NetworkX Graph Visualization

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- Math Representation
- Problem statement
- Hand Drawing
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Math Representation

$$
\begin{aligned}
G &= \langle V, E \rangle \\
V &= \{1 \ldots 9\} \\
E &= \{ \\
&\quad \{1,2\}, \{1,3\}, \{2,4\}, \{2,5\}, \{2,6\}, \\
&\quad \{3,5\}, \{3,6\}, \{4,7\}, \{4,8\}, \{5,7\}, \\
&\quad \{5,8\}, \{6,7\}, \{6,8\}, \{7,9\}, \{8,9\} \\
\}
\end{aligned}
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\end{aligned}
$$

TERRIBLE!!!

Problem statement

Input

Graph $G = \langle V, E \rangle$

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Output

Clear and readable drawing of G (we focus on straight-line edges).

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- short and similar in length edges

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- adjacent vertices close
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- as few crossings as possible

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Clear and readable drawing of G (we focus on straight-line edges).

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- adjacent vertices close
- non-adjacent vertices distant
- short and similar in length edges
- as few crossings as possible
- nodes distributed evenly

Problem statement

Input

Graph $G = \langle V, E \rangle$

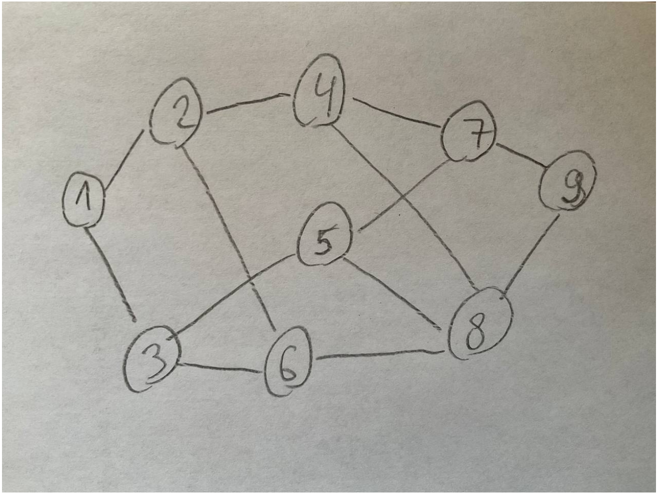
Output

Clear and readable drawing of G (we focus on straight-line edges).

Criteria

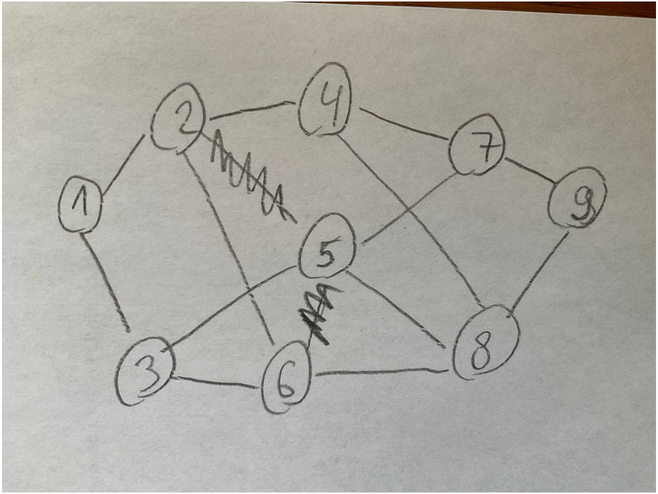
- adjacent vertices close
- non-adjacent vertices distant
- short and similar in length edges
- as few crossings as possible
- nodes distributed evenly
- clusters together

Hand Drawing

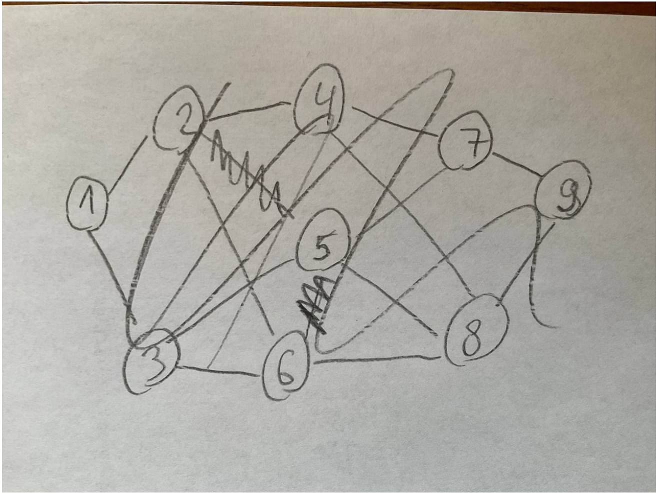


Hand Drawing

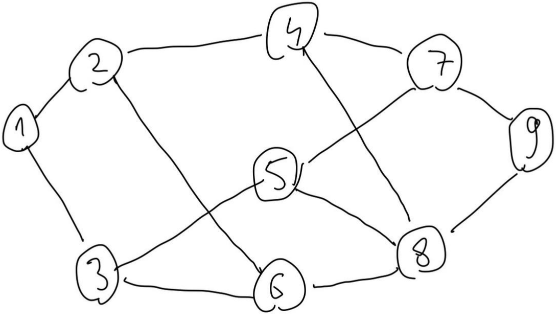
Mistake



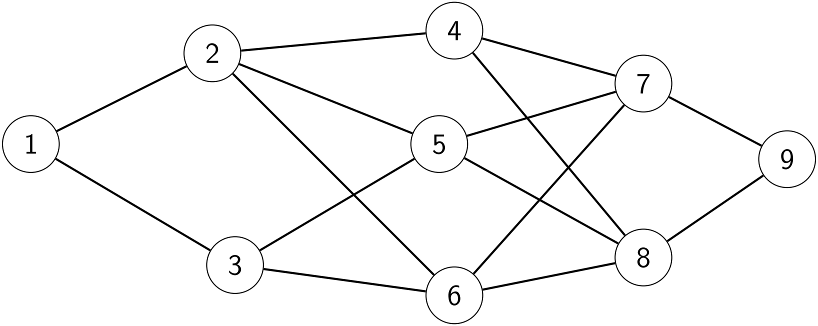
Hand Drawing
Mistake



Tablet Drawing

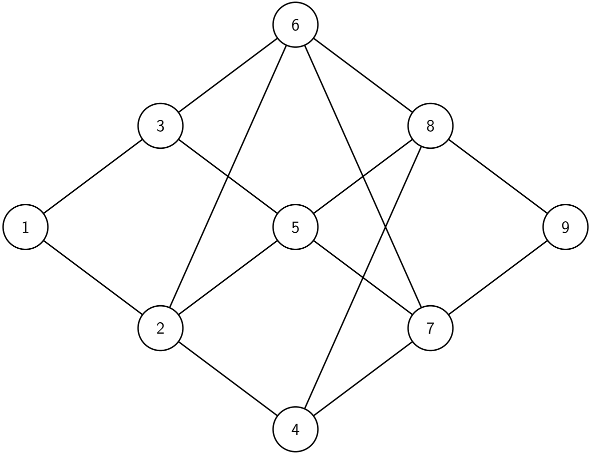


Tikz



```
\node[e4c node] (1) at (0.00, 0.89) {1};
\node[e4c node] (2) at (0.24, 1.01) {2};
\node[e4c node] (3) at (0.27, 0.73) {3};
\node[e4c node] (4) at (0.56, 1.04) {4};
\node[e4c node] (5) at (0.54, 0.89) {5};
\node[e4c node] (8) at (0.81, 0.74) {8};
\node[e4c node] (7) at (0.81, 0.97) {7};
\node[e4c node] (9) at (1.00, 0.87) {9};
\node[e4c node] (6) at (0.56, 0.69) {6};
\path[draw,thick]
    (1) edge[e4c edge]  (2)
    (1) edge[e4c edge]  (3)
    (2) edge[e4c edge]  (4)
    ...
```

NetworkX



```
G = nx.Graph()
G.add_edges_from([
    (1, 2), (1, 3), (2, 4), (2, 5), (2, 6),
    (3, 5), (3, 6), (4, 7), (4, 8), (5, 7),
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pos = nx.bfs_layout(G, 1)
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Materials for presentation

GitHub - `https://github.com/Rentib/graph-visualization`
Google Colab - `http://tiny.cc/networkx`

How is it done?

- Overview
- Bipartite
- BFS
- ForceAtlas2
- Force-directed drawings

Overview

Algorithms

NetworkX provides several algorithms for graph visualization, focusing on different layout strategies to represent nodes and edges effectively.

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Support

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- Image, PDF, SVG, and other formats

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- Image, PDF, SVG, and other formats
- Interactive visualization using matplotlib

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Eye candy

- Nodes, edges, labels, and other graph elements
- Custom positioning
- Flexible styling

Support

- Image, PDF, SVG, and other formats
- Interactive visualization using matplotlib
- **LaTeX** (Tikz, PGF)

Bipartite

Algorithm

Do 2-coloring and group nodes by color.

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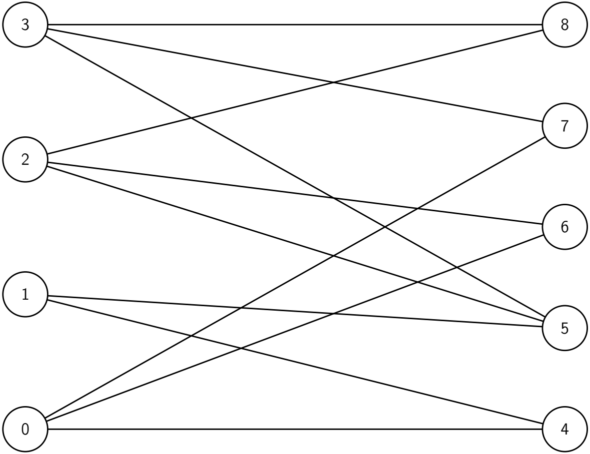

BFS

Algorithm

Run breadth first search and group nodes by depth.

Algorithm

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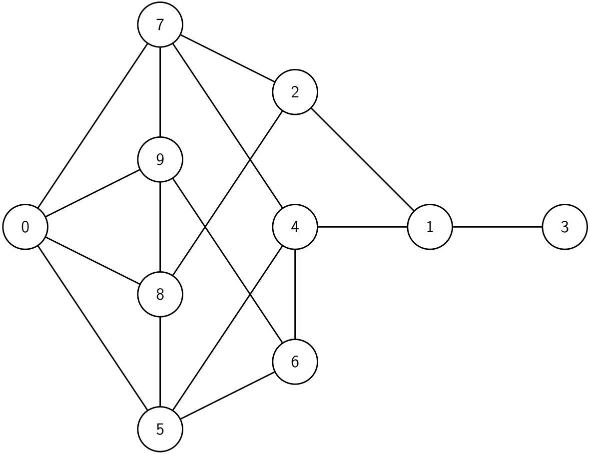

ForceAtlas2

Algorithm

Out of scope for this presentation, but worth mentioning as the results are fantastic.

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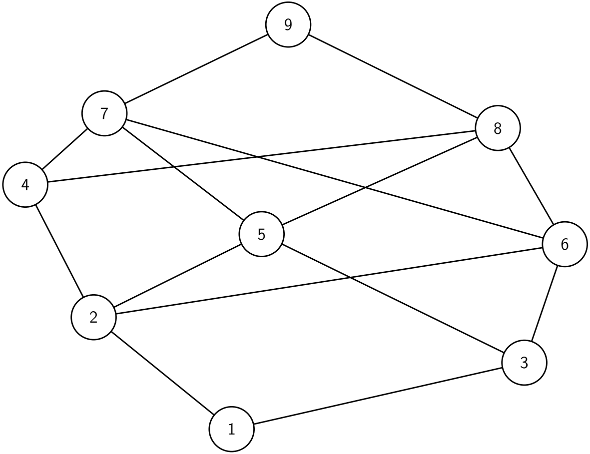

Force-directed drawings

Analogy to physics

Edges are *springs*, vertices are *repelling objects*.

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function ForceDirected($G = \langle V, E \rangle, p = (p_v)_{v \in V}, \varepsilon > 0, K \in \mathbb{N}$)

return p

end function

Force-directed drawings

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Edges are *springs*, vertices are *repelling objects*.

function ForceDirected($G = \langle V, E \rangle, p = (p_v)_{v \in V}, \varepsilon > 0, K \in \mathbb{N}$)
  $l \leftarrow 1$
  while $l < K \wedge \max_{v \in V} \|F_v(t)\| > \varepsilon$ **do**
    $l \leftarrow l + 1$
  end while
  return p
end function

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    for all $u \in V$ **do**
      $F_u(t) \leftarrow \sum_{v \in V} f_{\text{rep}}(u, v) + \sum_{uv \in E} f_{\text{attr}}(u, v)$
    end for
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function ForceDirected($G = \langle V, E\rangle, p = (p_v)_{v \in V}, \varepsilon > 0, K \in \mathbb{N}$)
  $I \leftarrow 1$
  while $I < K \wedge \max_{v \in V} \|F_v(t)\| > \varepsilon$ **do**
    for all $u \in V$ **do**
      $F_u(t) \leftarrow \sum_{v \in V} f_{\mathbf{rep}}(u, v) + \sum_{uv \in E} f_{\mathbf{attr}}(u, v)$
    end for
    for all $u \in V$ **do**
      $p_u \leftarrow p_u + \delta(t) \cdot F_u(t)$
    end for
    $I \leftarrow I + 1$
  end while
  return p
end function

Conclusion

NetworkX is GREAT!!!