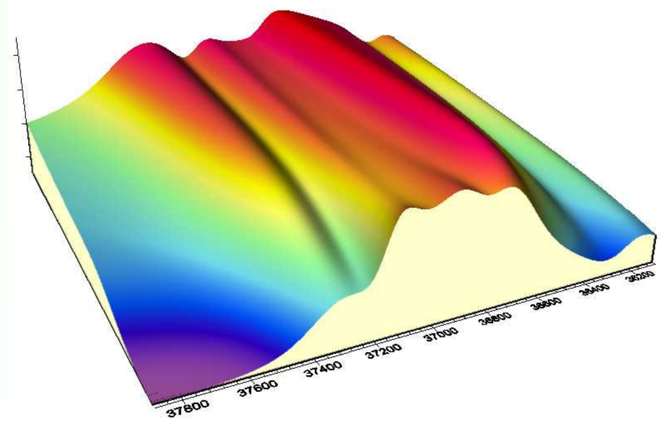






Environmental data

- Multi-scale behavior, high variability at several spatio-temporal scales
- Uncertainties: from raw data to the results
- Input spaces (No. of independent variables): high dimensional [~(10-100)]
- Multivariate
- Detection of patterns in complex data, analysis of predictability. Difficult problem in a high-dimensional space
- Non-homogeneous data: data integration problem - discrete/classes, continuous variables, science-based models, etc…
- Environmental phenomena are nonlinear



Spatio-temporal environmental data in terms of patterns/structures:

- pattern recognition
- pattern modelling
- pattern prediction

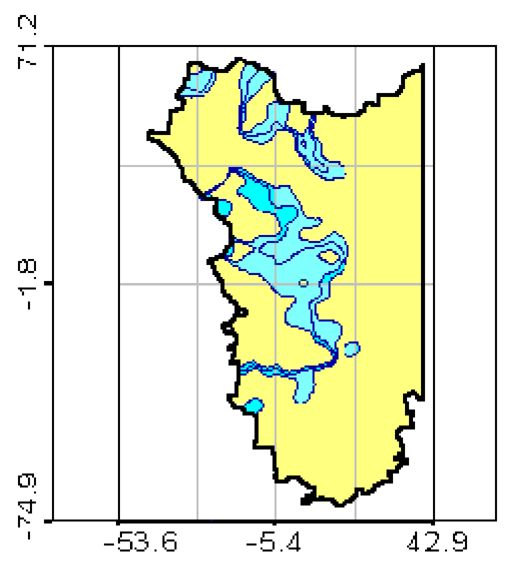
ML algorithms are efficient for many environnemental applications

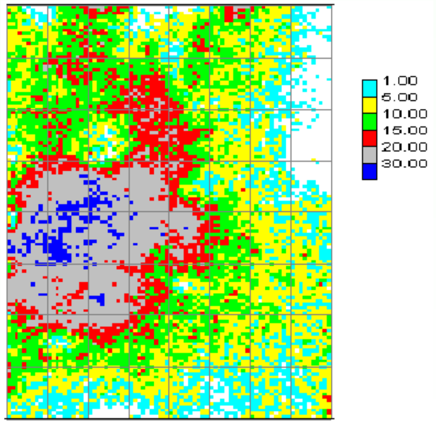
They are: universal, data-driven, nonlinear, robust…

- Artificial neural networks of different architectures: Multilayer Perceptron, Radial Basis Function Neural Network, General Regression Neural Network, Probabilistic Neural Network, Self-Organizing Maps,…
- Random Forests, Ensemble Learning
- Support Vector Machines; Support Vector Regression and other Kernel-based models

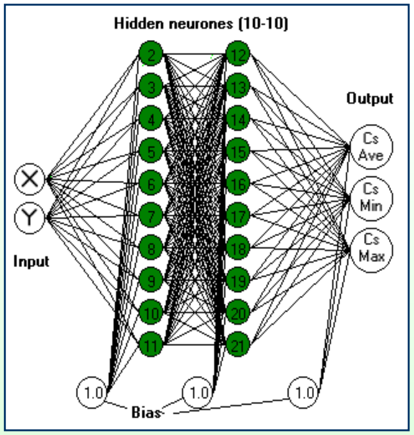
Our Experience

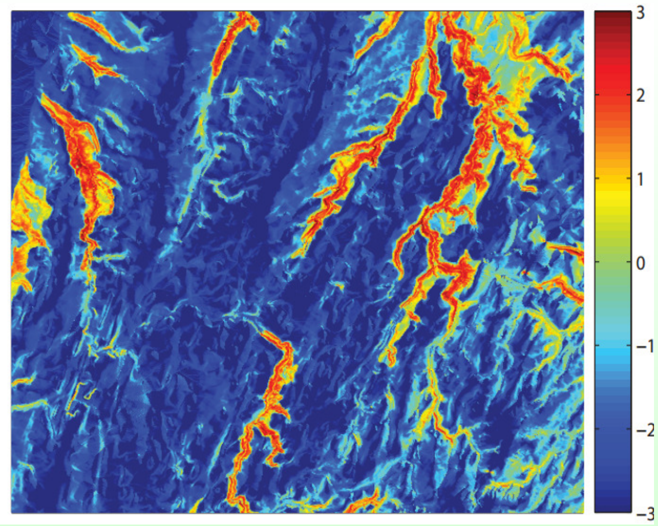
- GIS, automatic cartography
- Remote sensing
- Geosimulations
- Geostatistics
- Monitoring and time series

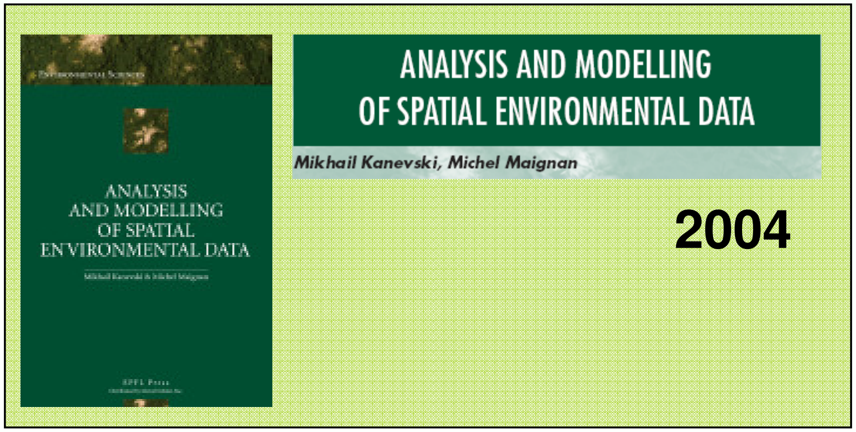


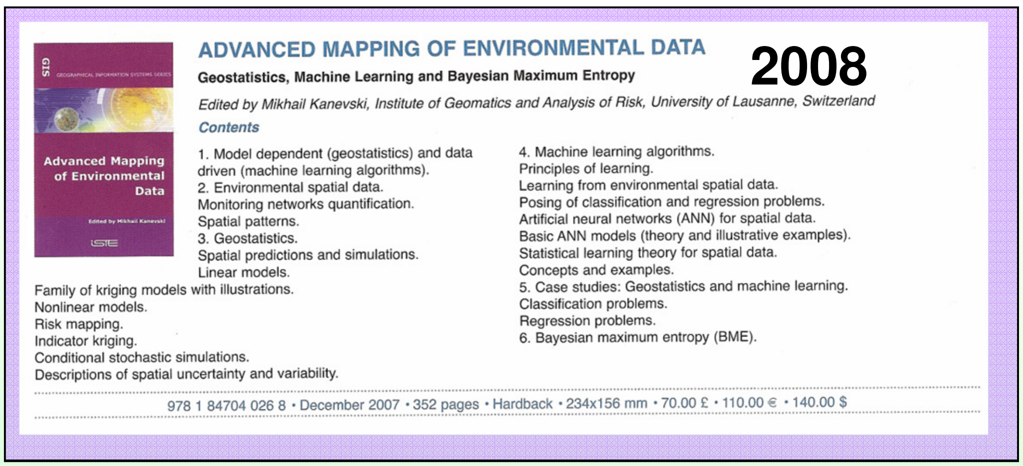


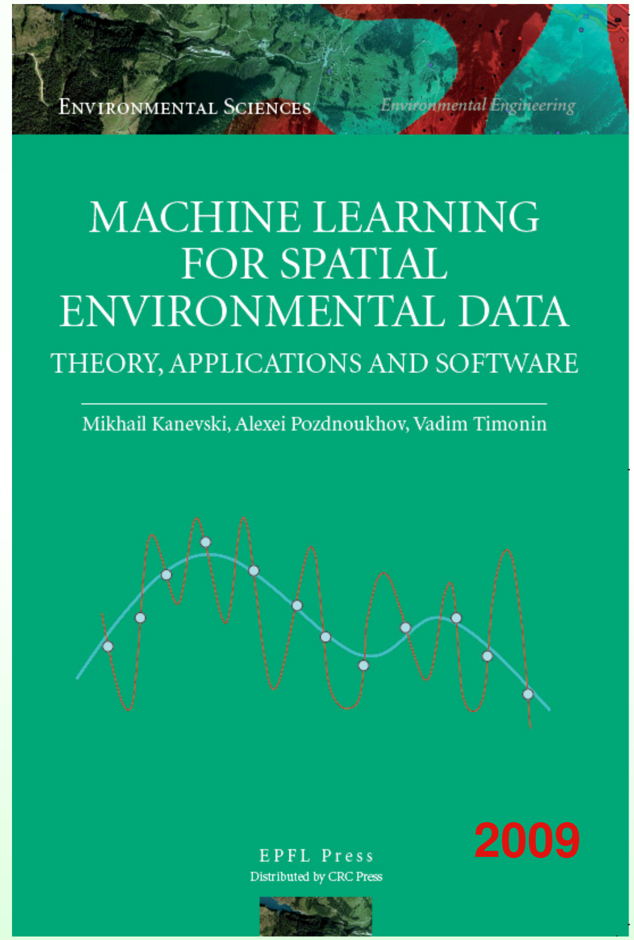
- Natural hazards
- Environmental risks
- Modelling & analysis of socio-economic data
- Geodemography
- Epidemiology
- Crime data
- ……






ANALYSIS AND MODELLING OF SPATIAL ENVIRONMENTAL DATA
Mikhail Kanevski, Michel Maignan
2004
ANALYSIS AND MODELLING OF SPATIAL ENVIRONMENTAL DATA


ADVANCED MAPPING OF ENVIRONMENTAL DATA
2008
Geostatistics, Machine Learning and Bayesian Maximum Entropy
Edited by Mikhail Kanevski, Institute of Geomatics and Analysis of Risk, University of Lausanne, Switzerland
Contents
1. Model dependent (geostatistics) and data driven (machine learning algorithms).
2. Environmental spatial data.
Monitoring networks quantification.
Spatial patterns.
3. Geostatistics.
Spatial predictions and simulations.
Linear models.
Family of kriging models with illustrations.
Nonlinear models.
Risk mapping.
Indicator kriging.
Conditional stochastic simulations.
Descriptions of spatial uncertainty and variability.
4. Machine learning algorithms.
Principles of learning.
Learning from environmental spatial data.
Posing of classification and regression problems.
Artificial neural networks (ANN) for spatial data.
Basic ANN models (theory and illustrative examples).
Statistical learning theory for spatial data.
Concepts and examples.
5. Case studies: Geostatistics and machine learning.
Classification problems.
Regression problems.
6. Bayesian maximum entropy (BME).
978 1 84704 026 8 • December 2007 • 352 pages • Hardback • 234x156 mm • 70.00 £ • 110.00 € • 140.00 $
Advanced Mapping of Environmental Data
GIS


Environmental Sciences
Environmental Engineering
MACHINE LEARNING FOR SPATIAL ENVIRONMENTAL DATA
THEORY, APPLICATIONS AND SOFTWARE
Mikhail Kanevski, Alexei Pozdnoukhov, Vadim Timonin
EPFL Press
Distributed by CRC Press
2009

Geo-data in social context

Intriguing multidisciplinary application scenarios and collaboration

dr inż. arch. Małgorzata Hanzl

Institute of Architecture and Town Planning
Lodz University of Technology

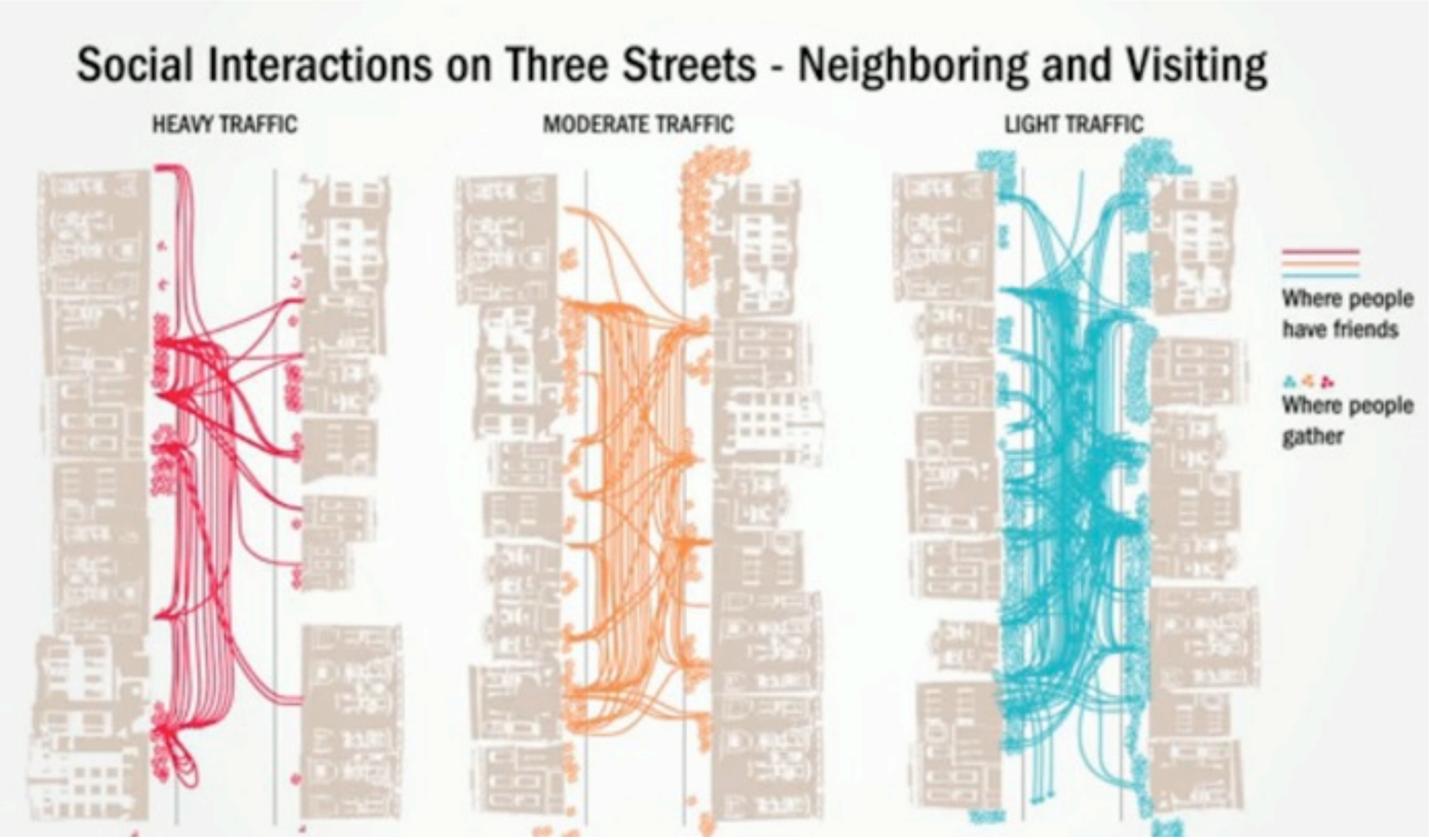
Visiting Lecturer Faculty of Architecture
Warsaw University of Technology
Poland

Monofunctional, car-oriented development - designed from a single perspective of transportation planning. St Laurent du Var, photo M.Hanzl

dr Małgorzata Hanzl
Lodz University of Technology, PL

Traditional neighbourhood, shaped in time, fulfilling many various requirements of human habitat, including need for social contacts. Nice Old Town, photo M. Hanzl

dr Małgorzata Hanzl
Lodz University of Technology, PL



Donald Appleyard "Livable Streets", 1981

Source of graphics: http://www.streetfilms.org/

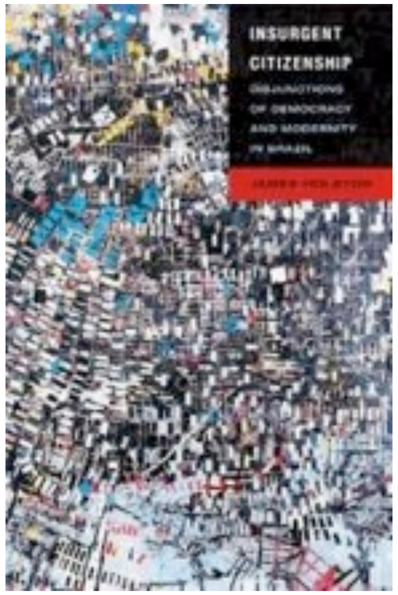
dr Małgorzata Hanzl
Lodz University of Technology, PL

- Attempts to make the discourse more inclusive – shift towards lay perception and common sense approach and towards more comprehensive and more general, inclusive approach to science.

The requirement to establish “urban studies” as a separate discipline – Henry Lefebvre

- The revival of urban form and urban morphology studies.

- Right to the City – James Holston, The Right to the City Movement http://www.righttothecity.org/



Development of geo-data applications observed recently is enormous. Though the requirements to interpret or just deal with interpretation of data analyses results requires knowledge of multiple scientific disciplines. As an urban planner I am used to heuristic approach to input data. Any urban planning elaboration is multidisciplinary. Anyway going into theoretical research there is a sort of epistemological problem which must be solved to allow for collaboration. The requirements to establish a common platform of research in urban studies - as we deal mostly with urban areas - has been so far stated in multifarious elaborations, coming from various disciplines. Albeit it still is not obvious in research practice.

Requirement to establish the **commensurability** of approaches of various disciplines: urban design, urban planning, urban morphology studies, GIS studies, sociology, anthropology, etc., as one of basic assumptions for ontology of outdoor spaces.

One of possible solutions could be object/ physical space oriented approach. E.g. a void/ an enclosure of street/square as a physical representation of anthropological notion of scene for public space activities.

an example:

a definition of a border

social entities sociologist/ anthropologist	vs	public and private urban planner

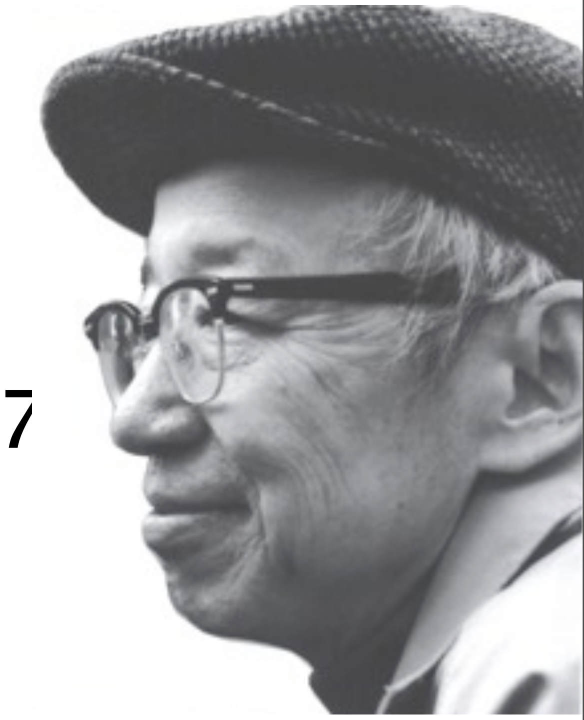
dr Małgorzata Hanzl
Lodz University of Technology, PL

Possibilities to examine ways of usage of space basing on the available analyses of GIS data describing human behaviour in outdoor spaces.

Exemplary studies:
(1) the Space Syntax group, e.g., the Cityware project UK and several projects using methodology provided by Space Syntax all over the world; (2) MIT SENSEable City Lab, among others the Real-time city data project; (3) Urban Informatics Research Lab, QUT; and (4) Architectural League of NY, i.e.,: Sentient City, compare M. Hanzl et al. :Human Geomatics in Urban Design—Two Case Studies Future Internet 4 (1), 347-361

The hitherto pointed examination allows to define cultures of usage of space proper for various groups of people, of different characteristics. It opens new field

Yi Fu Tuan – started a new discipline called “human geography”.
Space and place: the perspective of experience, 1977



What about foundation of “human geomatics?”

In lieu of the final conclusions:

"Golem" by Patrick Mccue, Tobias Wiesner based on a story Golem XIV by Stanisław Lem
Teaser: https://vimeo.com/56566980 / Final version: https://vimeo.com/50984940

"In this endless freedom of thought you find no answers to these basic matters of human being (...). This freedom of choice in its multitude and randomness led to burn up and confusion. As a consequence you got read of freedom to find security and meaning in self constructed cultures. Unaware you have started to plaque this whole of uncertainty with myths and cultures over thousands of years. Several bitter and sweet perceptions were necessary to add dignity to your lonely fate and to justify your existence on earth (…)."

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IARIA
Nice, France
Date: February 26th, 2013

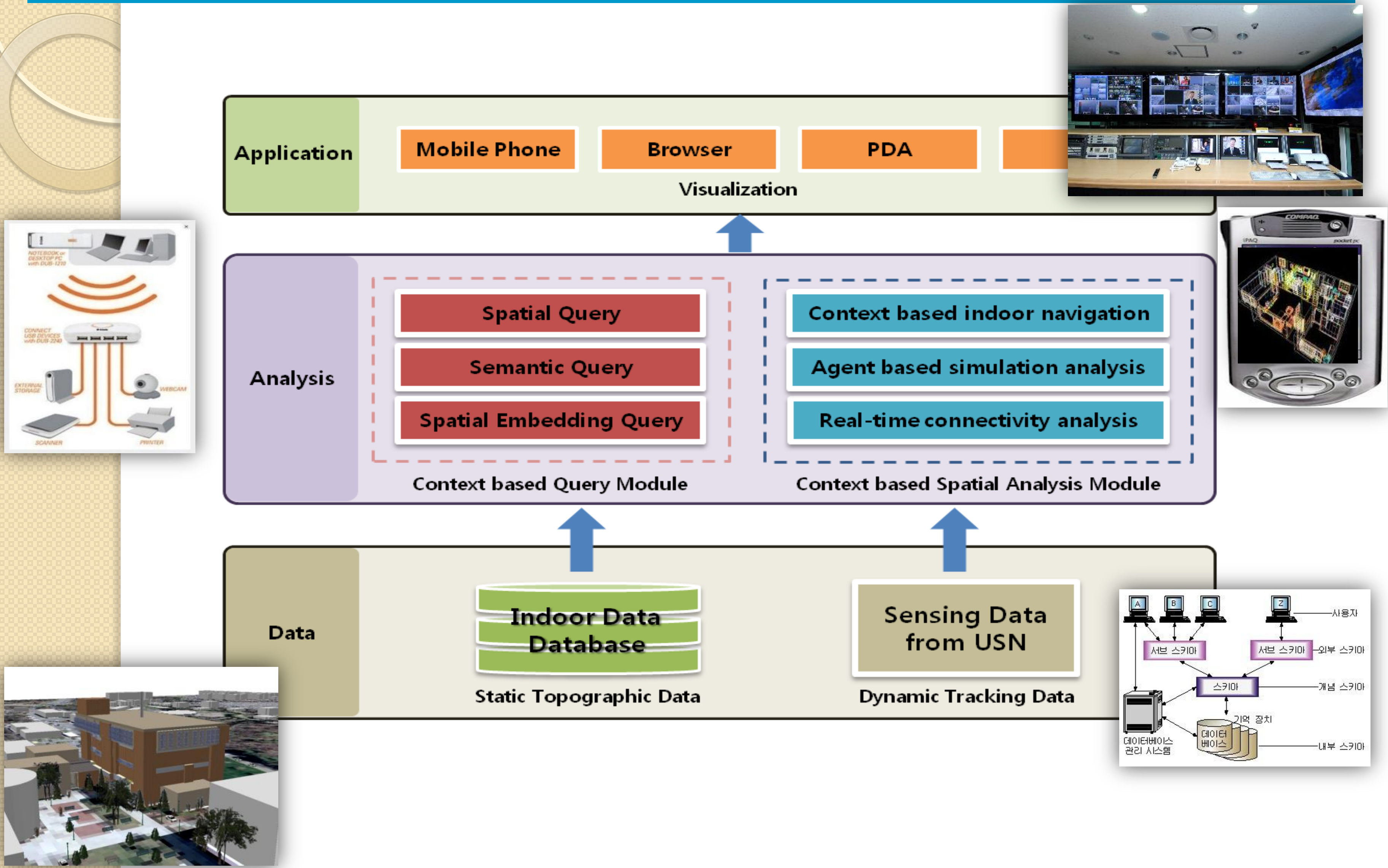
3D Indoor Space:
Indoor Spatial Awareness

Jiyeong Lee, Ph.D.
Department of Geoinformatics
University of Seoul, South Korea

Research Background:

- After September 11, Madrid (2004) and London Bombings (2005)
- interested in developing and implementing Geo-spatial technologies to manage the disaster occurred in **3D Micro-Spatial Urban Area**
- Requiring Intelligent Indoor Location-based System
- 80% of Life Time spending in indoor space.

Architecture of Real-time Emergency Response System

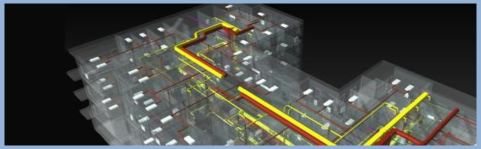


Overview of IndoorGML (OGC)

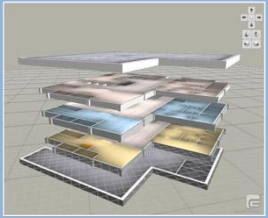
IndoorGML

Derivation ***Import***

IFC



KML



CityGML

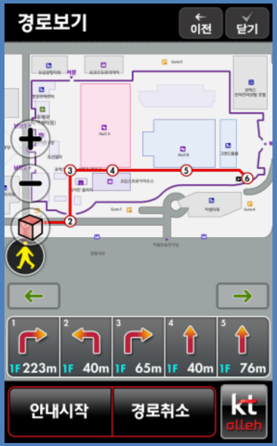
2D Indoor Floor Plan

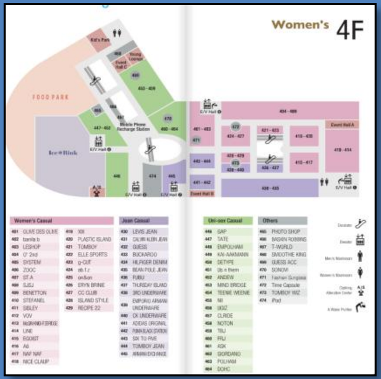
Application

Services for handicapped persons

Emergency Control

Indoor LBS





Indoor mCommerce

Indoor Robot

Research Challenges:

- Indoor Spatial Theory and Data Modeling;
- Spatial-Temporal Data Model and Analysis
- Indoor Positioning and Tracking;
- Indoor Spatial Context-Awareness