06101 Abstracts Collection
Spatial Data: mining, processing and communicating
— Dagstuhl Seminar —

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Abstract. From 05.03.06 to 10.03.06, the Dagstuhl Seminar 06101 "Spatial Data: mining, processing and communicating" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

06101 Report – Spatial Data: mining, processing and communicating

This workshop has been organized as a successor to four preceding ones. The major goal has been to bring together experts from digital cartography, spatial modelling, computational geometry and cognitive science to meet with professionals from data mining and data interpretation. This has lead to a fruitful exchange of different – but very close – disciplines and hopefully to the creation of new collaborations. The Dagstuhl seminar has not only posed R&D probles, but provided crucial incentives and directions shaping the entire field. The group of participants was diverse both w.r.t. to their academic discipline and their professional background. Researchers and developers from within industry, government, and universities (senior and young) sha-red their latest topics, problems, doubts, and investigations.

Dagstuhl Seminar Proceedings 06101
Spatial Data: mining, processing and communicating
http://drops.dagstuhl.de/opus/volltexte/2006/591

Joint work of: Sack, Jörg-Rüdiger; Sester, Monika; Worboys, Michael; van Oosterom, Peter

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/590

06101 Group – Challenges of GIScience - green + red topic list

The task for the discussion groups was to identify challenges for GIScience in the next 5 years; topics of no interest (red list) and topics of high interest (green list); specification of research issues for (selected) topics on green list - preferably on the level of topics for PhD thesis.

Joint work of: Sester, Monika & Members of Group 1

06101 Group 3 – Challenges of GIScience - green + red topic list

Alexander Wolff (Universität Karlsruhe, D)

The task for the discussion groups was to identify challenges for GIScience in the next 5 years; topics of no interest (red list) and topics of high interest (green list).

Keywords: Challenges in GIScience

How can we represent complex man-made structures?

Claus Brenner (Universität Hannover, D)

How can we represent complex man-made structures? In this talk I raise the question if we care enough about the representation of the structure of man-made objects. For example, in the area of building reconstruction from measurements (such as images or laser scanner data), it is very common to bottom-up extract features and combine them to obtain some surface representation. The concept of what constitutes a valid building structure goes often little beyond very general heuristics such as planar faces, minimum size, or rectangular shape. To name another area, in 2D map generalization we are also trying hard to extract common spatial patterns from maps, in order to generalize them in meaningful ways. I argue that we have to represent our spatial data as rich descriptions including e.g. symmetries, repetitive structures, hierarchy, and design intentions. This will be fundamentally different from today's prevailing geometry + some attributes approach, and will allow the easy conversion between different representations, such as in 2D/3D map generalization.

Keywords: Building reconstruction, map generalization, structure representation

Generalisation Services on the Web

Dirk Burghardt (Universität Zürich, CH)

Much progress has been made in the field of web-based cartography through standards developed by the Open Geospatial Consortium (OGC). While automated access and presentation of cartographic data have been defined, the services for automated generalisation are yet to be standardised. The presentation aims to show advantages of applying the service concept to generalisation and suggests several classification schemas of generalisation services at different levels of granularity. It is shown how software developers can make their generalisation functionality available as a service and how these services can be accessed dynamically. For the implementation, the open source Java Unified Mapping Platform (JUMP) was extended to work as a framework for generalisation. Generalisation services could be used in different application scenarios, for instance as a middleware component extending a web map service with adaptive zooming or as stand-alone services, supporting the production of topographic maps by national mapping agencies. They may also allow the development of a common research platform, where researchers would have access to a common generalisation framework.

Keywords: Web Generalisation Services, Automated Generalisation, Web mapping, Map production

Joint work of: Burghardt, Dirk; Neun, Moritz; Petzold, Ingo; Bobzien, Matthias; Edwardes, Alistair; Weibel, Robert

Multi-resolution Modeling of Multi-dimensional Scalar Fields

Leila De Floriani (University of Genova, I)

This talk gives an overview of our research in the area of multi-resolution modeling of multi-dimensional spatial data describing scalar fields. Specifically, the following three topics are covered in the talk: multi-resolution modeling of 3D spatial data, out-of-core modeling and visualization of terrain and geospatial data sets, and on multi-resolution work and future perspectives are discussed as well.

Keywords: Multi-resolution geometric modeling, multi-dimensional spatial data, scalar fields

Shape deformation in continuous generalization

Satyan Devadoss (Williams College - Williamstown, USA)

Given a collection of objects on a map, we seek a method of enlarging the objects over time so that these objects are still visible when the map is zoomed out. This question is brought to rigor as well-defined problems in homotopic deformation. We ask the objects, over time, to preserve topology, area-ratios and relative position. A solution is conjectured, using differential methods, leading to possible applications to cartograms.

Keywords: Cartograms, cartographic generalization, white space management, homotopy

Joint work of: Devadoss, Satyan; Danciger, Jeff; Mugno, John; Sheehy, Don; Ward, Rachel

GeoSpatial Lifelines

Max J. Egenhofer (University of Maine, USA)

A geospatial lifeline models continuous movement through geographic space as a time-stamped record of locations that an object has occupied over a period of time, enabling such analyses as alibi testing by evaluating whether two individuals could have met. Lifelines are embedded in an abstract three-dimensional space that is comprised of the two-dimensional plane and an orthogonal, directed time axis. Typically the gaps between recorded space-time samples are filled by using suitable interpolation techniques, revealing one likely path the object may have taken. A complementary semantics of the gaps is described through the set of all possible space-time points that the object may have occupied between the space-time samples. Based on heuristics about an object's maximum travel speed, a lifeline bead captures for the object all possible space-time points between two consecutive space-time observations. A bead is modeled as the intersection of two halfcones pointing in opposite directions—one from the origin pointing in the direction of the time axis, and one from the destination pointing in opposite direction. The aggregate of simply connected beads forms then a lifeline necklace.

Keywords: Moving objects

Recovering terrain from laser point clouds

Sagi Filin (Technion - Haifa, IL)

The extraction of terrain models from laser point clouds has received considerable amount of attention in recent years.

To separate terrain points from off-terrain points the definition of terrain characteristics becomes a mandatory step. Based on concepts of continuity, smoothness, and the realization that terrain points are locally the lowest in the point cloud, models have been developed in the past. An analysis of these models has shown that most of them operate on a local neighborhood, with data classification carried out in one of three possible ways: point-to-point, point-to-points and points-to-point. Consequently, while handling well most types of landscapes, they suffer from limitations in complex urban areas, rough terrain with vegetation, sharp ridges, steep slopes, and disconnected terrain.

Realizing these limitations we present an algorithm that integrates a global representation with a local one. The global representation is useful in bridging discontinued and disconnected terrain surfaces and in linking terrain points that are sparsely spaced. The local representation allows refining the global model, particularly around edges. The global model is implemented in the form of set of orthogonal polynomials estimated robustly. Such representation captures the terrain surface in some level of detail, but it is limited in capturing fine details. The local refinement, which is guided by normal differences evaluation, allows adding the fine details that were skipped by the global model.

Testing the algorithm over datasets with available "ground truth" separation, shows in most cases better performance than existing algorithms. Misclassification errors between terrain and off-terrain points are relatively small in number. Nonetheless, visual inspection of the misclassified points shows that in almost all cases classification errors refer to marginal points that could have been reversely classified by another observer. This raises a question about the uniqueness of the terrain definition, challenging the standard view of a clear cut separation between terrain and off-terrain points and prompting alternative approaches that introduce uncertainty into the modeling as the next phase in filtering laser point clouds.

Keywords: Terrain modeling, filtering, laser scanning

New Technologies: Functional Languages

Andrew Frank (TU Wien, A)

Our research is not only influenced by the technological development that has produced new, more capable hardware to allow us new experimentation or to lead us to new forms of application. Personal computers with touch sensitive screens that can differentiate multi-point gestures for input lead to new controls of visualization and ultimately to new products. New hardware can also influence how we present research results and computers that make drawing of sketches simpler. This development will reduce the dominance of verbal description and add more figures to our scientific papers, which change in a subtle way our research directions and results.

The language in which we formulate research influences what we research and how we progress. I consider therefore the functional programming languages as

an important step towards bridging the gap between the mathematical formulae of theories and the programs we use to implement and test the theories. In a first step, unnecessary elements of ordinary programming languages can be eliminated. The different types of loop control method (for i := 1 to N do ... etc.) can be left out; only if .. then .. else and recursion are required. Similarly, products and sums are the two methods to construct data types. If we add second order functions, i.e., functions which take functions as inputs and produce new functions as output we have a small and powerful language (Peyton Jones, Hughes et al. 1999). To construct new theories, mathematicians have identified functors as a principled way to extend from known to new theories. Everybody is familiar with many examples: Integer are extended to rationals (to allow division), reals are extended to complex numbers (to allow radix of negative numbers), reals extend to vectors, vectors to homogenous coordinates. All these extensions are constructed with the same principle, namely using a functor (Mac Lane and Birkhoff 1967). Functors map values to values and operations to operations while preserving the rules for the operations. For example: 0 is the unit for addition (a + 0 = a). Integer a maps to the rational number a/1; this preserves the rule: a/1 + 0/1 = a/1! A functor can be used to map from static points to moving points; a moving point is a function from time to a point. Operations with moving points are possible. For example, to calculate the distance between two moving airplanes, p1 and p2, can be calculated with the same distance operations applied for each point in time. Another functor can be used to map the relation calculus, which is mathematically clean but difficult to implement to a functional view-avoiding many of the difficulties of Codd's calculus for relational database.

I conclude that new languages-like functional programming languages-make new ways of thinking available. They allow to streamline the theory of spatial databases operations for spatial and temporal data and also data mining. Functors are a principled way of extending from a well-known theory to applications where current methods are limited. Similar to the introduction of complex numbers to have a solution to the calculation of v-1, we can introduce new constructs like moving points or relations with which we can calculate following the familiar rules. Functional languages are a technology that works! (and it is free: download from www.haskell.org)

Keywords: Functional Languages

See also: Mac Lane, S. and G. Birkhoff (1967). Algebra. New York, Macmillan

Spatial Cognition: Agents between sensation and reality

Christian Freksa (Universität Bremen, D)

Cognitive agents (specifically humans, animals, and autonomous robots) require abilities to localize themselves in space, to navigate and solve spatial tasks, to communicate about space, and to assist other agents in performing spatial tasks.

To this end, cognitive agents employ knowledge about the spatial environment; they require suitable representations of this knowledge as well as approaches to make use of this knowledge for the specific tasks to be performed. In my talk, I will address three areas of research of the SFB/TR 8 Spatial Cognition: (1) the relation between spatial structures in the physical environment and representational structures in mental representations; (2) the relation between mental representations and external representations for reasoning, for communicating, and for assisting cognitive agents in understanding spatial situations; (3) the relation between spatial environments and their external representations in the light of mental concepts. For these three areas of research, I will describe concepts of qualitative spatial reasoning that we employ in the interaction between the different domains involved in spatial reasoning and spatial communication.

Keywords: Spatial cognition, localization, representation structures, mental representations, external representations

Aggregation of Areas – Concepts and new Ideas

Jan-Henrik Haunert (Universität Hannover, D)

The aggregation of areas is a typical generalization problem. Motivated by some shortcomings of commonly used region growing algorithms, some new ideas for a global optimization method are presented. To overcome the computational hardness of this problem, it is proposed first to reduce the adjacency graph to a tree, then to perform an optimal tree partitioning by dynamic programming.

Keywords: Aggregation, tree partitioning

Mining the Web for Knowledge of Vague Places

Christopher B. Jones (Cardiff University, GB)

Geographical queries on the web often employ vernacular place name names that are not recorded in conventional gazetteers and hence cannot be recognised automatically. Experiments have been conducted to acquire knowledge of the spatial extent of such names derived from documents on the web. Queries mentioning a target vague place can retrieve documents containing other more precise names of places that may be located inside the target place. Analysis of the frequency of occurrence of such co-located places can be used to generate surface density models of their spatial distribution. The main peak in these surfaces appears to coincide with expert opinions of the extent of the target place and evaluation using precise target places confirms this view. Thresholding of the surfaces can be used to generate approximate crisp boundaries.

Keywords: Vague places, web mining

Joint work of: Jones, Christopher B. ; Joho, Hideo ; Clough, Paul ; Purves, Ross

Communicating about spatial data: the role of relations

Werner Kuhn (Universität Münster, D)

I call for more research on modeling spatio-temporal relations on types, rather than on individuals. The presentation briefly reviews work on relations in GI-Science, summarizes a case study on relations needed to explain geospatial semantics, and outlines a formalization done in Haskell.

Keywords: Geospatial semantics, ontologies, foundational relations, information retrieval

Modelling Three-dimensional Fields in Geoscience with the Voronoi Diagram and its Dual

Hugo Ledoux (Univ. of Glamorgan, GB)

The objects studied in geoscience are usually not man-made, but rather the spatial distribution of three-dimensional continuous geographical phenomena such as the salinity of a body of water, the humidity of the air or the percentage of gold in the rock. These are referred to as 'fields', and have traditionally been modelled with raster structures (voxels or octrees). To represent 3D fields, I propose using a new spatial model based the Voronoi diagram (VD) and its dual the Delaunay tetrahedralization (DT).

I argue that constructing the VD/DT of the samples that were collected to study the field can be beneficial for analysing and extracting meaningful information from the dataset. The two structures themselves make possible, and even optimise, several spatial analysis and visualisation operations. Examples are: the automatic extraction of isosurfaces; robust interpolation methods that adapt to the highly anisotropic distribution of geoscientific datasets; and the VD/DT also give a clear and consistent definition of neighbourhood for unconnected points in 3D. A further important consideration is that the VD/DT is locally modifiable (insertion, deletion and movement of points), which permits us to interactively explore a dataset and thus gain insight by observing on the fly the consequences of manipulations and spatial analysis operations.

From Interactive to Collaborative 3D Geoinformation Environments - Accessibility and Content Management Issues

Stephan Nebiker (FHBB - Fachhochschule Basel, CH)

3D landscape and city models of entire regions and countries are gradually enabling interactive information and entertainment services in the (mobile) Internet.

First operational examples of such services feature primarily static cartographic content which has to be updated centrally by the experts creating and maintaining the scene. However, there is a demand for up-to-date, relevant and personalised content and a clear trend towards the integration of user's content within these 3D services. The aim of the Geo-Roaming project is to develop a software framework for managing, updating and accessing such distributed 3D geoinformation services. This paper presents key issues of this project: a new concept and system architecture for the modelling, integration, management and updating of domain-specific spatial content.

Location-based content for 3D geoinformation services is very rich by its nature, since it includes not only points of interest and 2D vectors but also 3D objects together with photo-realistic appearance, viewpoint and animation information. 3D content management solutions also have to address levels of detail and multiple-representations for all types of content since they are inherent to any scalable 3D geoinformation solution. In order to handle rich content of this kind in different application domains, the model-driven content management mechanism GXL (geo-content exchange language) was developed. GXL is based on GML 3 (Geography Markup Language) and on a comprehensive 3D object type developed as part of the related 3D GIS project DILAS (Digital Landscape Server). GXL allows for a relatively simple but rigorous definition of domain-specific content models (e.g. for tourism or education) by the different content providers. All components of the Geo-Roaming content management framework are designed and implemented using the model-driven approach. Thus, the processes of creating, editing, transforming, validating and storing location-based content can automatically be driven by the GXL-based content models. The Content Editor component can either be embedded into the commercial web-based high-performance 3D viewer G-VISTA or be used in stand-alone mode. Embedding the content editor into a web-based viewer enables regional content providers or individual users (e.g. hikers or paragliders) to collect and update their information in an intuitive environment. The Content Manager component provides a solution for storing and managing the contents of 3D geoinformation services in a distributed environment. It features a persistence framework which combines XML and objectrelational spatial DBMS technology for optimal flexibility and performance.

Keywords: Mobile, Three-dimensional, Spatial, Information, Services, Internet, Modelling, Interoperability

Interfacing Spatial Data

Volker Paelke (Universität Hannover, D)

Most existing user interfaces for handling and analyzing spatial data are based on the standard WIMP (Windows, Icons, Menus, Pointer) paradigm. While this appoach has emerged as the standard and is well suited for many office applications it leads to usability problems in many applications that involve spatial data,

namely 3D interaction with 6DOF tasks, effective support for multi-user interaction and collaboration as well as mobile interaction. Additions to the standard user interface like haptic input/output devices and stereoscopic displays can help to adress some of these issues. In a more general view the interface paradigm of augmented reality (AR) in which information is embedded spatially correct into the real world has been promoted as a promising approach to spatial interaction. However, several problems remain: Current AR technology still lacks exact and lag-free positioning sensors for large scale and outdoor applications as well as suitable displays. More general questions include the extension of AR interfaces beyond "just looking" towards deeper interaction and the question of how to represent augmentation content both internally and visually.

To adress these questions within the limitations of current hardware I introduce a multi-tier approach. The framework of "scopes-of-interaction" provides a basis for identifying possible combinations of visualization and interaction techniques in AR interfaces. The concept is demonstrated by exploring the design-space of interaction techniques based on inside-out-vision (IOV), in which a handheld camera is used to affect interaction. To allow the examination of more general and complex AR interaction and visualization techniques the GeoScope, an AR input/output device based on mechnical tracking and a touch-sensitive display is introduced as a test platform. The combination of mechanical tracking with a high-resolution display and the interaction potential provided by the combination of tracking with the touchscreen functionality allow to examine a wide range of techniques with actual users while removing many of the shortcomings of current technology from the experiments.

Keywords: User interfaces, spatial interaction, augmented reality

Web services for improving the development of automatic generalisation solutions

Nicolas Regnauld (Ordnance Survey - Southampton, GB)

We have presented the results of a two years project aiming at automatically generalise very detailed vector data into a 1:50k vector product, looking similar t(in style) to the current 1:50k Ordnance Survey Map Series (OS Landranger). The project showed us that very few tools available in current GIS are fit for our purpose. We had to redevelop lots. The lack of tools available does not come from the lack of research, but the fact that research prototypes rarely find their way into commercial GIS, and are themselves rarely available. Generalisation Web Services, as developed at the University of Zurich, show a good potential to overcome this problem. It offers an easy way for publishing prototypes as services, making them available for others to test on their own data and from their own development platform. It also has the potential to provide a channel to make existing platforms (custom or mainstream GIS) interoperate. This should allow to collect all prototypes into a large library of services, on which new

research can be based, producing higher level services. Top level services could in the future provide a full generalisation process.

Keywords: Generalisation, Web Services

The Evaluation of Rotation Algorithms in a Moving Map Display

Jörg-Rüdiger Sack (Carleton University - Ottawa, CDN)

ABSTRACT Pedestrian navigation systems have been studied from a variety of perspectives. The current study tests six different ways of rotating a map in real-time as a user navigates through a space, with the aim of assessing the extent to which participants may perceive differences between these schemes. The lab study consisted of presenting 6 map rotation algorithms in each of eight simulated walks of a person on the Carleton University campus using the GPS-driven PDA. Two ratings were obtained after each simulated walk clip was shown on a PC. The lab study results indicate that the no threshold and the minimum threshold algorithms are most suited for curved pattern of movements while walking. On the other hand, the maximum threshold, as well as the minimum and maximum threshold algorithm is best suited for zigzag movements. A new adaptive algorithm is suggested that would take into account the types of movement pattern and adjust the algorithm accordingly. This paper addresses a question that had been posed at the predecessor of this Dagstuhl Seminar (on Computational Cartography).

Keywords: Pedestrian Navigation, GPS, Navigation, Rotation Schemes, Moving Maps

Joint work of: Narasimhan, Sheila; Parush, Avi; Gervais, Eric; Sack, Jörg-Rüdiger; Nussbaum, Doron

SILK: Efficient Query Processing on Spatial Networks

Hanan Samet (University of Maryland - College Park, USA)

A framework for determining the shortest path and the distance between every pair of vertices on a spatial network is presented. The framework, termed SILC, uses path coherence between the shortest path and the spatial positions of vertices on the spatial network, thereby, resulting in an encoding that is compact in representation and fast in path and distance retrievals. Using this framework, a wide variety of spatial queries such as incremental nearest neighbor searches and spatial distance joins can be shown to work on datasets of locations residing on a spatial network of sufficiently large size. The suggested framework is suitable for both main memory and disk-resident datasets.

Keywords: Query processing

Joint work of: Samet, Hanan; Sankaranarayanan, Jagan; Alborzi, Houman

Data Mining and Efficient Similarity Retrieval of Hierarchical Structures from Large Databases

Thomas Seidl (RWTH Aachen, D)

Hierarchical structures are to be found everywhere in biomedical applications, multimedia databases and spatio-temporal database applications. Tree edit distances (TED) have been proposed as a well-suited similarity model for hierarchical structures. Since they are highly computational expensive, efficiency has to be improved when applying TED to large databases of complex objects. We have developed several histogram-based filter distances that meet high filter qualities as they are complete, selective and efficient when employed in multi-step query processing architectures. Experiments demonstrate the good performance of our techniques.

Keywords: Multimedia data mining; similarity search; graph databases

Joint work of: Seidl, Thomas; Kriegel, Hans-Peter; Kailing, Karin; Schönauer, Stefan

See also: 9th Int. Conf. on Extending Data Base Technology (EDBT 2004), Heraklion - Crete, Greece. Springer LNCS 2992: 676-693

Streaming Generalization and 3D Building Generalization

Monika Sester (Universität Hannover, D)

The talk addresses two approaches in cartographic generalization. Firstly, a method for incremental, streaming generalization of vector data is presented which is based on a vocabulary of elementary generalization operations describing changes in geometry and topology. The approach is demonstrated with two simplification operations (buildings and lines). The program can be downloaded from the website of the ikg: www.ikg.uni-hannover.de.

Secondly, the problem of 3D-sympolization is addressed using 3D adaptive prototypes that are fitted to the original objects in an optimization process.

Keywords: Continuous generalization, transmission of data, 3D-Generalization

Full Paper:
http://www.ikg.uni-hannover.de/publikationen/publikationen/2004/sester_brenner.pdf

Communicating Spatial Data. Representation and Notation

John Stell (University of Leeds, GB)

Traditional means for the representation of geographical spatial data have evolved in cartography over a long period. These means have developed in a context of paper-based mapping and may not always be the most appropriate way of communicating spatial data in the digital world. The challenges presented by the digital context include the possibilities for continuous generalization and the tailoring of maps to individual requirements – rather than presenting a fixed view in a supposedly objective way. In addition to new challenges, there are also new opportunities in the form of new technologies for displaying and interacting with spatial data, such as virtual reality systems.

This talk reports on some experiences with artists as part of a project to explore techniques for drawing in 3D space. The motivation for working in collaboration with artists with expertise in contemporary drawing (principally Claude Heath in the case of this project) is to access new ways of thinking about how spatial data might be expressed using the ability to make and perceive marks in 3D space. The visual communication of space, as with any form of drawing, involves elements of the notational or symbolic and also elements of the representational in the sense of the mimetic reproduction of appearance. The project has raised some interesting issues about how artists and scientists can collaborate and about methodologies for developing new ways of visualizing spatial data.

Keywords: Spatial data visualization, art-science research, drawing

Spatial Object Representation: Some Issues

Rodney James Thompson (TU Delft, NL)

One of the critical issues in the storage and interchange of spatial data is the requirement that representations of spatial objects be handled consistently by different software environments. While some progress is being made in the definition and nomenclature of spatial primitives, a major inhibitor is to be found in the representations currently used to implement these primitives.

The larger body of research to date in the field of vector representation of spatial data has concentrated on developing the mathematical model based on an assumption of infinite precision, with the digital implementation of the mathematical model being less well understood. This presentation reviews some of the issues that this imbalance has created, and the symptoms of the failures of logic.

Several of the lines of research that do address the issue are reviewed, with an emphasis on the completeness and correctness of the logic, and also the practicality of the implementation. Discussed in particular are: Milenkovic Normalization,

the Realms approach, the Rational Polygon, the Dual Grid, and finally the Regular Polytope. The regular polytope approach is further analysed to determine its advantages and limitations, and its practicality as a spatial data storage and retrieval strategy. Finally, possible future directions for this line of research are suggested and discussed.

Keywords: Data interchange, data representation, standardization, interoperability, logic, finite mathematics

Approaches to Geospatial Database Integration

Steffen Volz (Universität Stuttgart, D)

If open and federated geospatial databases are set up, different approaches to geospatial database integration are necessary. Basically, these approaches either deal with integration on the schema or on the instance (data) level. Both schema and data integration encompass a matching phase during which corresponding elements are identified and a merging phase that produces a consolidated result. In the presentation, approaches on both levels have been presented.

Keywords: Geospatial Databases: Integration, Matching, Conflation

Management and Conflation of Multiple Representations within an Open Federation Platform

Steffen Volz (Universität Stuttgart, D)

Building up spatial data infrastructures involves the task of dealing with heterogeneous data sources which often bear inconsistencies and contradictions, respectively. One main reason for those inconsistencies emerges from the fact that one and the same real world phenomenon is often stored in multiple representations within different databases. It is the special goal of this paper to describe how the problems arising from multiple representations can be dealt with in spatial data infrastructures, especially focusing on the concepts that have been developed within the Nexus project of the University of Stuttgart that is implementing an open, federated infrastructure for context-aware applications. A main part of this contribution consists of explaining the efforts which have been conducted in order to solve the conflicts that occur between multiple representations within conflation or merging processes to achieve consolidated views on the underlying data for the applications.

Keywords: GIS, multiple representations, matching, conflation

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/588

Challenges in Representing a Multifaceted World in Multiple Representations

Robert Weibel (Universität Zürich, CH)

In multi-representation databases (MRDB) the same real-world phenomena are represented in different ways, at different scales or resolutions, and possibly at different levels of accuracy. As such, MRDBs have become an active research domain and a useful tool in a variety of applications ranging from cartography to vehicle navigation. However, current MRDB concepts also suffer from rather stringent limitations. Owing to their original application domain of topographic mapping and database production, they focus primarily on the representation of crisp, static entities at fixed levels of scale. The representation of imprecise or vague phenomena that would require field-based representation as well as the representation of change or the procedural derivation of new information not explicitly represented in the MRDB is presently not or only weakly supported.

The talk first reviews the achievements as well as the limitations of MRDBs and then goes on to discuss options for extending current MR approaches. Examples include methods for the delineation of imprecise named regions or places, shape morphing between scale levels, and progressive vector transmission. Fundamentally, the discussion revolves around the issue of whether representations of real-world phenomena should be stored explicitly or implicitly, whereby implicit representation can be achieved by stored procedures. In general, implicit representation seems favorable in the case of uncertain, dynamic, and process-oriented phenomena.

Intelligent Route Planning from Incomplete Transport Knowledge

Stephan Winter (University of Melbourne, AU)

Concurrent route planners assume complete and (near) up-to-date knowledge of the network. We study route planning in a different environment. We assume that transport is offered by vehiclesŮour host agentsŮand consumed by pedestriansŮour client agents. We further assume that the clients do their trip planning autonomously (decentralized) and ad-hoc, gaining network knowledge in a negotiation procedure with nearby hosts. Our hypothesis is that clients need to have only this local knowledge of the transport network to come up with nearly optimal trip plans. This idea suggests employing a mobile geosensor network, with clients and hosts forming the nodes. These nodes are mobile and location-aware (hence ŚgeoŠ-sensor), they may know the street network, and they can communicate in an ad-hoc manner (Nittel et al. 2004; Zhao and Guibas 2004). The trip negotiation is done periodically, due to the dynamically changing environment and new opportunities arising. We study the behavior of this complex system in simulations in a multi-agent model, and prove by that way the hypothesis.

For further information see the extended abstract.

Keywords: Route planning, mobile location-aware sensor networks

See also: Nittel, S.; Stefanidis, A.; Cruz, I.; Egenhofer, M.; Goldin, D.; Howard, A.; Labrinidis, A.; Madden, S.; Voisard, A.; Worboys, M.F., 2004: Report from the First Workshop on Geo Sensor Networks. SIGMOD Record, 32 (4)

Order in the Underground - How to Automate the Drawing of Metro Maps

Alexander Wolff (Universität Karlsruhe, D)

In this talk we investigate the problem of drawing metro maps which is defined as follows. Given a planar graph G of maximum degree 8 with its embedding and vertex locations (e.g. the physical location of the tracks and stations of a metro system) and a set L of paths or cycles in G (e.g. metro lines) such that each edge of G belongs to at least one element of L, draw G and L nicely. We first specify the niceness of a drawing by listing a number of hard and soft constraints. Then we present a mixed-integer program (MIP) which always finds a drawing that fulfills all hard constraints (if such a drawing exists) and optimizes a weighted sum of costs corresponding to the soft constraints. We also describe some heuristics that speed up the MIP. We have implemented both the MIP and the heuristics. We compare their output to that of previous algorithms for drawing metro maps and to official metro maps drawn by graphic designers.

Keywords: Graph drawing, geometric networks, metro maps, mixed-integer programming

Generating Realistic Terrains with Higher-Order Delaunay Triangulations

Marc van Kreveld (Utrecht University, NL)

For hydrologic applications, terrain models should have few local minima, and drainage lines should coincide with edges. We show that triangulating a set of points with elevations such that the number of local minima of the resulting terrain is minimized is NP-hard for degenerate point sets. The same result applies when there are no degeneracies for higher-order Delaunay triangulations. Two heuristics are presented to reduce the number of local minima for higher-order Delaunay triangulations, which start out with the Delaunay triangulation. We give efficient algorithms for their implementation, and test on real-world data how well they perform. We also study another desirable drainage characteristic, few valley components, and how to obtain it for higher-order Delaunay triangulations. This gives rise to a third heuristic. Tables and visualizations show how the heuristics perform for the drainage characteristics on real-world data.

Keywords: Terrain modeling, higher-order Delaunay triangulations

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See also: Proceedings ESA 2005

Vario-scale topological data structures suitable for progressive transfer: the GAP-face tree and GAP-edge forest

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The first data structure for a variable scale representation of an area partitioning without redundancy of geometry is presented. At the highest level of detail, the areas are represented using a topological structure based on faces and edges; there is no redundancy of geometry in this structure as the shared boundaries (edges) between neighbor areas are stored only once. Each edge is represented by a Binary Line Generalization (BLG)-tree, which enables selection of the proper representation for a given scale. Further, there is also no geometry redundancy between the different levels of detail. An edge at a higher importance level (less detail) does not contain copies of the lower-level edges or coordinates (more detail), but it is represented by efficiently combining their corresponding BLG trees. Which edges have to be combined follows from the generalization computation, and this is stored in a data structure. This data structure turns out to be a set of trees, which will be called the (Generalized Area Partitioning) GAP-edge forest. With regard to faces, the generalization result can be captured in a single tree structure for the parent-child relationshipsŮthe GAP face-tree. At the client side there are no geometric computations necessary to compute the polygon representations of the faces, merely following the topological references is sufficient. Finally, the presented data structure is also suitable for progressive transfer of vector maps, assuming that the client maintains a local copy of the GAP-face tree and the GAP-edge forest. A proposal for extending Web Feature Service with notion of importance (GetFeature with importance and delta-importance) is made. An implementation of the server-side is currently being realized. Real testing will start in context new 3 year project 'Usable, well-scaled mobile maps'(with TNO Human Factors, ANWB, ITC, ESRI, LaserScan).

Keywords: Map generalization, topological structure, planar partition, client/server, progressive

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