Graph Drawing with Applications to Bioinformatics and Social Sciences

Seminar 08191

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1 Introduction

Graph drawing deals with the problem of communicating the structure of relational data through diagrams, or drawings. Graphs with vertices and edges are typically used to model relational data. The vertices represent the objects (or data points) and the edges represent the relationships between the objects. The main problem in relational visualization is to display the data in a meaningful fashion that may heavily depend on the application domain. Some of the application areas where graph drawing tools are needed include computer science (data base design, data mining, software engineering), bioinformatics (metabolic networks, protein-protein interaction), business informatics (business process models), and the social sciences and criminalistics (social networks, phone-call graphs).

The ability to represent relational information in a graphical form is a powerful tool which allows us to perform analysis through visual exploration. With the aid of graph visualization we can find important patterns, trends, and correlations. Real-world applications such as bioinformatics and sociology pose additional challenges, e.g., semantic information carried by the diagram has to be used for obtaining meaningful layouts and application-specific drawing conventions need to be fulfilled. Moreover, the underlying data often stems from huge data bases, but only a small fraction shall be displayed at a time; the user interactively selects the data to be displayed and explores the graph by expanding interesting and collapsing irrelevant parts. This requires powerful graph exploration tools with navigation capabilities that allow dynamic adaption of the graph layout in real time.

2 Topics of the Seminar

In this seminar we focused on the application of graph drawing in two important application domains: bioinformatics (metabolic pathways, regulatory networks, protein-protein interaction) and social sciences and criminalistics (case information diagrams, phone-call graphs). In both application domains, the underlying information is usually stored in large data bases constituting a huge and complex graph, but only a suitable fraction of this graph is visualized; the selection of that subgraph is guided by the user and even more user interaction occurs in order to further

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explore the underlying graph. Thus, the user becomes a central actor that triggers dynamic updates of the displayed graph and its layout. The support of application-specific update functionality in conjunction with high quality graph layout is essential for achieving user acceptance in the targeted application areas.

The interactive navigation through the graph poses new challenges to graph drawing algorithms. Whereas traditional graph drawing deals with the visualization of static graphs, we are now concerned with graphs that change over time, and the layout has to be adjusted in real time. The new layout has to observe aesthetic and application specific drawing criteria, as well as the preservation of the user's mental map; in particular only few changes in the layout are desired.

A similar dynamic component occurs in the visualization of graphs that evolve over time like minute-by-minute phone-call graphs which have application in police investigations. Here, we have a graph at each time point and an edge corresponds to a phone call between two telephones. In contrast to interactive navigation, we know in advance all of the changes the graph will undergo, and we can exploit this fact for producing a smoother animation sequence.

3 Aims of the Seminar

In the application, we formulated the following aims for the Dagstuhl seminar:

1. To bring together theoreticians and practitioners from the targeted graph drawing application areas: bioinformatics, social sciences and criminalistics;
2. To focus on interaction with and navigation in large and dynamic networks arising in these application areas;
3. To identify and define open graph drawing problems that are motivated by practical applications in the targeted application areas and to tackle selected open problems;
4. To formulate the findings as a first step to the solution of the problems considered and to define further research directions.

In order to promote the communication and cooperation between graph drawing researchers and practitioners, we used a more interactive format for the seminar. The first two days were reserved for the presentation of practical aspects of graph drawing and required background in the targeted application areas. We also used the first two days to formulate about a dozen open problems. The remaining three days were used mainly by smaller working groups consisting of practitioners and GD researchers in order to formalize the definition of open problems and to formulate first solution approaches on specific open problems.

4 Achievements of the Seminar

Over forty participants from both academia and industry attended the seminar producing a productive atmosphere. The achievements in the seminar were numerous and varied. Some of the more important ones can be summarized as follows:

1. We enjoyed three survey lectures on the graph drawing aspects of bioinformatics by Falk Schreiber, Oliver Kohlbacher and Mario Albrecht and another two survey lectures on the visualization of social networks by Ulrik Brandes and Stephen Borgatti.

2. Beyond the survey lectures, highlights of the seminar included lectures on Networks of European Science in the 18th Century, Combining Graph Drawing and Information Visualization Techniques to Support Sensemaking, and An Information Visualization View on Graph Drawing.

3. We also had a small number of stimulating presentations and demos of new software. In particular, new approaches to the layout of huge and/or dynamic graphs as well as new visualization paradigms were presented.

4. A small number of relevant open problems were formulated early in the seminar and working groups formed around related open problems succeeded in formalizing the specific theoretical and practical challenges. Further, several of the working groups obtained new results, some of which have already led to conference paper submissions. We are expecting at least 5-6 research publications to result directly from the Seminar.

Arguably the best, and most-appreciated, feature of the Seminar was the opportunity to engage in discussion and interactions with experts in biology and social networks in the setting of working groups. The seven working groups focussed on the following topics:

- Use Cases in Biology
- Visualization of Trajectories
- Edge Thresholding
- Exploring and Navigating Large Graphs
- X-graphs and Y-graphs: Visualization and Interaction
- Graph Drawing Techniques for Successive Augmentation of Multiple Layer Drawings
- Visually Comparing a Set of Graphs

In summary, it is our impression that the participants enjoyed the great scientific atmosphere offered by Schloß Dagstuhl, and profited from the scientific program. We are grateful for having had the opportunity to organize this seminar.

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