Introduction to Spring Embedder Layouts

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Achievement: You can do anything you set your mind to when you have vision, determination, and an endless supply of expendable labor.

Overview

- Motivation
- Spring Embedder
- Variations

Problem: Finding General Layouts

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that are

- robust
- flexible
- easy to understand.

Solution: Physical Analogies

in physics:

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- stable configurations (instances) are those with minimal energie levels

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for layout algorithms:

- nodes correspond to (physical) objects
- edges correspond to interactions
- (good?) layouts correspond to stable configurations

Spring-Embedder

spring model:

- node are small balls with electrical charge (same sign)
- edges are springs with given constant (ideal length)
- nodes repel each others (repulsive force)
- edges cannot be arbitrary long (attractive force)

Spring-Embedder (2)

- coordinates p_v for each node v
- lengths l_e for each edge e
- $$f_{\text{rep}}(u,v) := \frac{c_1}{\|p_v - p_u\|^2} \cdot \overrightarrow{p_u p_v}$$
- $$f_{\text{spring}}(u,v) := c_2 \cdot \log \frac{\|p_u - p_v\|}{l_e} \cdot \overrightarrow{p_u p_v} \qquad \text{for } (u,v) = e \in E$$

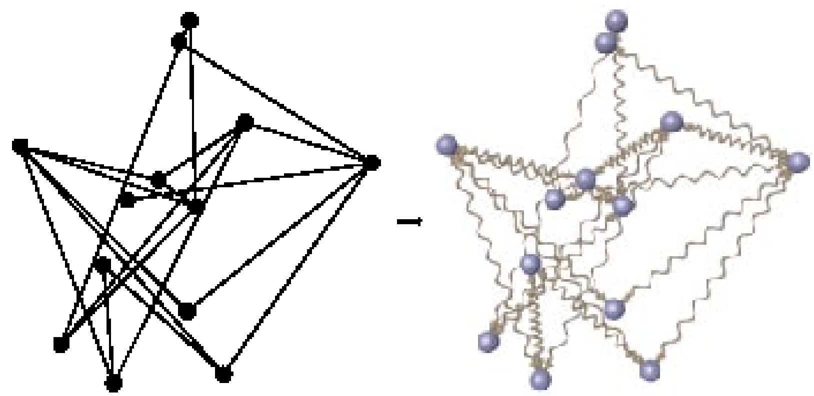
Spring-Embedder (3)

algorithmic approach:

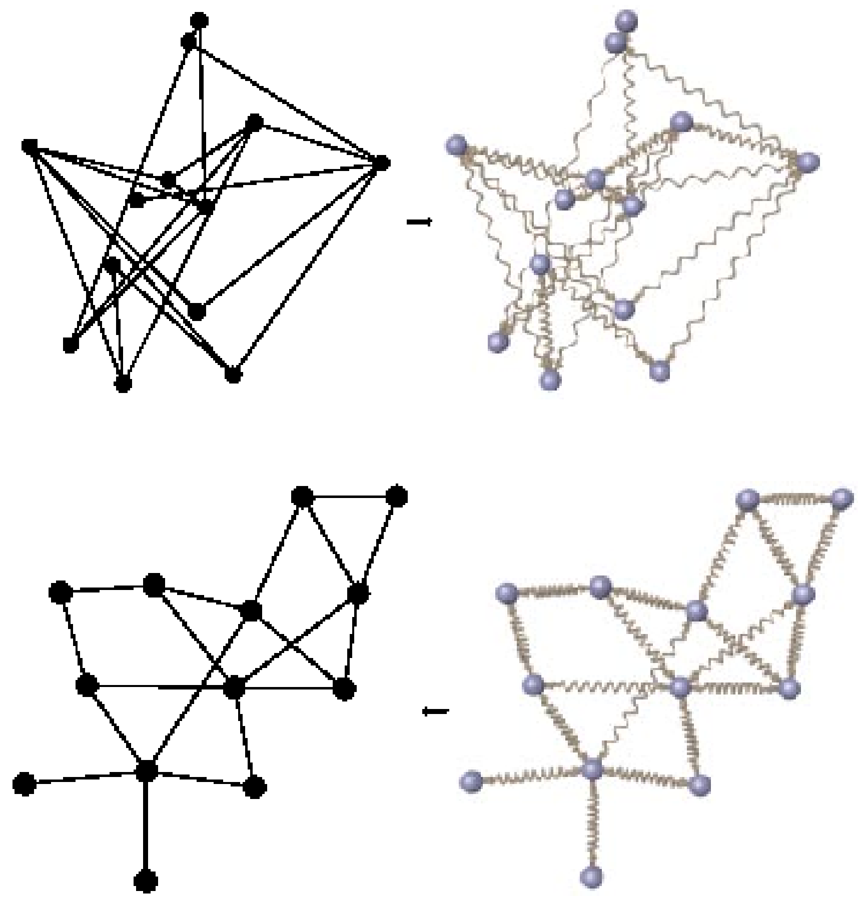
- choose a random placement (for each node)
- iterate
  - calculate for each node v its force vector $F(v)$
  - move each node v according to its force vector

$$p_v \leftarrow p_v + \delta \cdot F(v)$$

Spring-Embedder (4)



Spring-Embedder (4)



Variation [Fruchtermann, Reingold]

- repulsive force:

$$f_{\mathsf{rep}}(u,v) := \frac{l_{uv}^2}{\|p_u - p_v\|} \cdot \overrightarrow{p_u p_v}$$

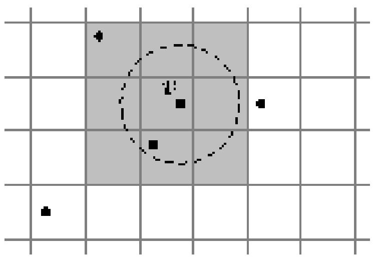
- attractive force:

$$f_{\mathsf{attr}}(u,v) := \frac{\|p_u - p_v\|^2}{l_e} \cdot \overrightarrow{p_v p_u} \qquad \text{for } (u,v) = e \in E$$

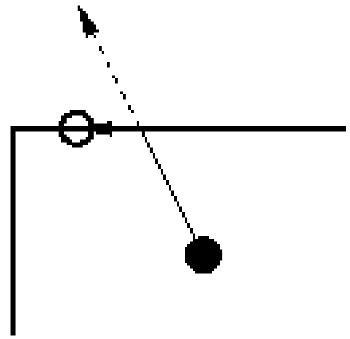
advantage: 'spring' force is super linear in l (better convergence)

Variations

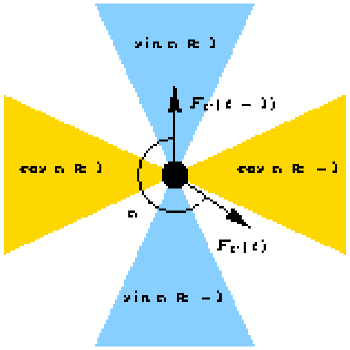
grid



clipping



rotation



- time dependency
- gravitational forces
- approximation of forces
- multi-level approaches