Algorithms for Graph Visualization

Wrap Up

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6.2.2017
Organizational

Exams
- Oral Exam (20 Minutes)
- 13, 14 February 2017
- 20, 21 March 2017
- Room 315
- Myself + Benjamin (or substitute) taking protocol.
  Language: English.

Content
- Material from lectures/exercises
- Skript, Slides, Blackboard proofs - only what have been discussed

Goals
- Layout problems (Problem definitions, Aesthetic criteria)
- Algorithms (Proof ideas)
Layout Problem – General Definition

Graph visualization problem

given: Graph $G = (V, E)$
find: (good) drawing $\Gamma$ of $G$, that
- complies with drawing conventions
- optimizes aesthetics
- satisfies local/partial constraints
Material Overview

- Graph Classes
- Drawing Conventions, Aesthetic Criteria
- Algorithms and their type (D & C, Incremental, LP)
- Techniques
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Let’s Draw a Graph!
Topic 1: Trees

Layered Layout
- **Aesthetics:** symmetry, area
- **Conventions:** planarity, vert. on layers
- **Algorithm:** Divide & Conquer, Time $O(n)$, Area $O(n^2)$

HV-Layout
- **Aesthetics:** symmetry, area
- **Convention:** h/v edges, planarity
- **Algorithm:** Divide & Conquer, Time $O(n)$, Area $O(n \log n)$

Radial Layout
- **Aesthetics:** vertex distribution
- **Convention:** vertices on co-centric circles, planarity
- **Algorithm:** Divide & Conquer, Time $O(n)$
Topic 2: Series-Parallel Graphs

- **Convention:** planarity, upwardness
- **Aesthetics:** symmetry, vertical automorphisms
- **Algorithm:** Divide & Conquer based on SPQ-decomposition, Time $O(n)$, Area $O(n^2)$. Embedding varies.
- **Area lower bound** with fixed embedding $\Omega(4^n)$
Topic 3: Planar Graphs - Shift Algorithm

- **Conventions:** planarity
- **Aesthetics:** ...
- **Algorithm:** Incremental based on **Canonical Ordering**. Time $O(n)$, Area $O(n^2)$. Embedding fixed.
- **Highlights:** Proof of planarity, linear time implementation based on relative $x$-distances
Topic 4: Planar Graphs - Schnyder Realizer

- **Conventions:** planarity
- **Aesthetics:** … ?
- **Algorithm:** Based on **Barycentric representation**, **Schnyder forest**. Time $O(n)$, Area $O(n^2)$. Embedding fixed.
- **Highlights:** Proof of planarity of baricentric representation, Schnyder forest - useful tool on its own.
Topic 5: General Graphs - Force Directed

- **Conventions:** ...
- **Aesthetics:** edge length
- **Algorithm:** Eades, Fruchteman-Reingold. Time $O(n^2)$ per iteration.
- **Modifications:** Inertia, Gravitation, Magnetic Forces. Bounded Drawing area. Adaptive displacement. Computation of forces using Quad-tree - Time $O(n \log n)$ per iteration. Multilevel approach - Time $O(n \log^2 n)$ overall.
Topic 6: Directed Graphs - Layered Layout

- **Conventions:** vertices on layers, edges upward
- **Aesthetics:** upwardness, edge length, edge bends, edge straightness, drawing width/height, crossings.
- **Algorithm:** Sugiyama Framework.

**Resolve cycles** - Heuristic solutions. Time $O(|V| + |A|)$.  
**Layer Assignment** - minimize height: topological numbering ($O(|V| + |A|)$), total edge length: ILP  
**Crossing Minimization** - swap. Two layers: heuristics: barycenter, median (approximation factor) ($O(|V| + |A|)$), ILP.  
**Node Positioning** - edge straightness: quadratic program.
Topic 7: Degree 4 - Orthogonal Drawings

- **Conventions:** Edges on grid.
- **Aesthetics:** Height, Width, Bends

- **Algorithm:** Biedl & Kant: incremental algorithm. Time
  Uses ear-decomposition, topological ordering. Time $O(n)$. Area $O(n^2)$.

- **Highlights:** Planar Drawing in case of Planar Embedded Graphs
Topic 8: Degree 4 - Orthogonal Drawings - Flow

- **Conventions:** Edges on grid.
  **Aesthetics:** Height, Width, Bends

- **Algorithm:** Topology-shape-metric.
  Crossing Reduction

**Bend Minimization:** Orthogonal Representation. Flow Network. Time $O(n^{3/2})$

**Area Minimization:** All faces rectangles: total edge length, area, flow network. Time $O(n^{3/2})$. Topological numbering. Rectilinear faces - face refinement.
Topic 9: Upward Planarity

- **Conventions:** Planarity, Edges Upward
- **Aesthetics:** ...
- **Algorithm:** Characterization (drawing planar st-digraphs), Assignment vertices to faces, Flow Network, Face subdivision. Time $O(n^2)$. 
Topic 10: Contact Representations

- **Conventions:** Vertices polygons, Edges-contacts
- **Aesthetics:** Complexity of polygons
- **Algorithm:** Rectangular dual. Characterization. Regular Edge Labeling, Canonical Ordering, st-digraphs, topological ordering. Time $O(n)$. 

![Graph Diagram](image)

![Rectangular Dual Diagram](image)
Visualization of GD Publications

- Graph Drawing Contest holding at Graph Drawing conference each September
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- This year graph: data of all publications in the Proceedings of Graph Drawing between 1994 and 2015
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- it is not compulsory to make use of the extra data
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- 1 Submission: by Sophie von Schmettow
Visualization of GD Publications

Sophie von Schmettow
Practical Course on Graph Visualization

**Background:** International Symposium on Graph Drawing (GD) and Graph Drawing Challenge
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**Task:** develop software for a given graph visualization problem
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2014

- Area Minimization for Orthogonal Drawings
- part of the lecture
- best team won graph drawing contest
Practical Course on Graph Visualization

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- part of the lecture
- best team won graph drawing contest

2015
- Crossing Minimization in Book Embeddings
- separate course
- one team - collaborative work
- second place at the contest
- Best Poster Award in 2016
Practical Course on Graph Visualization

Background: International Symposium on Graph Drawing (GD) and Graph Drawing Challenge

Task: develop software for a given graph visualization problem

2017

- Maximizing the Angles Between Crossing Edges in Straight-line Drawings
- 5 credit points
- 8 participants (registration by email to me)
HiWi Place

**Topic**
- Visualization of Citation Network of Graph Drawing Publications
  - Target: participate in the GD contest
  - Trying out various layout styles (edge bundling), clustering methods
  - Implementation (D3 or other framework)
  - Clustering Methods
  - Topic Extraction and Labeling Methods

**Details**
- Up to 40 hours/month
- Send your requests to me
HiWi Place (Master’s Thesis possible)

Topics
- Visualization of Text Variant Graphs and Sonic Topology of Poems with Curves
- Basic Computational Geometry Problems: routing curve through obstacles, minimizing curve complexity.
- Text variant: obstacles can move, Sonic Topology: obstacles do not move

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