Spatial Data: mining, processing and communicating

Short report of Dagstuhl Seminar Nº 06101 (05.03.-10.03.06)

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1   Background

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 problems, 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) shared their latest topics, problems, doubts, and investigations.

2   Challenges

The importance of spatial data in our daily lives is rapidly increasing and so are the challenges and demands on the research and commercial communities to address the different facets of spatial data. In these communities, spatial data have generated tremendous interest over the last decade.

Interpretation of spatial constellations or situations is a process, that is closely linked to human capabilities and can be formalized using formal semantics (OWL, ODM, etc.). Making implicit information explicit is needed not only for many spatial analysis problems, but also for aspects of information communication: in digital cartography a "hot topic" today is adaptive visualization. A user is presented exactly the information that is needed for a specific purpose in a dedicated specific situation. This presumes that first of all such a situation is identified, and secondly an adaptive presentation is generated from it. A typical adaptation is made according to the scale or resolution of the data – the traditional generalization problem. However, adaptation can be interpreted in a much wider way by also adapting according to the personal profile, behaviour and wishes of the user. Such adaptive representations are especially important in the con-

text of mobile or wireless GIS, where the spatial information has to be transmitted via possibly limited bandwidth channels.

Spatial data also pose exciting questions for the algorithms and data structuring communities. It is vital that computational geometrists meet with the spatial data community to exchange ideas, pose problems and offer solutions. Most algorithmic problems arising in that field are indeed geometric.

Many different application areas arise from the general availability of spatial data, e.g. using data in mobile applications, integrating data for complex tasks (e.g. traffic monitoring, risk management), inferring behaviour patterns from data sets. The problems relating to data interpretation and data mining with respect to these applications have been discussed in the seminar. Other integrated topics are ubiquitous spatial processing and formal spatial semantics.

3 Program

Before the meeting all participants have been asked to feed back their interest and their research ideas to the organizers. Based on this material, a set of focus topics have been penciled out, namely 1) Spatial databases – 3D / uncertainty / Time, 2) Data Integration 3) Data Mining – spatio-temporal Data Mining, 4) Cartography – Computational Geometry, 5) Visualization and Interaction, 6) New Technologies (e.g. Sensor-Nets, Google Maps).

In the very first session every participant had the chance to present his/her project and ideas in a brief 5-minute-statement. This gave on the one hand the possibility for everybody to introduce himself/herself to the group, on the other hand it helped to narrow down the set of pre-defined focus group topics, as each participant also indicated his/her main interest. It turned out, that the last topic was not interesting as a separate one, but was considered as part of the others, as new technologies have a strong influence on the development of science and technology.

The sessions were held as usual during the mornings and late afternoons; in addition, the focus groups had short 1h-parallel meetings before the afternoon coffee.

The topics addressed in the presentations covered the wide range of problems in the context of the seminar theme: 1) generalization (continuous generalization, vario-scale, generalization web services, aggregation using optimization, as well as algorithms for underground maps and cartograms) 2) Visualization (interactive, collaborative environments, 3D-city models, new user interfaces, moving map display) 3) space and time (spatial patterns, geospatial lifelines, analysis of track logs, route planning) 4) data mining (vague places, efficient retrieval, efficient query processing) 5) modeling and representation (spatio-temporal relations, "rich descriptions", multi-resolution and multiple representation modeling, representation and notation, data integration) 6) 3D (3D voronoi-diagram, interpretation of laser data, higher-order Delaunay-triangulation) 7) spatial cognition, functional languages

The focus groups had their special sessions in parallel, and the results were reported back to plenary sessions. This enabled exploring both the necessary depth of a special topic and at the same time allow for the presentation of an adequate breadth of topics.

Due to the efforts of both the presenters and the audience, the disciplinary boundaries were crossed many times and this resulted in refreshing discussions. This was directly after the presentations, but also during the breaks in the pleasant environment of the Schloss Dagstuhl, there was sufficient time to go into more detailed discussions. It has been a very fruitful meeting for all participants. The meeting place traditions (problems/ challenges sessions, ample time for questions and interactions between talks, environment: library, computer room, common rooms, etc.) indeed helped to break down barriers imposed by academic disciplines. Some of the new research results presented were solving open questions posed at, or obtained through collaborative projects (and cooperations) which started after, the previous Dagstuhl seminar.

Given that visualization is one important aspect of spatial modeling, Cartography and GIS, the organizers decided to hold one joint session with the co-located GI-Dagstuhl-Seminar: "Human-Centered Visualization Environments". In this session, the two groups summarized research topics and challenges to the other communities.

4   Outcomes

Outcomes of the seminar include a collection of abstracts, presentations (slides) and some papers surveying the current state of the art in this field and latest research initiatives (available on the website http://www.dagstuhl.de/06101/Materials/). Similar to the previous seminar on 'computational cartography and spatial modeling', it is expected that new partnerships and collaborations between multi-disciplinary groups (reinforced and established during the current seminar) will further advance this field with the inclusion of emerging topics.

Another important result of the seminar is the 'Challenges of GIScience - green + red topic list', which can be found on the seminar's website. The idea was to identify topics for the next 5 years that are worth and challenging to work on – and at the same time also state, which topics should not be treated.

5   The Program in detail

The program of the seminar was as follows:

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9-10:30	Introduction	Egenhofer Quak Regnauld	Döllner Volz Burghardt Wolff	Kolbe Ledoux v. Oosterom Gudmundssen	De Floriani ***Challenges in GIScience for***
10:30-10:50	Coffee				
10:50-12:00	Winter Freksa Haunert	Frank ***Initial Feedback group meetings***	Paelke Stell Seidl	Sack Nebiker Samet	***the next 5 years (3 groups)***
12:15-1:00	Lunch				
2:30-3:30	***Group Meetings***	***Group Meetings***	Hike	***Group reports in plenary***	
3:30-4:00	Coffee				
4:00-6:00	v. Kreveld Speckmann Jones Kuhn Weibel	Brenner Satyan Nittel *Interaction with other group 30´*		Sester Thompson Filin Kothuri	
6:00-7:00	Dinner				

Monday 06.03. 2006

1) Stephan Winter (University of Melbourne, AU): Intelligent Route Planning from Incomplete Transport Knowledge

2) Christian Freksa (Universität Bremen, D): Spatial Cognition: Agents between sensation and reality

3) Jan-Henrik Haunert (Universität Hannover, D): Aggregation of Areas   Concepts and new Ideas

4) Marc van Kreveld (Utrecht University, NL): Generating Realistic Terrains with Higher-Order Delaunay Triangulations

5) Bettina Speckmann (TU Eindhoven, NL): Cartograms

6) Christopher B. Jones (Cardiff University, GB): Mining the Web for Knowledge of Vague Places

7) Werner Kuhn (Universität Münster, D): Communicating about spatial data: the role of relations

8) Robert Weibel (Universität Zürich, CH): Challenges in Representing a Multifaceted World in Multiple Representations

Tuesday 07.03.2006

9) Max J. Egenhofer (University of Maine, USA): GeoSpatial Lifelines

10) Wilko Quak (TU Delft, NL): Automatic analysis of GPS tracklogs

11) Nicolas Regnauld (Ordnance Survey - Southampton, GB): Web services for improving the development of automatic generalisation solutions

12) Andrew Frank (TU Wien, A): New Technologies: Functional Languages

13) Claus Brenner (Universität Hannover, D): How can we represent complex manmade structures?

14) Satyan Devadoss (Williams College - Williamstown, USA): Shape deformation in continuous generalization

15) Silvia Nittel (Univ. Maine, USA): Sensor networks

Wednesday 08.03.2006

16) Jürgen Döllner (Hasso-Plattner-Institut - Potsdam, D): Visualization of 3D City Models

17) Steffen Volz (Universität Stuttgart, D): Approaches to Geospatial Database Integration

18) Dirk Burghardt (Universität Zürich, CH): Generalisation Services on the Web

19) Alexander Wolff (Universität Karlsruhe, D): Order in the Underground - How to Automate the Drawing of Metro Maps

20) Volker Paelke (Universität Hannover, D): Interfacing Spatial Data

21) John Stell (University of Leeds, GB): Communicating Spatial Data. Representation and Notation

22) Thomas Seidl (RWTH Aachen, D): Data Mining and E-cient Similarity Retrieval of Hierarchical Structures from Large Databases

Thursday 09.03.2006

23) Thomas H. Kolbe (Universität Bonn, D): Identification of Spatial Configurations using Inexact Relational Matching and Minimum Description Length

24) Hugo Ledoux (Univ. of Glamorgan, GB): Modelling Three-dimensional Fields in Geoscience with the Voronoi Diagram and its Dual

25) Peter van Oosterom (TU Delft, NL): Vario-scale topological data structures suitable for progressive transfer: the GAP-face tree and GAP-edge forest

26) Joachim Gudmundsson, National ICT Australia, Sydney): Data mining in spatio-temporal sets

27) Jörg-Rüdiger Sack (Carleton University - Ottawa, CDN): The Evaluation of Rotation Algorithms in a Moving Map Display

28) Stephan Nebiker (FHBB - Fachhochschule Basel, CH): From Interactive to Collaborative 3D Geoinformation Environments – Accessibility and Content Management Issues

29) Hanan Samet (University of Maryland - College Park, USA): SILK: E-cient Query Processing on Spatial Networks

30) Monika Sester (Universität Hannover, D): Streaming Generalization and 3D Building Generalization

31) Rodney James Thompson (TU Delft, NL): Spatial Object Representation: Some Issues

32) Sagi Filin (Technion - Haifa, IL): Recovering terrain from laser point clouds

33) Ravi Kothuri (Oracle Corp. - Nashua, USA): Spatial Enabled Mining in Oracle

Friday 10.03.2006

34) Leila De Floriani (University of Genova, I): Multi-resolution Modeling of Multi-dimensional Scalar Fields

35) Challenges in GIScience for the next 5 years (3 groups)