BOUNDARY CONSTRAINTS IN FORCE-DIRECTED GRAPH LAYOUT

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INTRODUCTION

- **Graph Drawing**
  - addresses the problem of constructing geometric representation of graphs
  - application:
    - social network analysis
    - cartography
    - software visualization

*Gephi render example. From http://gephi.org/tag/gsoc/*
Introduction (Cont.)

- Graph Layout
  - Graph drawing \rightarrow graph layout
  - Force-directed approach
    - Physical model
    - Straight-line drawing
    - Physical objects subject to various forces
    - A local minimum energy configuration of the physical system
INTRODUCTION (CONT.)

- Properties
  - Symmetries
  - Planarity
  - Limited space

Graph Drawing acceptances and the Lombardi Spirograph
http://11011110.livejournal.com/201066.html

- A multi-objective optimization problem
Aesthetics

- Minimization of number of crossings, area of drawing ...
- Maximization of the symmetries displayed by the drawing ...

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Introduction (Cont.)

- Constraints – Additional Input
  - Place a given vertex in the “center” of the drawing
  - Place a given subset of vertices “close together”
  - Draw a given path horizontally aligned from left to right (or vertically aligned from top to bottom)
  - Draw a given subgraph with a predefined “shape”

- Constraint satisfaction in interactive applications
  - Update the graph
  - Preserve the metal map
INTRODUCTION (CONT.)

- Problem to solve is
  - Boundary Constraints on Graph Layout
    - Allow users to define arbitrary boundary on graph layout
    - Develop an algorithm that represent boundary as constraints in the optimization problem
    - The algorithm should be fast and preserve the metal map
    - Visualize the process of graph layout
**Motivation**

- Not much relevant research:
  - Internal linked nodes as boundary
  - Outside/environment forces as boundary
  - Clutter boundaries
  - Overall boundary

_A 400 node lattice with the outside nodes constrained to a circle_

_A large biological pathway with non-overlapping convex hull boundaries around clusters_
Motivation (Cont.)

- Practical Applications:
  - Furniture layout
  - Automatic chart layout


**RELATED WORK**

- **Fruchterman and Reingold (1991)**
  - use a complex system of force-directed algorithms
  - control the size of the drawing by assuming that the boundary of the prespecified drawing region acts as a “wall”

- **Ryall Kathy and Joe Marks (1997)**
  - build an interactive constraint-based editor
  - feature a vocabulary of visual organization constraints for graph drawing, such as alignment, zone separation
**Related Work (Cont.)**

- **Tim Dwyer (2009)**
  - constraint-satisfaction method based on position-based dynamics
  - support a much more powerful class of constraint: inequalities or equalities over the Euclidean distance between nodes
PROPOSED RESEARCH DIRECTION

- The force-directed approach
  - Use a physical model where the vertices and edges of the graph are viewed as objects subject to various forces
  - Line between two nodes as edges, edges linked together as boundaries
  - Treat boundary as repelling forces
  - Recalculating positions of nodes

- Future work
  - Speed?
  - other approach
REFERENCE