3rd ICA Workshop on Geospatial Analysis and Modeling
August 6-7, 2009, Gävle, Sweden

Program
+
Abstracts

International Cartographic Association
Commission on Geospatial Analysis and Modeling

Program overview

Thursday, 6 August		**Friday, 7 August**	
9:00 - 9:15	Opening	9:00 - 10:30 (parallel)	Session 4-1
9:15 - 10:00 (plenary)	Keynote I		Session 4-2
10:00 - 10:30	Coffee break	10:30 - 11:00	Coffee break
10:30 - 12:00 (parallel)	Session 1-1	11:00 - 11:45 (plenary)	Keynote II
	Session 1-2	11:45 - 12:00	Wrap-up
12:00 - 13:30	Lunch break	12:00 - 13:30	Lunch break
13:30 - 15:00 (parallel)	Session 2-1	Locations: 99:131 for session X-1 and keynotes 99:133 for session X-2 The Wednesday gathering will be at the main entry of the campus (17:30 – 20:00)	
	Session 2-2		
15:00 - 15:30	Coffee break		
15:30 - 17:00 (parallel)	Session 3-1		
	Session 3-2		
19:00 - 21:00 (workshop dinner)			

Keynote I **99:131**
Chair: Bin Jiang, Sweden

Vassilis Kostakos, University of Madeira, Portugal
Urban encounters of the 3rd type

Mobile phones are becoming increasingly powerful platforms in terms of processing, networking and storage capabilities. As these devices continue to proliferate, researchers are coming up with ways to utilize and exploit them for a number of purposes: proximity-based advertisement, movement tracking, presence detection, proximity detection, situated voting, epidemic simulations, and implicit interactions. This talk will present an overview of my research on urban encounters that exploits people's Bluetooth-enabled mobile devices as a detection mechanism. The message I want to convey is that there is tremendous untapped potential in harnessing such information, and the potential benefits span multiple domains.

Session 1-1: Spatio-temporal modeling and analysis **99:131**
Chair: Hongbo Yu, USA

Hongbo Yu, Oklahoma State University, USA, and
Shih-Lung Shaw, University of Tennessee, USA
A space-time GIS approach to exploring clusters in large moving objects datasets

The increasing number of large tracking datasets of moving objects in various research fields has challenged the GIS community to develop effective analysis tools to derive useful information from such datasets. In this study, we adopt the concepts of Hägerstrand’s time geography to help us represent and restructure the tracking data of moving objects and explore the spatiotemporal patterns of locations where the paths of many objects converge. In particular, the space-time path concept is used to model the trajectories of moving objects, and the station concept is used to guide the aggregation of space-time paths to define the locations where the paths converge in space and time. Since the spatial and temporal extent of a station can vary in different applications, several spatial and temporal methods are introduced and discussed in this paper to aggregate the paths. A space-time GIS design is developed accordingly to support the implementation of the concepts and methods. Stations derived by aggregating space-time paths are represented and visualized as spatiotemporal cylinders in the space-time GIS. The space-time GIS, together with the aggregation methods supported by the station concept, offers a useful exploratory analysis environment to support the investigation of hidden spatiotemporal patterns in a large moving objects dataset.

Mikael Jern, Linköping University, Sweden,
Tobias Åström, Linköping University, Sweden, and
Markus Johnsson, Linköping University, Sweden
Collaborative GeoAnalytics applied to regional temporal data

Recent advances in Web 2.0 graphics technologies have the potential to make a dramatic impact on developing collaborative geovisual analytics (GeoAnalytics). In this paper, tools are introduced that help establish progress initiatives at sub-national levels aimed at measuring and collaborating, through statistical indicators, economic, social and environmental developments and to engage both statisticians and the public in such activities. Given this global dimension of such a task, the “dream” of building a repository of progress indicators, where experts and public users can use GeoAnalytics collaborative tools to compare situations for two or more countries, regions or local communities, could be accomplished. While the benefits of GeoAnalytics tools are many, it remains a challenge to adapt these dynamic visual tools to the Internet. For example, dynamic web-enabled animation that enables statisticians to explore temporal, spatial and multivariate demographics data from multiple perspectives, discover interesting relationships, share their incremental discoveries with colleagues and finally communicate selected relevant knowledge to the public. These discoveries often emerge through the diverse backgrounds and experiences of expert domains and are precious in a creative analytics reasoning process. In this context, we introduce GAV Flash and the associate eXplorer application, a customized tool for interactively analyzing, and collaborating gained insights and discoveries based on a novel story mechanism that capture, re-use and share task-related explorative events. The research is done in close collaboration with OECD and Eurostat.

Jean-Claude Thill, University of North Carolina - Charlotte, USA, and
Xiaojia Wang, University of North Carolina - Charlotte, USA
Modeling functional spaces: the case of the migration space in the Unites States

The Newtonian conception of an "absolute space" that has long defined spatial analysis is increasingly being replaced by the more flexible and intuitive concepts of perceived space and functional space. While the former is in line with the physical definition of space as commonly captured in Geographic Information Systems, the latter incorporate a variety of elements rooted in individual perception and cognition of space (including common sense geography), as well as in the lived experiences of people within certain territories. In this paper, the authors propose to uncover the dimensions of space produced by patterns of human migration. The paper follows the methodology proposed by Plane in his 1984 article. The principle consists of a reverse calibration of the doubly constrained gravity model to elicit functional relationships between places that collectively form the migration space from observed migration matrices. In this paper, we integrate this spatial econometric approach with geospatial techniques that map relative migration spaces out of relative distances. With a custom application, warped maps are produced that convey the migration functionality of the interacting places. The approach is applied to inter-state migrations in the United States. The evolution of the U.S. migration space is depicted over a three-decade period. The paper concludes with some remarks on the broader use of this approach to study functional spaces.

Session 1-2: CA and Agent-based modeling **99:133**
Chair: Suzana Dragicevic, Canada

Flávia Feitosa, University of Bonn, Germany
Quang Bao Le, University of Bonn, Germany, and
Paul Vlek, University of Bonn, Germany
Multi-agent simulator for urban segregation (MASUS): A tool to explore alternatives for promoting inclusive cities

Urban segregation represents a significant barrier to achieving social inclusion in cities. In order to mitigate this problem, it is necessary to implement policies founded upon a better understanding of segregation dynamics. This paper proposes MASUS, a multi-agent simulator for urban segregation, which provides a virtual laboratory for exploring the impact different contextual mechanisms have on the emergence of segregation patterns. We illustrate the potential of MASUS through three experiments on segregation in São José dos Campos, a medium-sized city in south-east Brazil. The first experiment validates the model by comparing it with empirical data and shows that

the simulated data is a good representation of segregation in São José dos Campos. The second experiment exemplifies the ability of MASUS to test theories by exploring the relationship between segregation and income inequality. The results of this experiment show that decreasing levels of income inequality promote spatial integration of different social groups. Finally, the third experiment tests an anti-segregation policy based on the dispersion of poverty. The simulated outputs indicate that this policy is not able to produce an expressive change in the level of poverty isolation in São José dos Campos. Such result suggests that this social-mix strategy, which has been adopted in cities in Europe and the United States, is less effective in developing countries, where poor families represent a large share of the population.

Fang Wang, University of Calgary, Canada,
Jean-Gabriel Hasbani, University of Calgary, Canada,
Xin Wang, University of Calgary, Canada, and
Danielle Marceau, University of Calgary, Canada,
Identifying dominant factors for calibrating a land-use Cellular Automata model using rough set theory

In the last two decades, Cellular Automata (CA) have been increasingly used for modeling urban growth and land-use changes. However, the methods for identifying dominant factors that drive the landscape dynamics when calibrating CA models still need to be improved, specifically in the context where a large number of potential factors have been identified. In this paper, we propose to use Rough Set Theory (RST) to guide the factor selection. This approach was tested for the calibration of a CA model to simulate land-use changes in the Elbow River watershed, in southern Alberta, Canada. Simulations results obtained using a total of 18 original factors, a random selection of a small number of factors, and the factors identified with RST were compared to historical land-use maps. Preliminary results reveal that the simulated maps generated with the factors selected by RST contain less error, expressed in number of cells and spatial distribution, than the maps produced using the original factors and the randomly selected set of factors, while requiring less computation time.

Suzana Dragicevic, Simon Fraser University, Canada, and
Liliana Perez, Simon Fraser University, Canada
Modeling human infectious diseases using complex system theory and spatial agents

Infectious human diseases are emerging in local and global communities with increasing frequency and intensity. In the case of human disease outbreaks and transmission, human populations are impacted by multiple factors such as population locations and demographics, human and wildfowl density, land use change, seasonality, and travel network activity. Also, these factors are related in unpredictable ways and require advanced analytical and computational tools to adequately simulate propagation across geographic space and time. Complex systems (CS) theory, more particularly an agent-based modeling (ABM) approach, provides a suitable framework to study the relationships between associated factors and dynamic complex interactions at an individual level and the emergent property of disease patterns at an aggregated level.

The goal of this study is to design and implement a spatially-explicit model that simulates the dynamics of infectious disease propagation in human populations by linking agent-based modeling and geographic information systems (GIS). The resulting model incorporates the geography of place, demography and epidemiology in its structure. The specific objectives are to: (1) prepare relevant geospatial and epidemiology data in a GIS database, (2) propose and design the GIS-ABM of infectious disease propagation for an urban environment, and (3) adapt the proposed model for understanding the dynamics of measles propagation in the city of Burnaby, British Columbia, Canada.

Individuals are represented in the model by agents associated to spatial locations and urban features such as shopping malls, public transportation or educational institutions where they interact with other individuals. The individuals are simulated as agent software routines characterized with mobility through the city transportation network. The model is designed to allow agents to disperse between different locations in the city and interactions lead to diseases transmission. The model simulations use the Susceptible-Exposed-Infectious-Removed (SEIR) general infection framework to document the progression of the disease. The results provide spatial patterns of the ratio of susceptible to infected individuals with time as the disease progresses.

The outcomes of this research study can improve epidemic preparedness by facilitating the examination of infection scenarios and their spatial impacts on human populations. The GIS-agent based model proposed can be

customized to simulate spread dynamics for other infectious disease. The proposed model can facilitate rapid forecasting of the spread dynamics of the infectious disease to better inform citizens and health organizations for more responsive resource allocation and epidemic control.

Session 2-1: Visual analytics approach to spatial analysis and modeling **99:131**
Chair: Gennady Andrienko, Germany

Patrik Lundblad, Linköping University, Sweden
Weather and ship data monitoring applied to Geovisual Analytics

This paper focus on the development of a tool for Ship and Weather Information Monitoring (SWIM) visualizing weather data combined with data from ship voyages. The project was done in close collaboration with the Swedish Meteorological and Hydrological Institute (SMHI) who also evaluated the result. The goal was to implement a tool which will help shipping companies to monitor their fleet and the weather development along planned routes and provide support for decisions regarding route choice and to evade hazard. A qualitative usability study was performed to gather insight about usability issues and to aid future development. Overall the result of the study was positive and the users felt that the tool would aid them in the daily work.

Kazi Ishtiak Ahmed, National University of Ireland, Ireland,
Urška Demšar, National University of Ireland, Ireland, and
Xavier Monteys, Geological Survey of Ireland, Ireland
Examining statistical segmentation of multibeam backscatter images with Geovisual Analytics

Multi-Beam Echo Sounders are often used for classification of seabed type, as there exists a strong link between sonar backscatter and sediment characteristics of the seabed. There are several automatic classification methodologies, one of which uses a combination of 132 statistical features, PCA and k-means clustering. This paper examines the complexity of this particular method using a Geovisual Analytical approach by exploring the features with a Self-Organising Map (SOM). This project is a work in progress and the paper presents only the first preliminary experiment of using a SOM for this problem. The ultimate goal of the project is to examine the potential of Geovisual Analytics to help reduce the complexity of the MBES classification method and thereby facilitate seabed type classification from MBES data.

Gennady Andrienko, Fraunhofer IAIS, Germany, and
Natalia Andrienko, Fraunhofer IAIS, Germany
Visual analytics for geographic analysis, exemplified by different types of movement data

We introduce Visual Analytics – a new research discipline defined as the science of analytical reasoning facilitated by interactive visual interfaces. Visual analytics combines automated analysis techniques with interactive visualisations so that to extend the perceptual and cognitive abilities of humans and enable them to extract useful information and derive knowledge from large and complex data and to solve complex problems. Particularly, data and problems involving geospatial components are inherently complex and therefore call for visual analytics approaches. We discuss in more detail the problems of analysing data about movement of various discrete objects in geographical space. We consider three types of movement data: data describing movements of a single entity during a long time period, data about simultaneous movements of multiple unrelated entities, and data about simultaneous movements of multiple related entities. The pertinent analysis tasks significantly differ for these types of data. For each type of data, we briefly introduce the visual analytics techniques and tools we have developed in the recent years.

Session 2-2: Modeling urban growth **99:133**
Chair: Dirk Stelder, the Netherlands

Ellen-Wien Augustijn, ITC, the Netherlands,
Johannes Flacke, ITC, the Netherlands, and
Asif Iqbal, ITC, the Netherlands
Simulating informal settlements growth in Dar es Salaam, Tanzania; a hierarchical framework

Informal settlements form self regulated complex systems within the larger city system that represent a worldwide problem, especially in developing countries. The complexity of the system itself makes it difficult to model, yet modeling may reveal further inside into the growth patterns and proof an important tool to gain inside in the consequences of economic, social or physical landscape interventions at different scales. Hierarchy theory is used to develop a conceptual framework for a combination of a city-wide settlement model and a micro-scale housing model for developing countries. A prototype model is developed for Dar es Salaam, Tanzania. This paper shows that actors exist that operate at different levels and shows the existence of feedback mechanisms between settlement and driving factors. A two-level hierarchical model is proposed consisting of a raster-based settlement model and a vector based housing model. A prototype of the housing model is implemented.

Qian Zhang, Royal Institute of Technology at Stockholm (KTH), Sweden,
Yifang Ban, Royal Institute of Technology at Stockholm (KTH), Sweden,
Jiyuan Liu, Chinese Academy of Science, China, and
Yunfeng Hu, Chinese Academy of Science, China
Simulating urban development scenarios using Markov-Cellular Automata: a case study of Shanghai, China

The objective of this research is to investigate the Markov-Cellular Automata model under different development schemes for simulations of the urban expansion scenarios of Shanghai in 2015 and 2025 in support of sustainable urban development. In this study, multitemporal Chinese National Land Cover Database, derived from remote sensing image from 1995, 2000 and 2005 were used for simulation and validation. The scenarios of urban expansion pattern of Shanghai in 2015 and 2025 under three different schemes, i.e., Non-Scheme (NS), Service Oriented Center scheme (SOC) and Manufacture Dominant Center scheme (MDC), were simulated and comparatively analyzed. The results demonstrated that Shanghai will experience less built-up area sprawl and retain a better environment in 2025 if the service orientated development policy is given priority. If favorable policy for MDC is adopted, however, there will be a lot of manufacturing industries gathering in Shanghai and more agricultural lands will be encroached. Through this study, the combined approach using remote sensing data, GIS spatial analysis environment and urban simulation model with scenario analysis proved to be effective to understand, represent and predict the spatial-temporal dynamics of urban evolution, and CA-Markov model is a useful tool to track the trajectories of urban historic development, and to simulate the scenarios of future urban developments, even though there are some issues that need to be investigated in the future, such as the construction of localized schemes, and the incorporation of political, social, economic and cultural factors.

Dirk Stelder, University of Groningen, the Netherlands, and
Meijster Arrnold, University of Groningen, the Netherlands
Where do cities form? A parallel simulation of agglomeration on global geographical grids

Spatial economic agglomeration models simulate city formation on a geographical gridusing a matrix of shortest paths from any cell to any other cell. An optimal geographical grid is one that covers the whole world globe in 3D space avoiding disturbances by boundaries that occur when isolated parts of the world are modelled on a 2D bounded grid. For a realistic economic-geographical agglomeration model the maximum distance between two neighbouring grid locations should be about 25 miles which implies that total land coverage excluding the North- and Southpole amounts to approximately 260.000 land grid points. The operational grid size of a model like this is limited due to large computational and storage requirements to calculate the distance matrix and transport costs of which the dimensions go to N2 . We overcome this problem by splitting the grid into subdomains for which local distance maps are computed. The sum of their sizes is much smaller than the size of the full matrix. At any moment the model needs an entry from the full matrix, it is calculated on the fly from these submatrices. At the submatrix level distances are computed concurrently using Dijkstra's shortest path algorithm. On a higher level a graph is imposed over the submatrices for which a modified version of Dijkstra's algorithm is used. This paper presents an implementation on a 16 core shared memory SMP PC and discusses the scalability of the algorithm

for larger parallel computer systems. In addition some first results of the global grid model will be presented.

Session 3-1: Visual approach to geospatial analysis and modeling **99:131**
Chair: Daniel A. Griffith, USA

Daniel Griffith, University of Texas at Dallas, USA
Visualizing analytical spatial autocorrelation components latent in spatial interaction data: an eigenvector spatial filter approach

Four decades ago, Curry argued that spatial autocorrelation (i.e., local distance and configuration effects) and distance decay (i.e., global distance effects) intermingle in the estimation of spatial interaction model specifications. Today, massive computer power available with a desktop PC offers the necessary resources to account for these spatial autocorrelation effects within spatial interaction. Simple gravity model respecifications have been analyzed by Griffith (2007) and by Fischer and Griffith (2008). These results have been extended to a doubly-constrained gravity model respecification by Griffith (2009a,b). This paper summarizes results from a further refinement of this doubly-constrained respecification, namely differentiating within and between areal unit flows. In doing so, an eigenfunction-based spatial filter description of spatial autocorrelation is constructed, which lends itself to visualization of analytical spatial autocorrelation components. Results are illustrated with the 2000 journey-to-work dataset for the extended state of Pennsylvania, USA.

Zhenjiang Shen, Kanazawa University, Japan, and
Mitsuhiko Kawakami, Kanazawa University, Japan
Visualization of district ecological network at urban partitions for public involvement

Organization for landscape and urban greenery technology development of Japan published a new guideline regarding ecological network plan (ENP), what has three levels, including urban ecological network plan (UENP), district ecological network plan (DENP) and regional ecological network plan (RENP). Objective of district ecological network plan is formation of green spaces in residential areas for biotope areas in schools, spaces reserved for small animals' moving, woods conservation, variegation of natural environment and so on. While making consensus of a district ecological network plan, public participation is necessary in a planning process. Because local residents are difficult to familiarize themselves with local environment conditions, environment-learning program should be scheduled in the planning process as usual. For public participation, planning information publication is necessary in environment learning program and green design decision. Generally, plan information means urban plan information or statistic information gathered in urban survey, such as land use, rate of building volume and so on. However, ecological network information is not included in the general planning information. In order to let local residents master their green environment and make green design decision, we have a suggestion of ecological network planning support system, which is a tool to generate a base map of district ecological network using GIS. In this paper, we introduce the ecological network plan in Japan, and make a suggestion of planning support system for the district ecological network plan using GIS. A GIS data set of our research project includes vector data of blocks for creating image mask and calculating green space ratio, photograph as raster data for image classification. GIS system used is TNTMIPS, which is product of Microimages Inc.

Christian Kaiser, University of Lausanne, Switzerland,
Mikhail Kanevski, University of Lausanne, Switzerland, and
Antonio Da Cunha, University of Lausanne, Switzerland
Swiss metropole: analysis and geovisualisation of population and service clustering

The definition of what is an urban agglomeration and its morphological properties is essential both for fundamental and applied studies in quantitative and theoretical geography. It helps also to perform different comparative statistical studies. Traditionally, agglomerations are defined using a rather qualitative approach based on various statistical measures. This definition varies generally from one country to another. In this paper, we explore the use of the City Clustering Algorithm (Rozenfeld et al., 2008) for the agglomeration definition in the context of Switzerland. This algorithm provides a systemic and easy way to define an urban area based solely on high resolution population data. The algorithm was applied at different scales and it was shown that it can highlight the same structures as the traditional approach. In the present paper the City Clustering Algorithm (CCA)

is also applied to other geospatial variables than population. This paper shows a simple application of CCA to specialized services. Economic clusters can be found by this way. This automatic and systematic way of cluster detection offers new possibilities for exploratory data analysis and decision support for public administrations. An interesting feature is the multi-scale analysis of the territory.

Session 3-2: Representing and modeling spatial phenomena **99:133**
Chair: Mark W. Horner, USA

Mark Horner, Florida State University, USA
Irene Casas, University at Buffalo-SUNY, USA, and
Joni Downs, University of South Florida, USA
Exploration of a polygon decomposition technique based on the ordinary Voronoi diagram

Voronoi diagrams have been integral to efforts aimed at reducing the difficulty of representing and modeling spatial phenomena. We develop a polygon decomposition procedure based on Ordinary Voronoi diagrams that can produce substitute representations for contiguous polygon objects in spatial analytic situations. It is based on a previously unexplored conceptual linkage between polygon objects in a vector environment and their ordinary Voronoi-based counterparts. It facilitates our ability to represent typical polygon data with ordinary Voronoi diagrams by exploiting the regularity inherent to the spatial configuration of the polygons in data structures. We provide a discussion of complexity issues and other theoretical concerns associated with using the decomposition procedure. Then we present a series of examples to explore the accuracy of the Voronoi based representations, including using them in a GIS-based spatial analysis of the bus transit coverage problem. Our initial results suggest that the Voronoi approach may successfully reproduce polygon data in certain analytical situations and reduce the complexity of spatial operations when using large datasets. Given this experience with the technique, we lay out several possibilities for future research.

Volker Walter, University of Stuttgart, Germany, and
Fen Luo, University of Stuttgart, Germany
Automatic map interpretation

In the past, the availability and/or the acquisition of spatial data were often the main problems of the realization of spatial applications. Meanwhile this situation has changed: on the one hand, comprehensive spatial datasets already exist and on the other hand, new sensor technologies have the ability to capture fast and with high quality large amounts of spatial data. More and more responsible for the increasing accessibility of spatial data are also collaborative mapping techniques which enable users to create maps by themselves and to make them available in the internet. However, the potential of this diversity of spatial data can only hardly be utilized. Especially maps in the internet are represented very often only with graphical elements and no explicit information about the map scale, extension and content is available. Nevertheless, human persons are able to extract this information and to interpret maps. For example, it is possible for a human person to distinguish between rural areas and industrial areas only by looking at the object geometries. Furthermore, a human person can easily identify and group map objects that belong together. Also the type, scale and extension of a map can be identified under certain conditions only by looking at the object geometries. All these examples can be subsumed under the term “map interpretation”. In this paper it is discussed how map interpretation can be automated and how automatic map interpretation can be used in order to support other processes. The different kinds of automatic map interpretation are discussed and two approaches are shown in detail.

Kenichi Sugihara, Gifu Keizai University, Japan
A GIS and CG integrated system for the automatic generation of 3-D building models

Based on building polygons (building footprints) on a digital map, a GIS and CG integrated system to generate 3-D building models automatically is proposed. Most building polygons’ edges meet at right angles (orthogonal polygon). A complicated orthogonal polygon can be partitioned into a set of rectangles. In order to partition an orthogonal polygon, we proposed a useful polygon expression and a partitioning scheme in deciding from which vertex a dividing line (DL) is drawn. After partitioning, the integrated system will place rectangular roofs and box-shaped building bodies on these rectangles. In this paper, we propose a new scheme for partitioning building polygons and for creating a complicated shape of building models based on the building polygons bounded by

outer polygons (multiple bounded polygons).

Session 4-1: Spatial analysis of urban systems **99:131**
Chair: Danielle Marceau, Canada

Dafna Fisher-Gewirtzman, Israel Institute of Technology (Technion), Israel
Visual analytical tools for environmental and urban systems - the visual openness & visual exposure model in regard to internal space layout and functionality

Combining two leading, contradicting, but also complementary visual analysis may contribute to the planning and design process. Visual Openness, high permeability to view is one of the main objectives in the development of dense urban areas. This can influence the resident's satisfaction and the real estate value. This is true up to a point where the visual privacy of the tenants is disturbed because of being exposed to uninvited eyes. Therefore, Visual Exposure, referring to privacy aspects, is also a major aspect influencing the human environmental quality and must be considered. Both have an impact on the perceived density. Both models refer to geometrical attributes measured from the external façade towards the surrounding environment. Studying the internals' space layout is a major theme, as different internal functions and activities demand different levels of privacy and can enjoy differently openness to the view. The Visual Openness and Visual Exposure analysis models are introduced and a study of the relation between internal and external visual analysis is suggested.

Susanne Linder, European Institute for Energy Research (EIFER), Germany, and
Pablo Viejo Garcia, European Institute for Energy Research (EIFER), Germany
Spatial analysis of the diffusion of photovoltaic installations in private households in Baden-Württemberg

The rising political interest in sustainable development has promoted the diffusion of renewable energy technologies over the last years. In Germany the renewable energy law (EEG) triggered a massive increase in photovoltaic (PV) installations, particularly in private households. The distribution of the technology is, however, spatially heterogeneous. Until now it has been unclear, how PV is diffused over space and time and what factors influence the process of diffusion. Therefore this study investigated in a spatial approach the diffusion of PV in private households on a municipality-level for the case of Baden-Wuerttemberg (BW). The results are consistent with Hägerstrand’s theory of spatial diffusion (1967), since the first installations of the technology were mostly located in cities and towns and over time PV spread to less populated municipalities. Although the implementation of the EEG in 2000 triggered a substantial increase in PV installations in the whole state of BW, spatial differences in the distribution of PV persist. The Hot Spot Analysis shows that, in 2007, clusters of municipalities with significantly higher installed power were mainly located in the less populated eastern part of BW, while clusters with significantly lower installed power appeared in cities and their surroundings. Thus, over time a shift in the diffusion of PV has occurred, where the installed power in cities and towns decreased relative to the increase in PV in less populated areas. The correlation coefficient of 0.632 indicates that the number of single family houses is related to the installed power in a municipality; further factors causing spatial differences in the distribution of PV will be investigated.

Syed Monjur Murshed, University of Karlsruhe, Germany,
Sébastien Girard, University of Karlsruhe, Germany, and
Jacques Ghisgant, University of Karlsruhe, Germany
Development of a top-down approach to calculate residential space heating demand in Baden-Württemberg

Increasing concern on energy efficiency, national and regional regulations as well as incentives in Germany have encouraged the adoption of renewable-based energy solutions especially in the residential sector. One of the most important aspects to establish such innovative solution is correct estimation of heat demand. Representing in average 75% to 80% of the final energy consumption, space heating is by far the most significant usage in this sector. Therefore, a synoptic top-down approach combining a wide variety of geographic and statistical data as well as spatial analysis and state of the art of visual analysis techniques are applied to calculate the space heating demand in the federal state of Baden-Württemberg, Germany. A Geographic Information System (GIS) has been used to analyse, quantify and map quantitative spatial distribution of heating demand at a resolution of 25m * 25m, thus making it possible to select areas of highest potentials. A calculation on such a large extent and at a detailed level is innovative. The validation is performed with the aggregated statistical data on space heating available at

bigger administrative units. The results would provide policy makers and energy companies with a general overview of the potentials of heat market and energy efficiency criteria for the entire region Baden-Württemberg, thus facilitating the development of sustainable territories.

Session 4-2: Data and methods in GIS and spatial analysis **99:133**
Chair: Antoni Moore, New Zealand

Itzhak Benenson, Tel Aviv University, Israel,
Karel Martens, Radboud University Nijmegen, the Netherlands,
Yodan Rofé, Ben Gurion University of the Negev, Beer Sheva, Israel, and
Ariela Kwartler, Radboud University Nijmegen, the Netherlands
Public transport versus private car GIS-based estimation of accessibility applied to the Tel Aviv metropolitan area

The increasing interest in sustainable development has underlined the importance of accessibility as a key indicator to assess transport investments, urban policy, as well as urban form. From both the environmental as the equity component of sustainability, a comparison of accessibility by car versus public transport is of the utmost importance. However, most studies in this direction have used rather rough estimates of travel time, especially by public transport. In this paper, we present the concept of the accessibility estimating and Urban.Access, an ArcGIS extension, which combines proprietary application for estimating car-based and transit-based accessibility to employment and other land uses and several standard ArcGIS tools. Urban.Access enables a detailed representation of travel times by transit and car and thus makes it possible to adequately compare accessibility levels by transport mode. The application of Urban.Access to the Tel Aviv metropolitan area shows that the gaps between car-based and transit-based accessibility are much larger than those found in other studies. We argue that this is not the result of a poorer transit system, but rather of a more detailed description of travel by transit we account for. It may be clear that the larger gaps point to a greater need for adequate policy responses, both terms of reducing car dependence and in terms of creating an equitable transport system. Hence, we uphold that an adequate representation of transit travel times is more than a scientific matter – it is a matter of great social importance.

Antoni Moore, University of Otago, New Zealand
Allan Jones, University of Plymouth, UK,
Peter Sims, University of Plymouth, UK, and
Grahame Blackwell, University of Plymouth, UK
Reasoning with uncertainty to intelligently retrieve geographic metadata for integrated coastal zone management

Integrated Coastal Zone Management (ICZM) is a process that requires much data, information and knowledge to be applied successfully. The scale of this substantial digital resource is acknowledged at an international level, and is known to be ever growing. However, the global repository of coastal data and information supporting ICZM is fragmented, often in widely different formats and occurring at various scales. Metadata, where it exists, is widely recognised as a valuable pointer to navigation of this resource, leading to the discovery of previously hidden data. This paper demonstrates the successful use of a knowledge-based system, COAMES (COAstal Management Expert System), to provide intelligently-driven access to a set of coastal metadata (for the Fal Estuary, Cornwall, UK). The knowledge-based system employs the Dempster-Shafer theory of evidence with the associated concept of ignorance and the property of integration to tackle the uncertainty and complexity inherent in a holistic model of the ICZM domain. It is suggested that the case study and the characteristics of the knowledge-based system discussed here have a ‘portability’ which may assist in the interpretation of other complex data sets in the geospatial domain.

Bin Jiang, University of Gävle, Sweden, and
Xintao Liu, University of Gävle, Sweden
The image of the city captured by the axial lines

Underlying Kevin Lynch’s findings about the image of the city is two novel concepts: city legibility and city imageability. City legibility refers to the ease with which people understand the layout of a city. All city objects such as buildings, streets, places, and squares (or whatever parts/units within a city) demonstrate a hierarchical

structure. That is, a majority of city objects can be filtered out, while only a minority of them is kept in our minds. Imageability is the quality of a physical object that gives an observer a strong, vivid image. The level of city legibility depends on the existence of imageable elements, and on their spatial configuration, i.e., the legibility comes from the imageability – a quality of the physical urban environment. We will illustrate and demonstrate that a city can also be perceived from another perspective by concentrating in open space of the city, i.e., the space between buildings or street blocks. Interestingly, the parts or units of open space also demonstrate a hierarchical structure. We will further demonstrate that it is the axial lines rather than the medial axes that capture the parts or units of open space.

Keynote II: **99:131**
Chair: Dafna Fisher-Gewirtzman, Israel

Jean-Claude Thill, University of North Carolina at Charlotte, USA
GI Science and Regional Science: Reconcilable Differences?

Regional Science and Geographic Information Science are two academic fields of research that, at first blush, operate rather independently from one another. The two disciplines have their respective journals and hold their own academic conferences in various parts of the world. A closer look reveals though that they have many commonalities, from a common perspective – that of space, to common academic roots, and a common intellectual heritage. The presentation provides an overview of the trajectories followed by the disciplines of Regional Science and Geographic Information Science, highlighting their origins and milestones. It compares and contrasts their core scientific principles and perspectives and concludes on the mutual benefits of rediscovering synergies, particularly within the framework of geospatial modeling and analysis.