University of Stuttgart
Visualization Research Center (VISUS)

# Comparative Evaluation of Bipartite, Node-Link, and Matrix-Based Network Representations

Moataz Abdelaal, Nathan D Schiele, Katrin Angerbauer, Kuno Kurzhals, Michael Sedlmair, Daniel Weiskopf

IntCDC CLUSTER OF EXCELLENCE
SFB-TRR 161 Quantitative Methods for Visual Computing
VISUS Visualization Research Center University of Stuttgart

# Network Visualization

Node-link Diagram

Adjacency Matrix

Adjacency Matrix

# Network Visualization

Node-link Diagram

Purchase ’98

Ghoniem et al. ’04
Keller et al. ’06
Henry and Fekete ’07

Alper et al. Beradi et al. ’13
Hlawatsch et al. ’14

Yoghourdjian et al. Okoe et al. ’18
Ren et al. ’19
Nobre et al. ’20
Jin et al. ’21


Overview
Tasks
Detailed
Purchase ’98
Ghoniem et al. ’04
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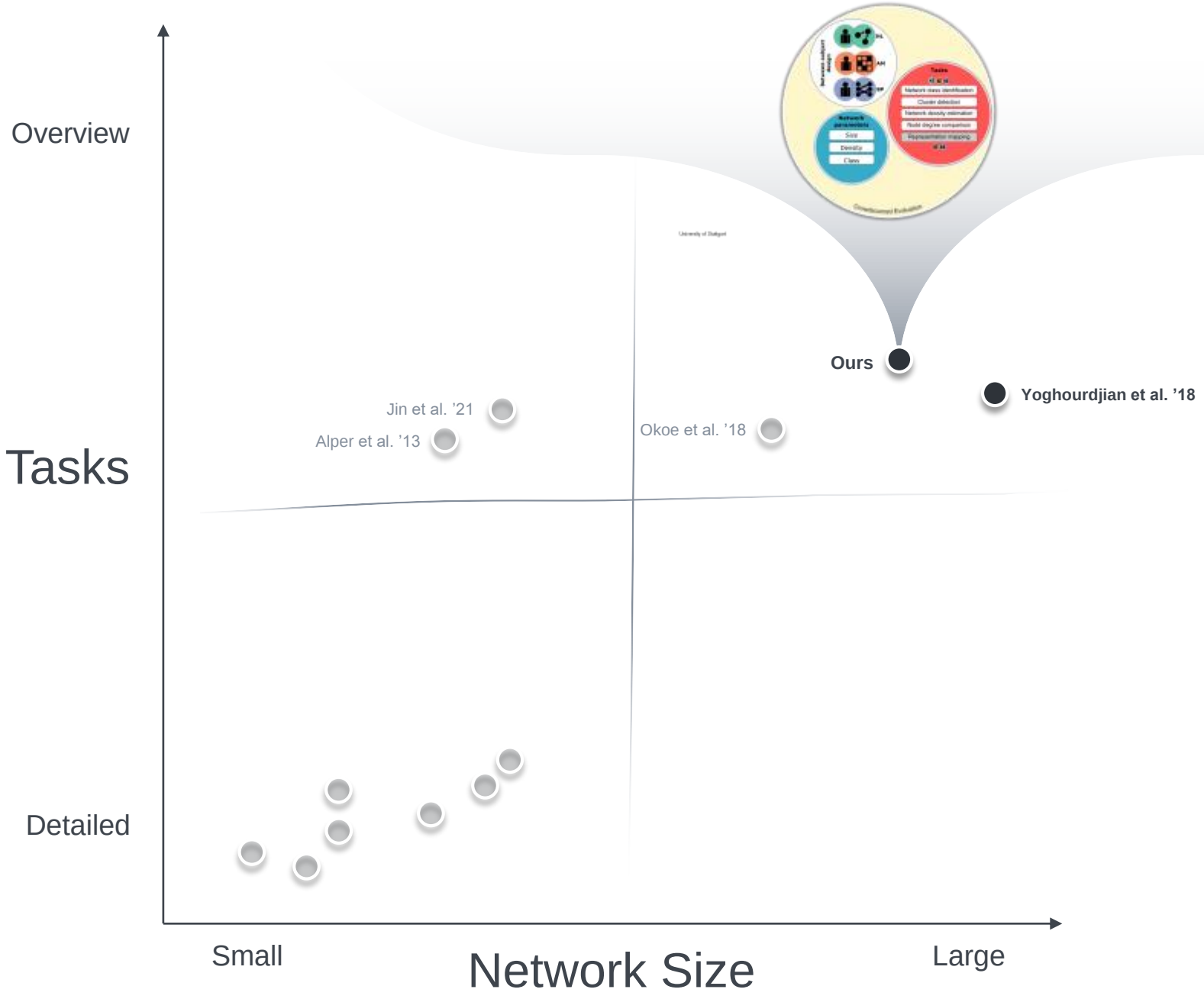
Alper et al. ’13
Okoe et al. ’18
Ours
Yoghourdjian et al. ’18
Small
Network Size
Large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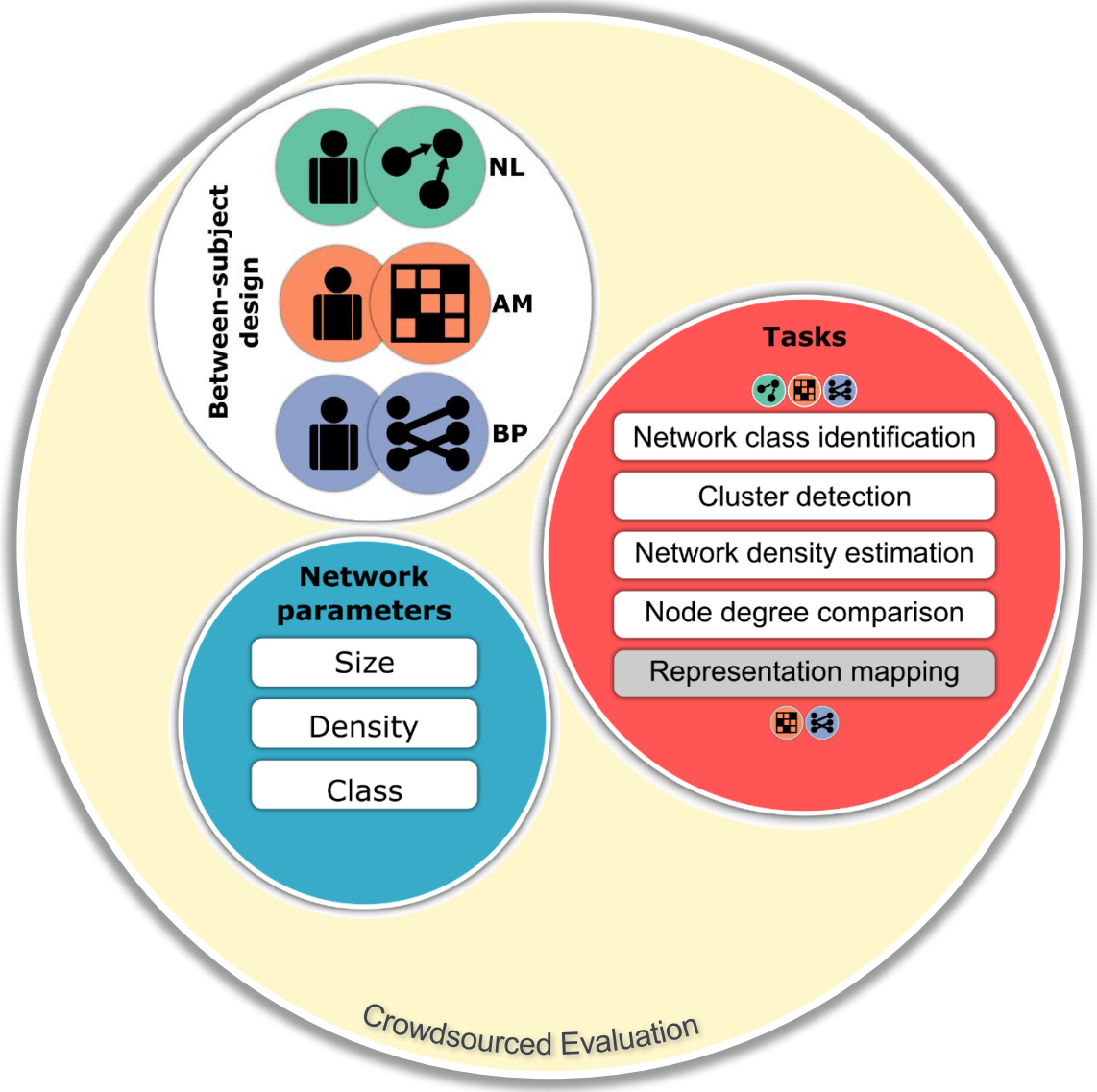
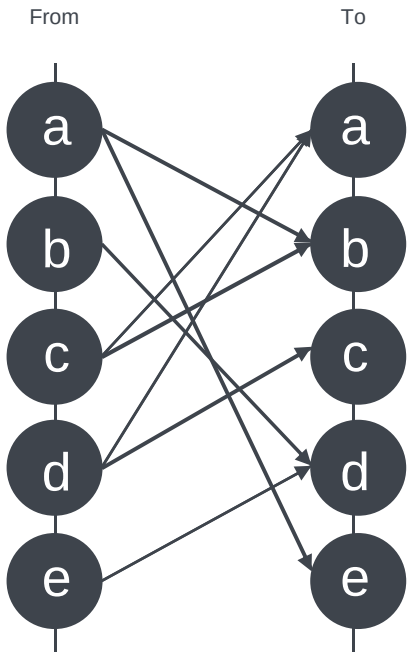
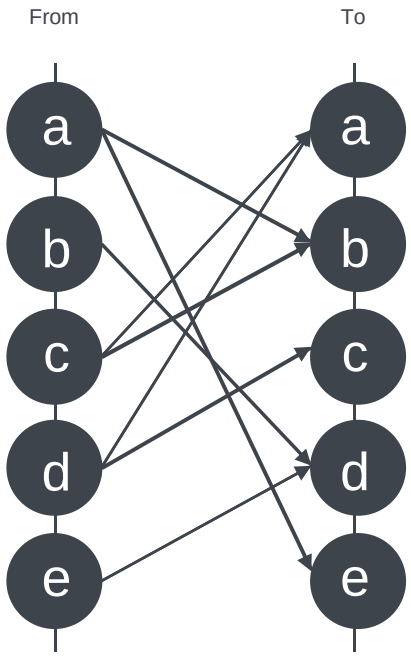

Between-subject design
NL
AM
BP
Tasks
Network class identification
Cluster detection
Network density estimation
Node degree comparison
Representation mapping
Network parameters
Size
Density
Class
Crowdsourced Evaluation

# Bipartite Layout




Bipartite Layout (BP)

# NL vs. AM vs. BP

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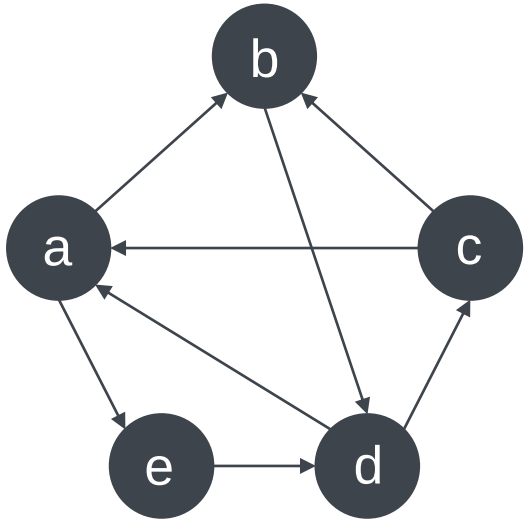
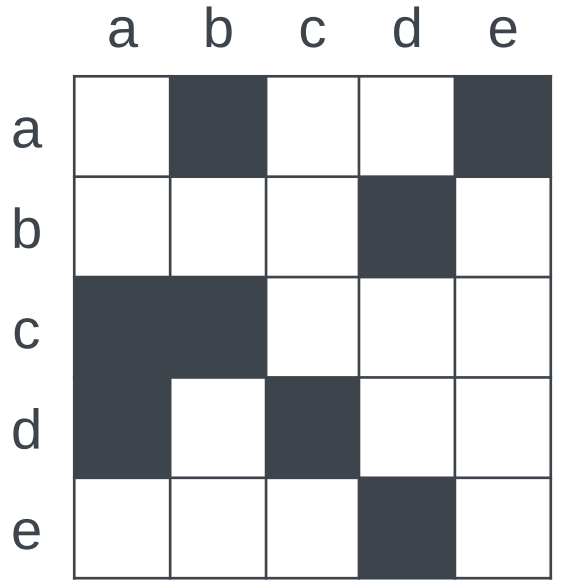



Node-link Diagram (NL)

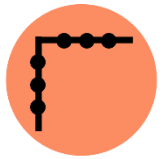



Adjacency Matrix (AM)

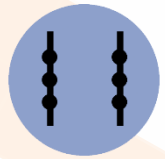
# NL vs. AM vs. BP

Node Encoding

x,y

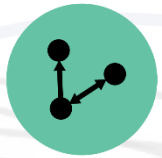


Orthogonal Axes



Parallel Axes

Edge Encoding

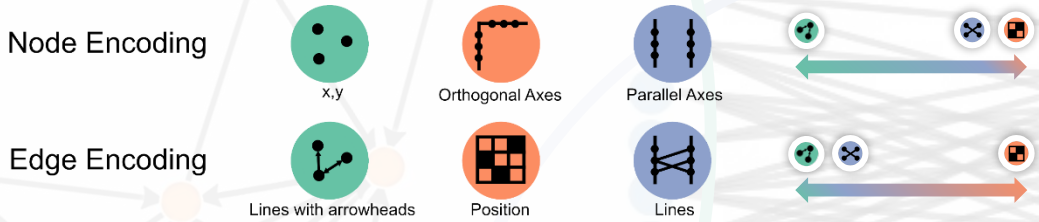


Lines with arrowheads

Position

Lines

# NL vs. AM vs. BP


Node Encoding
x,y
Orthogonal Axes
Parallel Axes
Edge Encoding
Lines with arrowheads
Position
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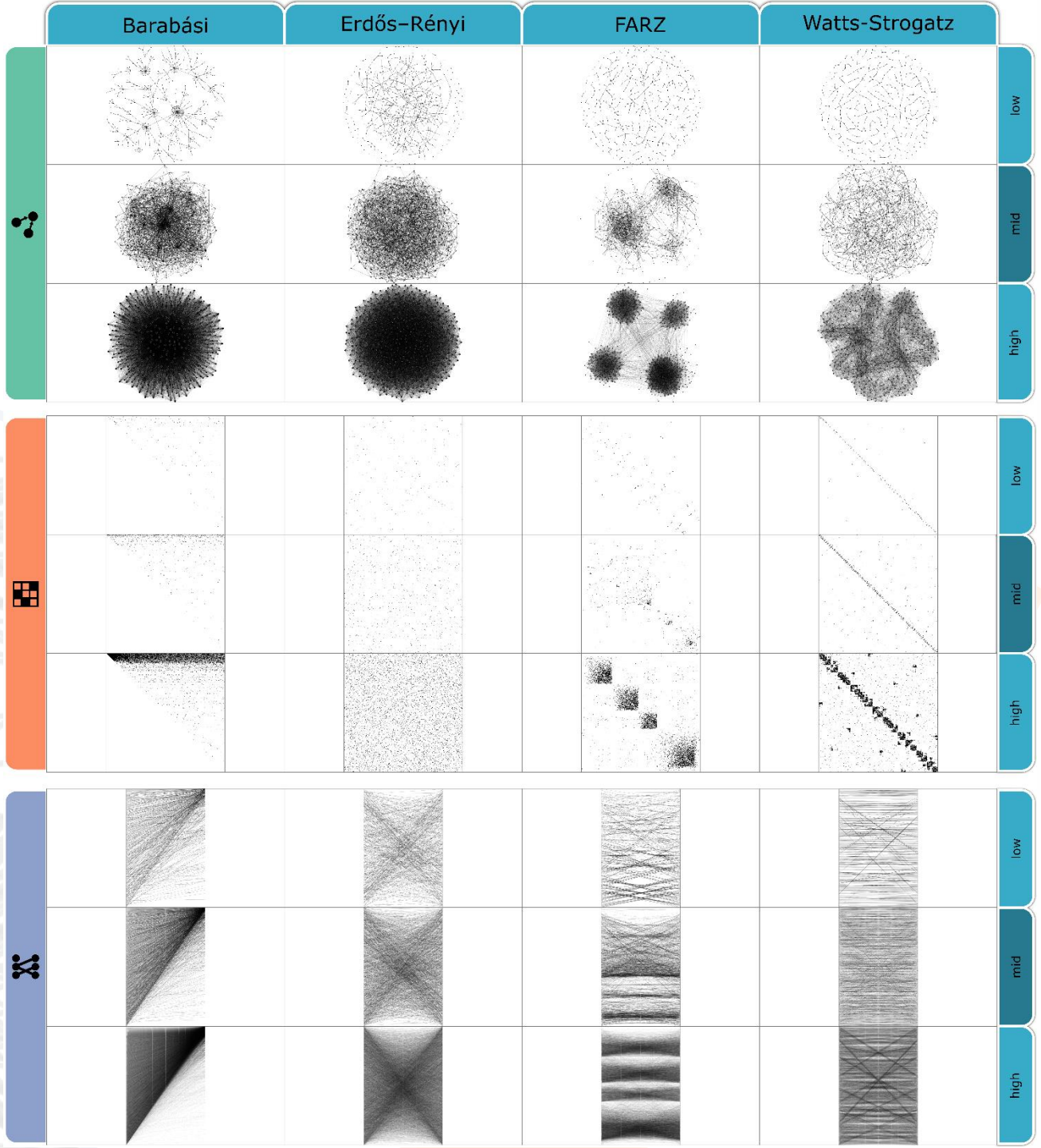
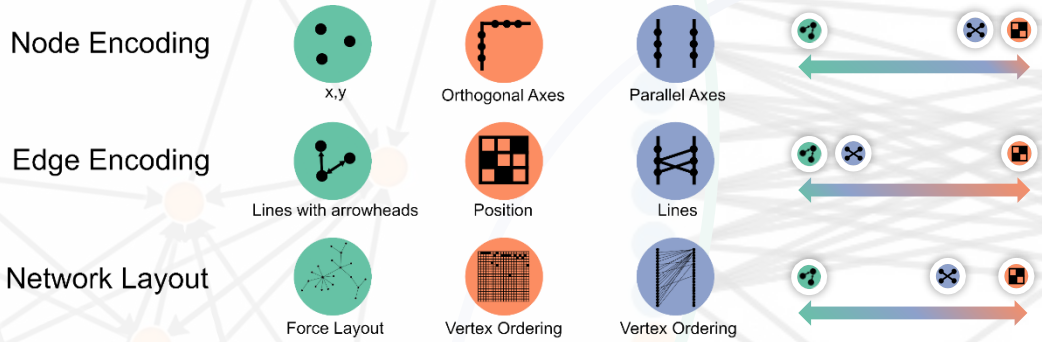

Barabási
Erdős–Rényi
FARZ
Watts-Strogatz
low
mid
high
low
mid
high
low
mid
high

# NL vs. AM vs. BP


Node Encoding
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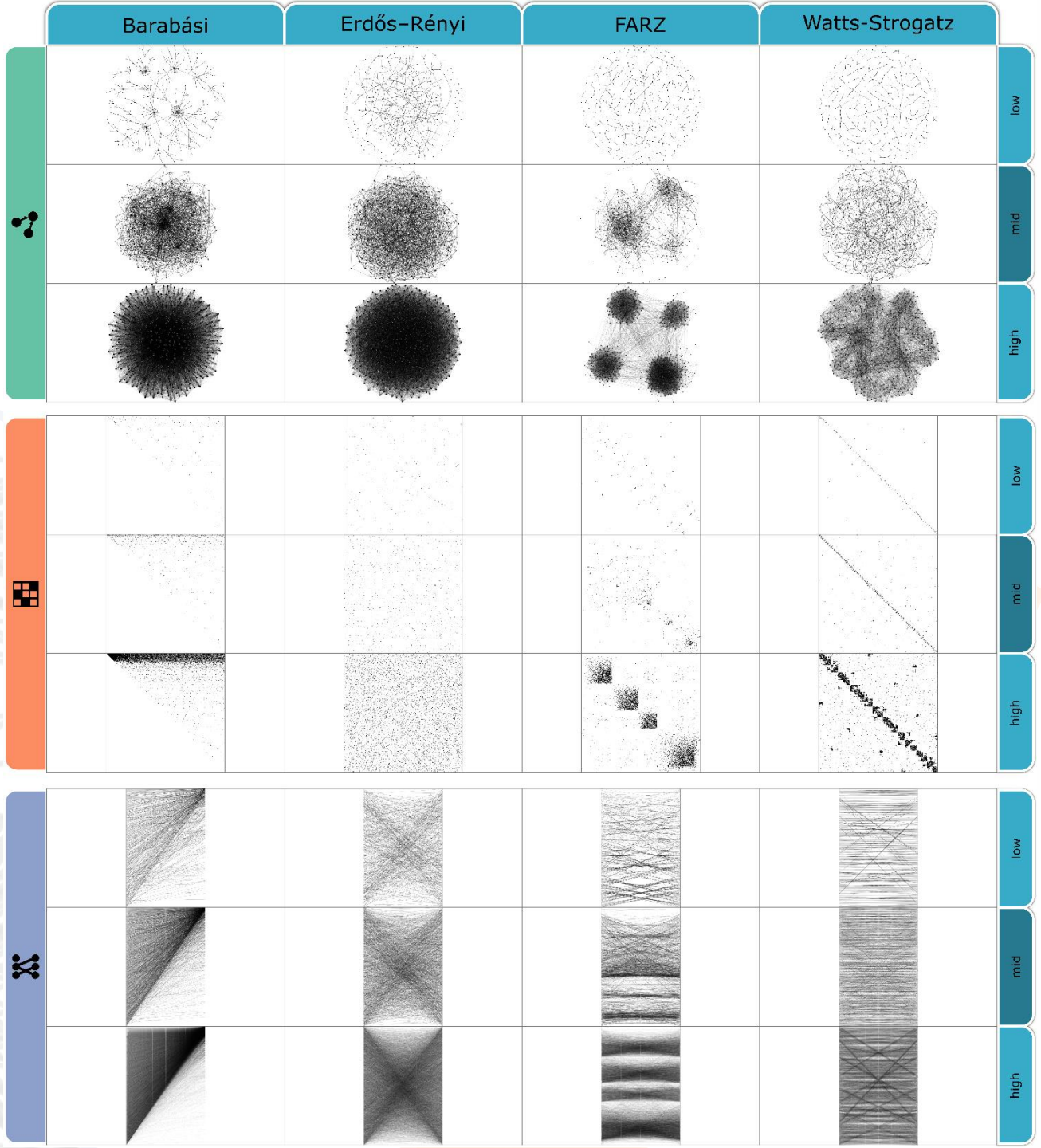
Edge Encoding
Lines with arrowheads
Position
Lines
Network Layout
Force Layout
Vertex Ordering
Vertex Ordering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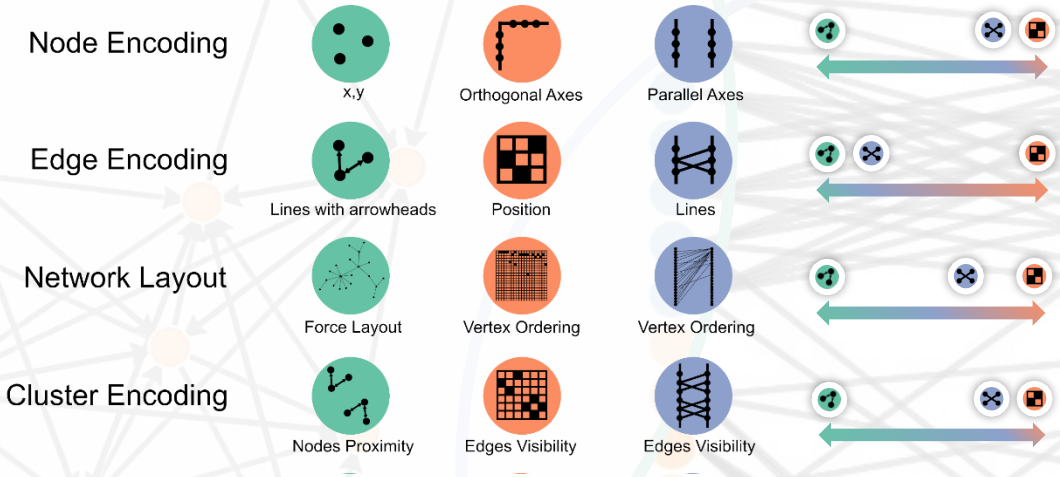
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Cluster Encoding
Nodes Proximity
Edges Visibility
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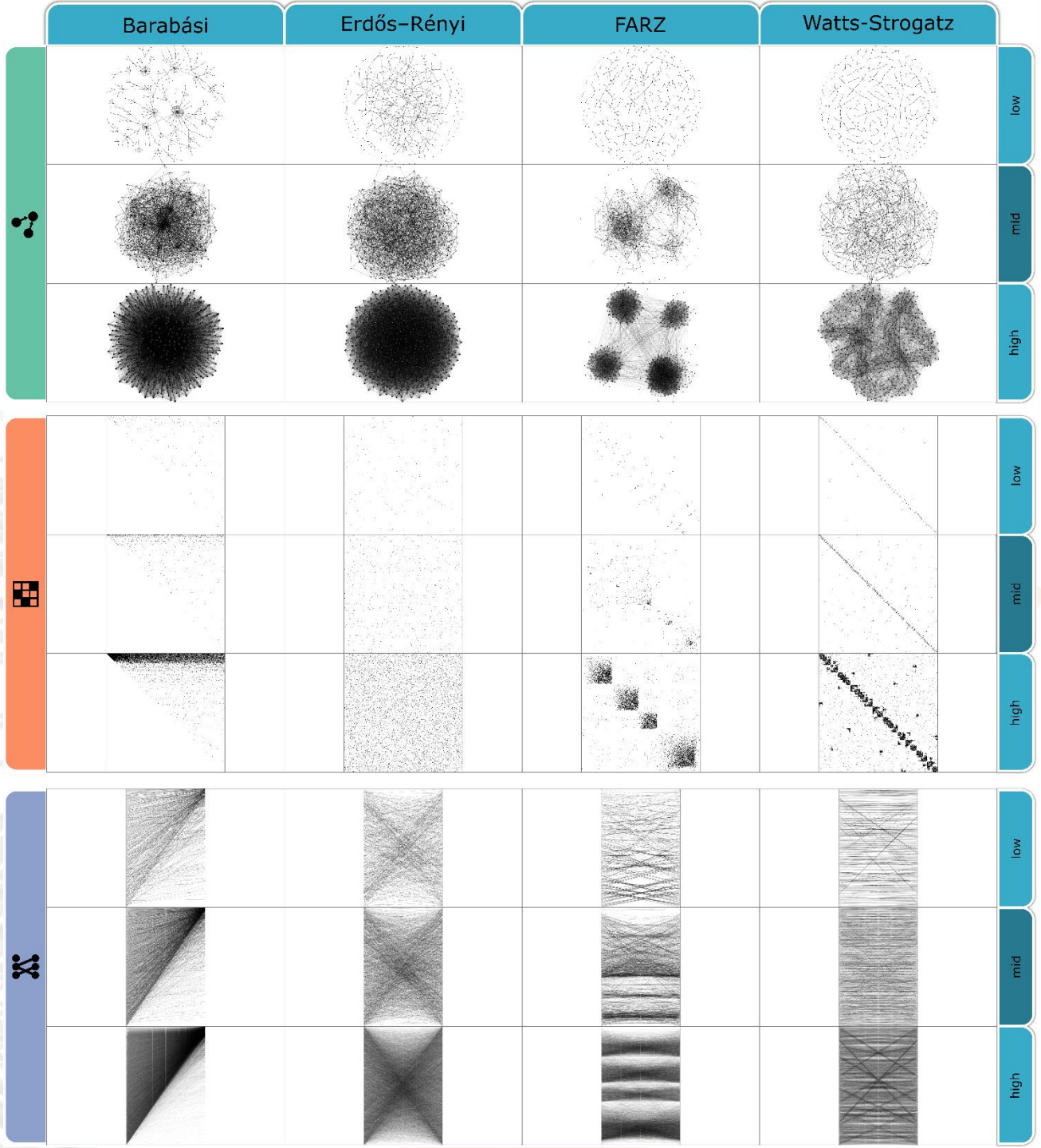
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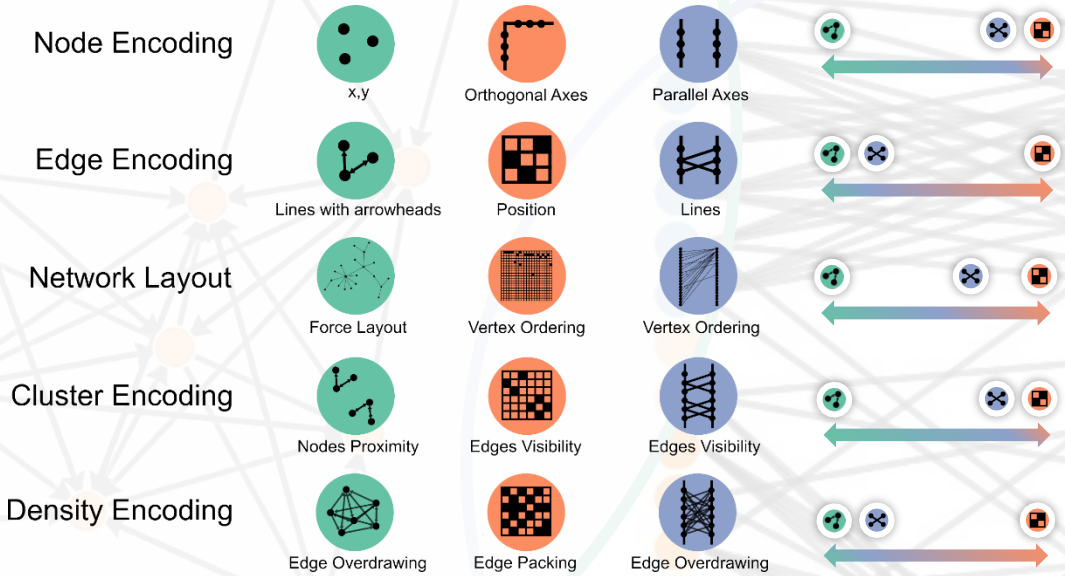
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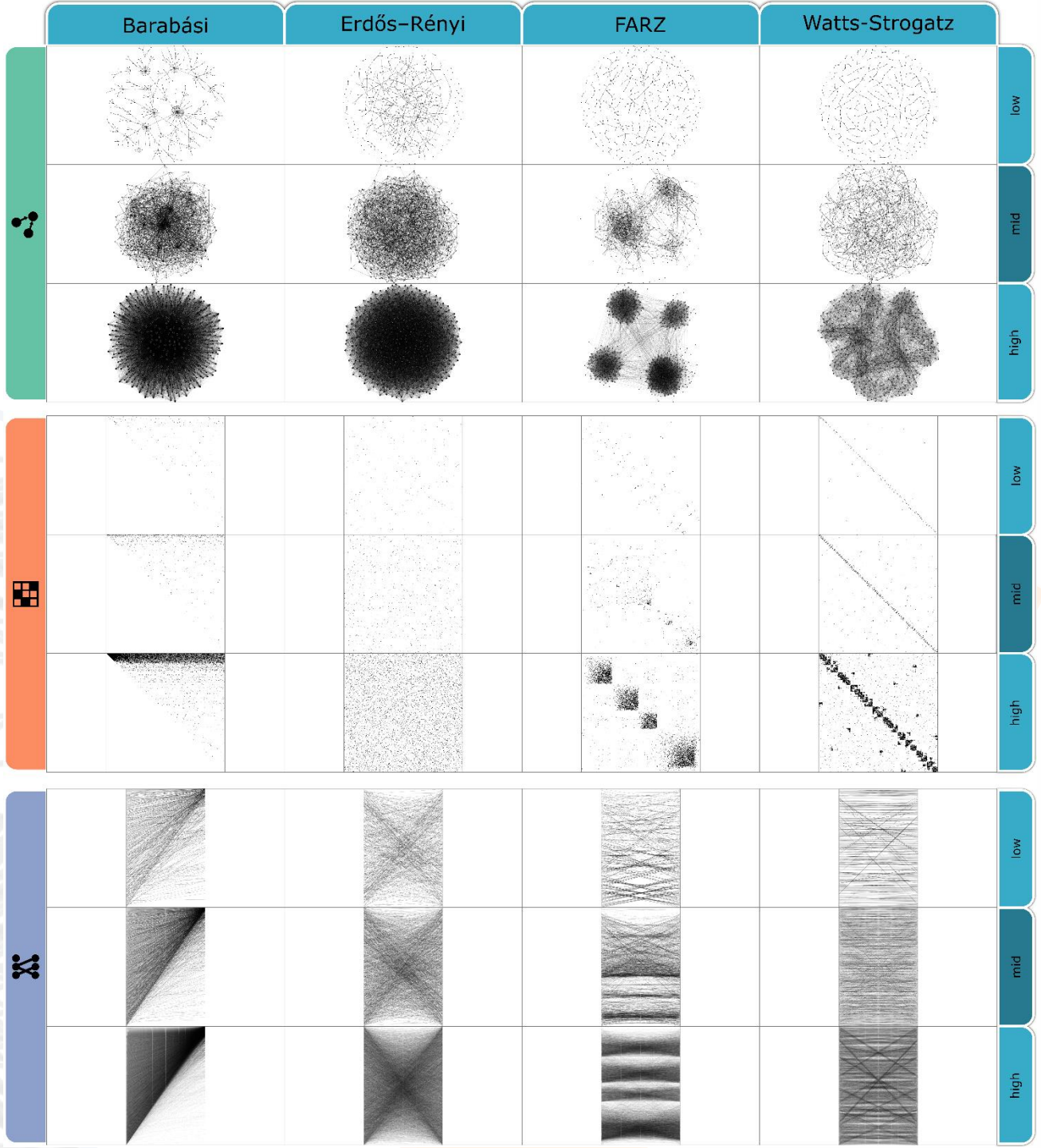
Edges Visibility
Density Encoding
Edge Overdrawing
Edge Packing
Edge Overdrawing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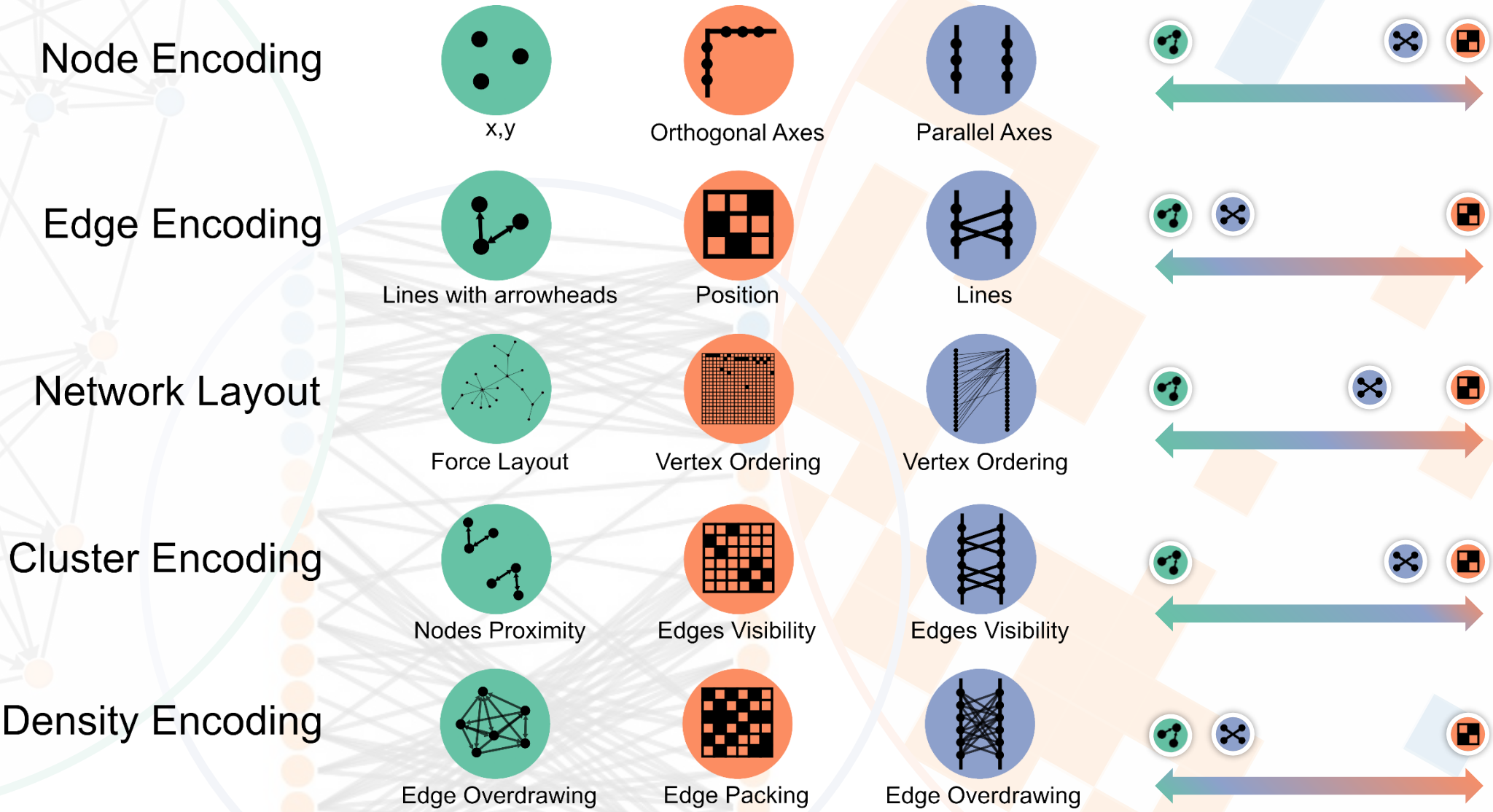
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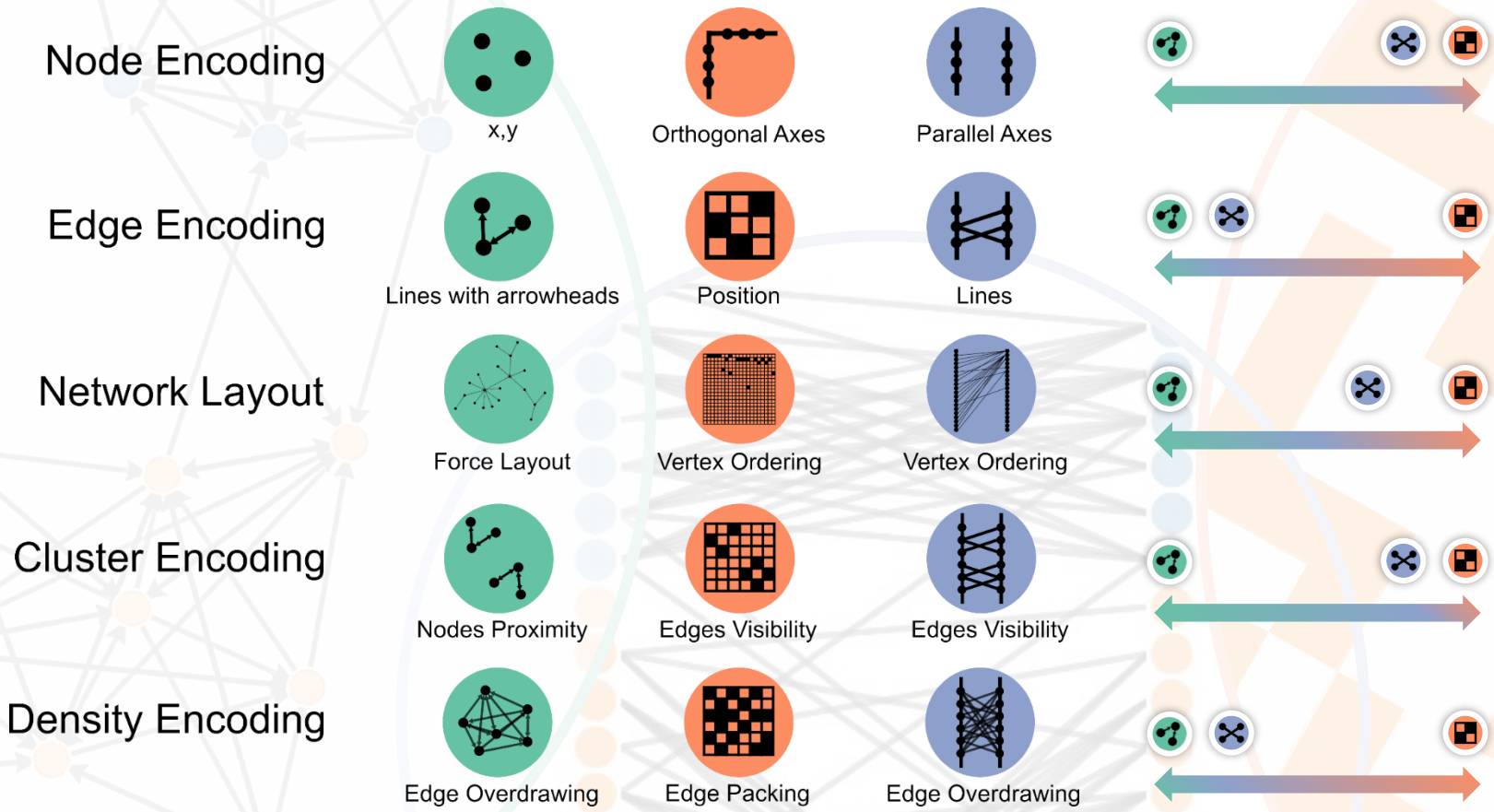


# Tasks

**T4: Node In-degree Vs. Out-degree**
$H_5$: AM is more accurate than NL and BP for T4

**T5: Representation Mapping**
$H_5$: BP is more accurate than AM for T5

**T1: Network Class Identification**
$H_1$: AM and BP are more accurate than NL for T1

**T2: Cluster Detection**
$H_2$: NL and BP are more accurate than AM for T2.

**T3: Network Density Estimation**
$H_3(0)$: There is no statistical significance in accuracy for T3

# Study: Design & Data

- Between-subject ($n = 150$) recruited on mTurk
- We measure task accuracy and completion time

- Synthetic data
- $n_{nodes} = 500$ for T1 – T3
- $n_{nodes} = 50$ for T4
- $n_{nodes} = 20$ for T5

- Hierarchical Clustering for ordering the vertices
- $d3 - force$ for laying out NL

# Results

**T1: Network Class Identification**
$H_1$: AM and BP are more accurate than NL for T1

**T2: Cluster Detection**
$H_2$: NL and BP are more accurate than AM for T2.

**T3: Network Density Estimation**
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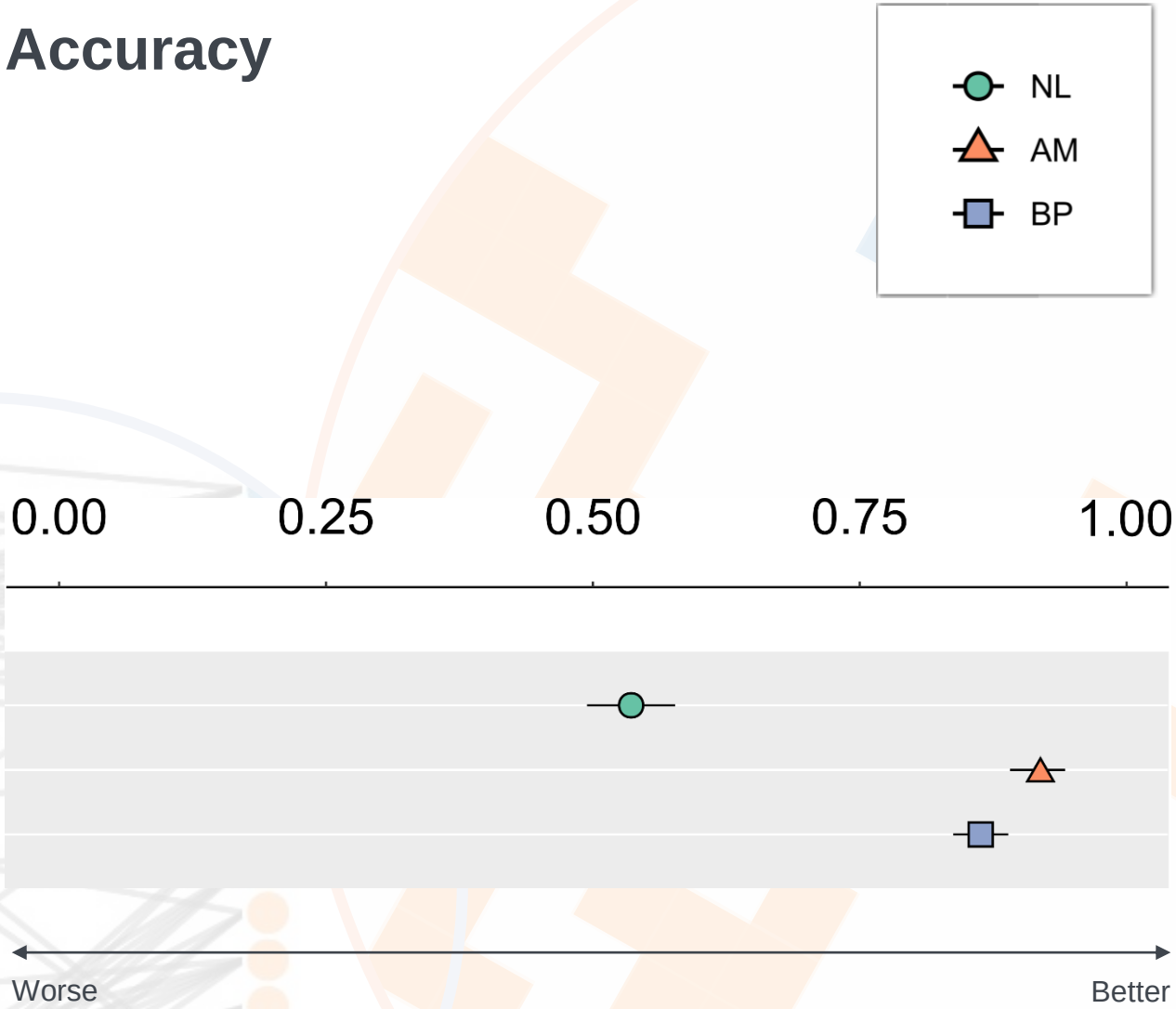
**T4: Node In-degree Vs. Out-degree**
$H_5$: AM is more accurate than NL and BP for T4

**T5: Representation Mapping**
$H_5$: BP is more accurate than AM for T5

## Accuracy



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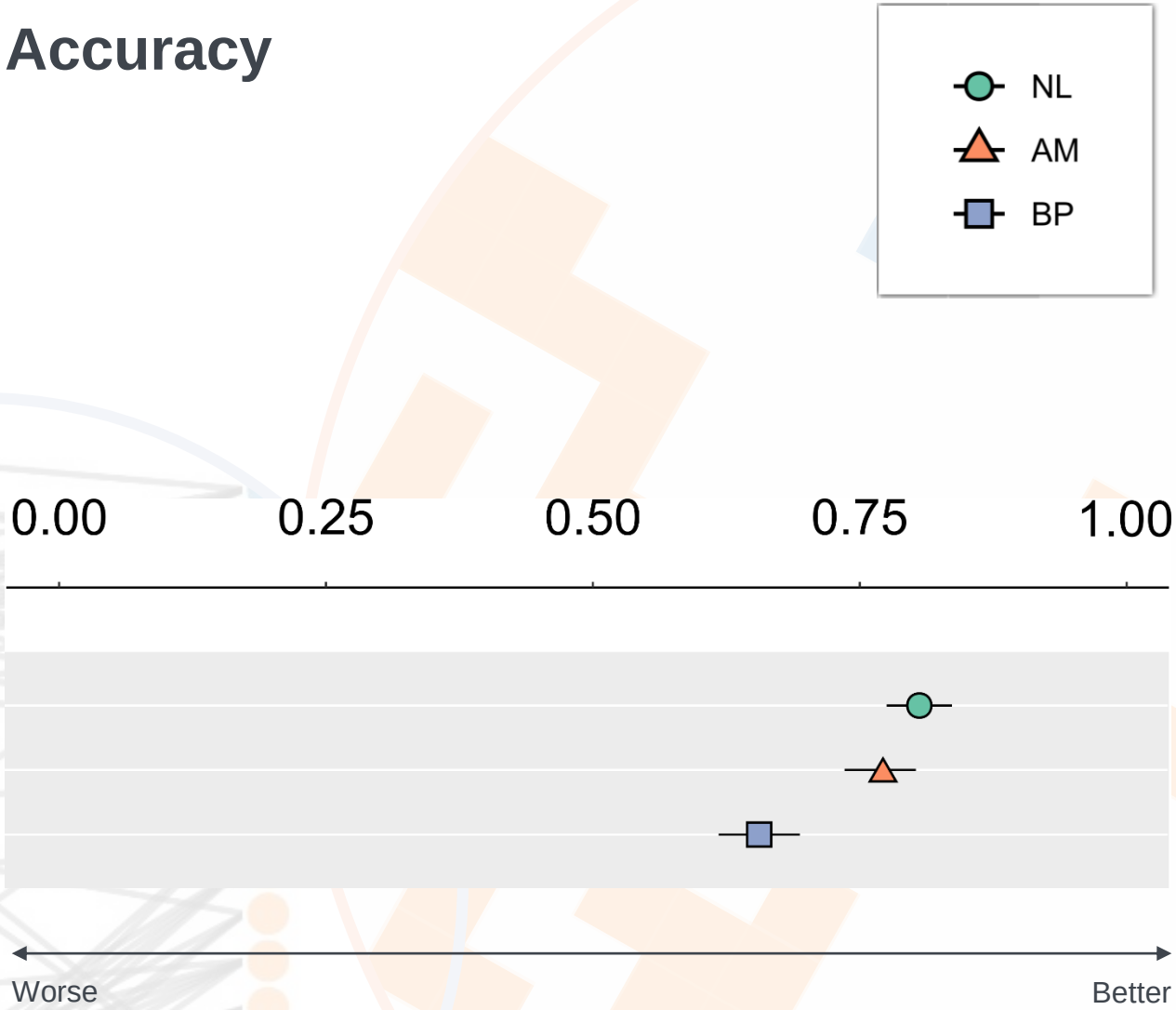

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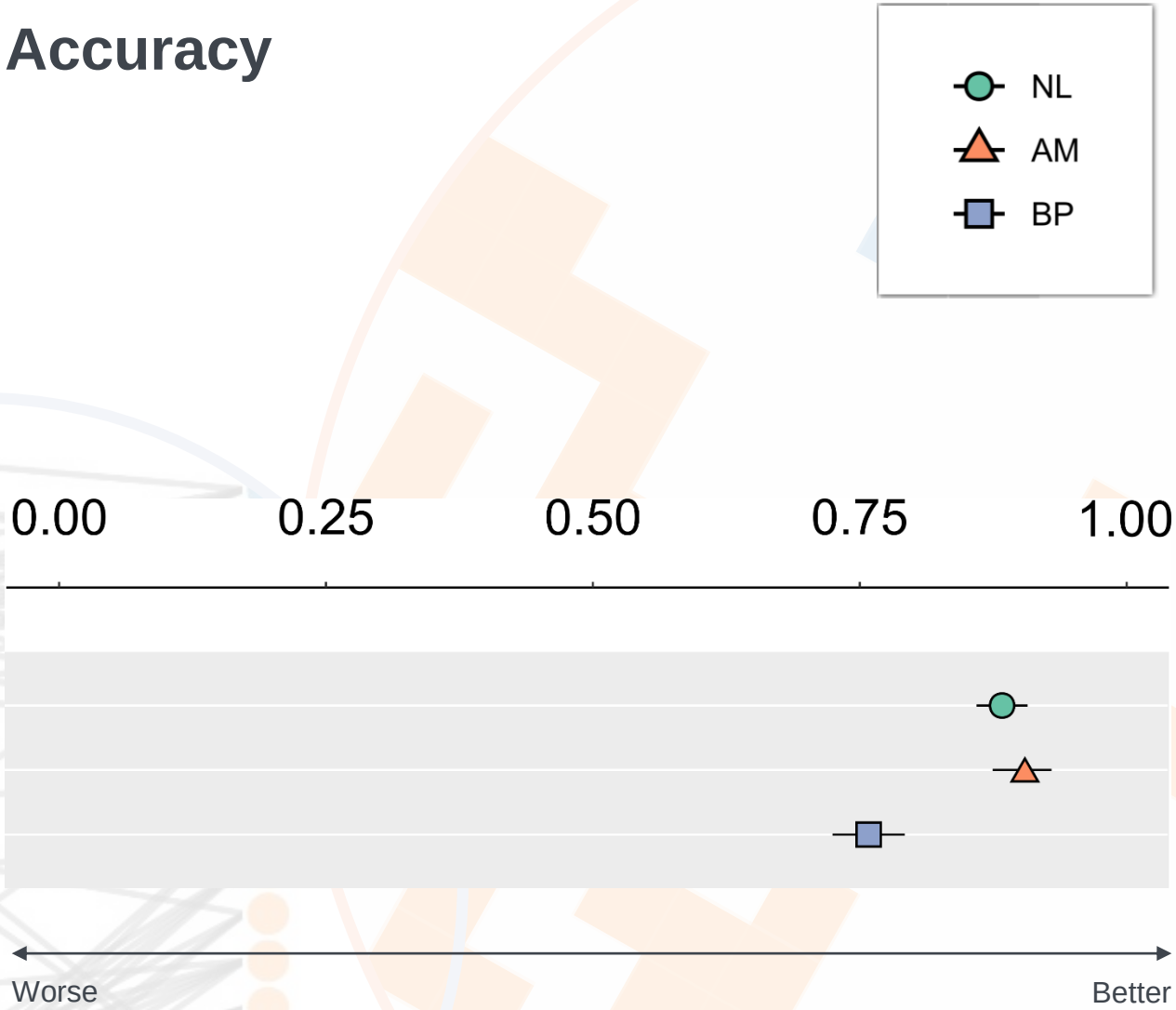


*Please see the paper for more results*

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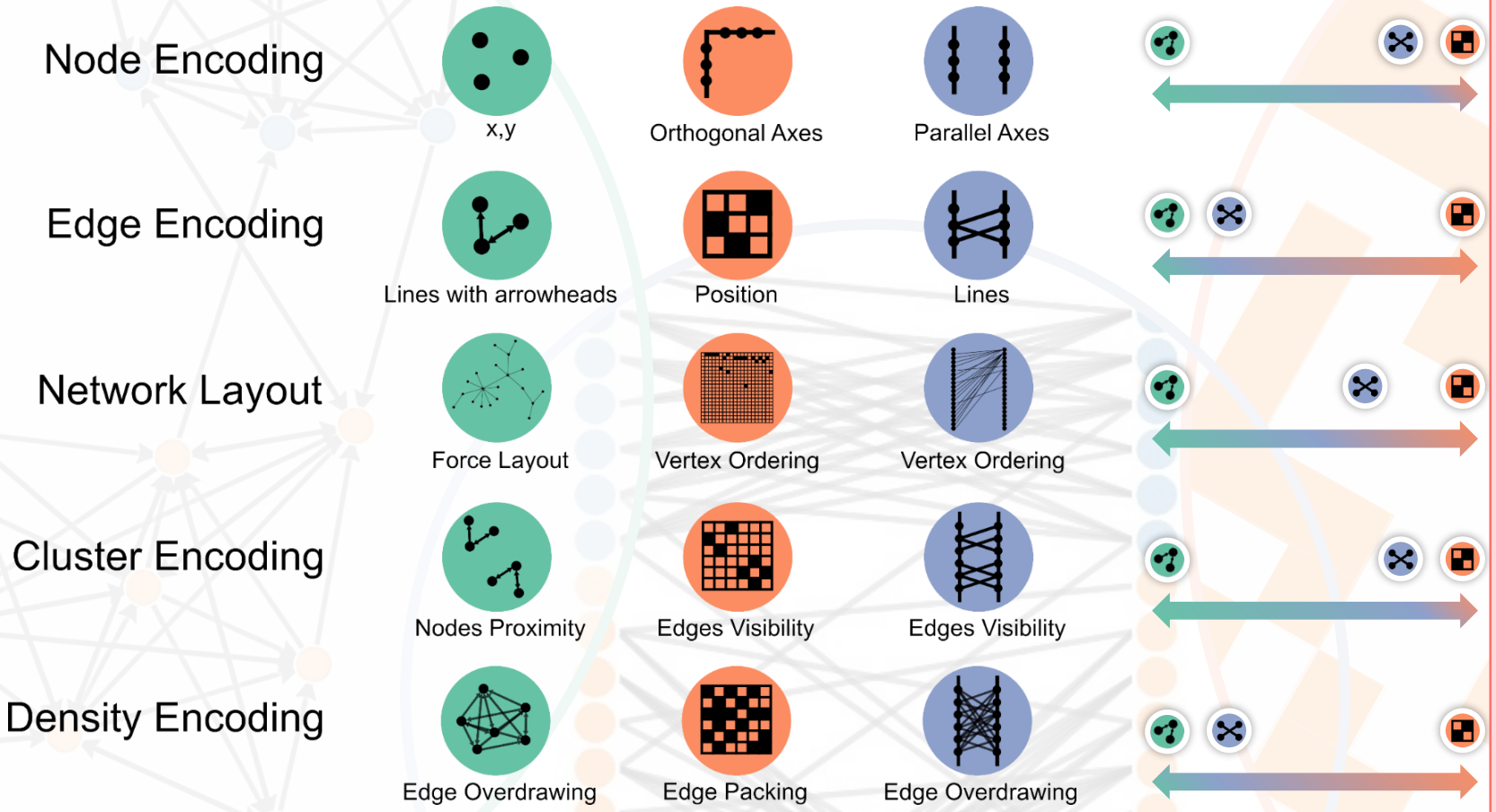


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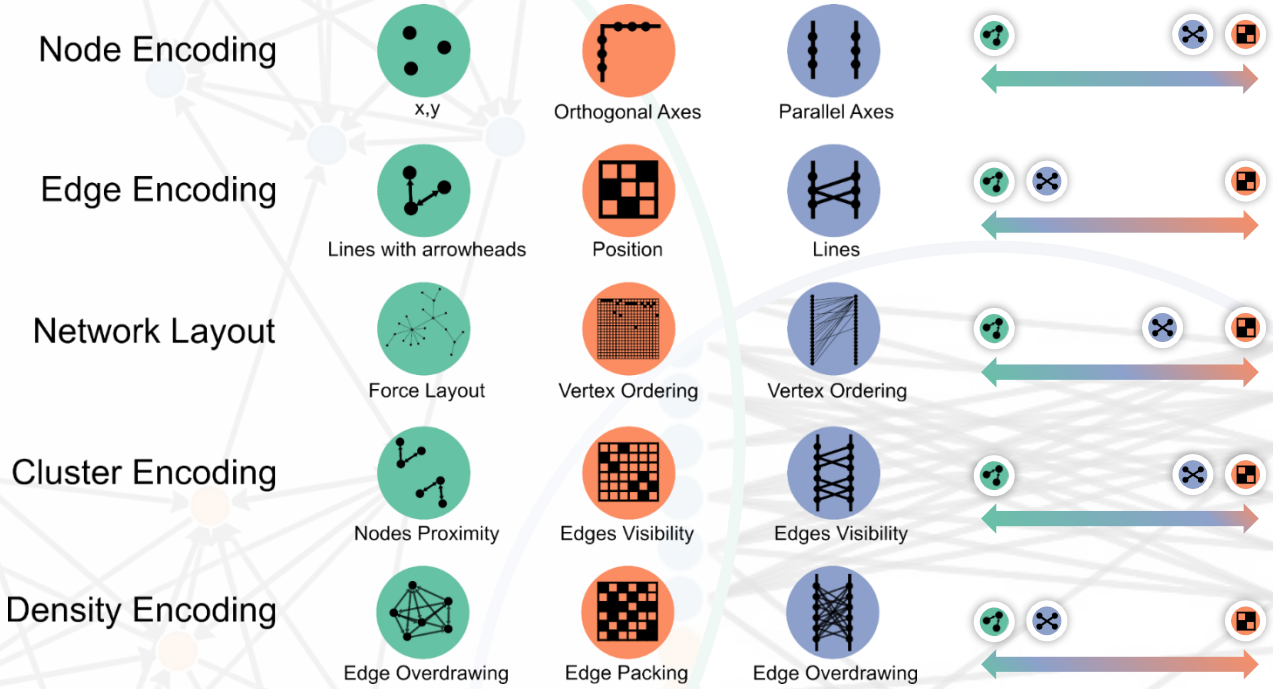


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# Takeaways

**Vertex Ordering > Force Layout**

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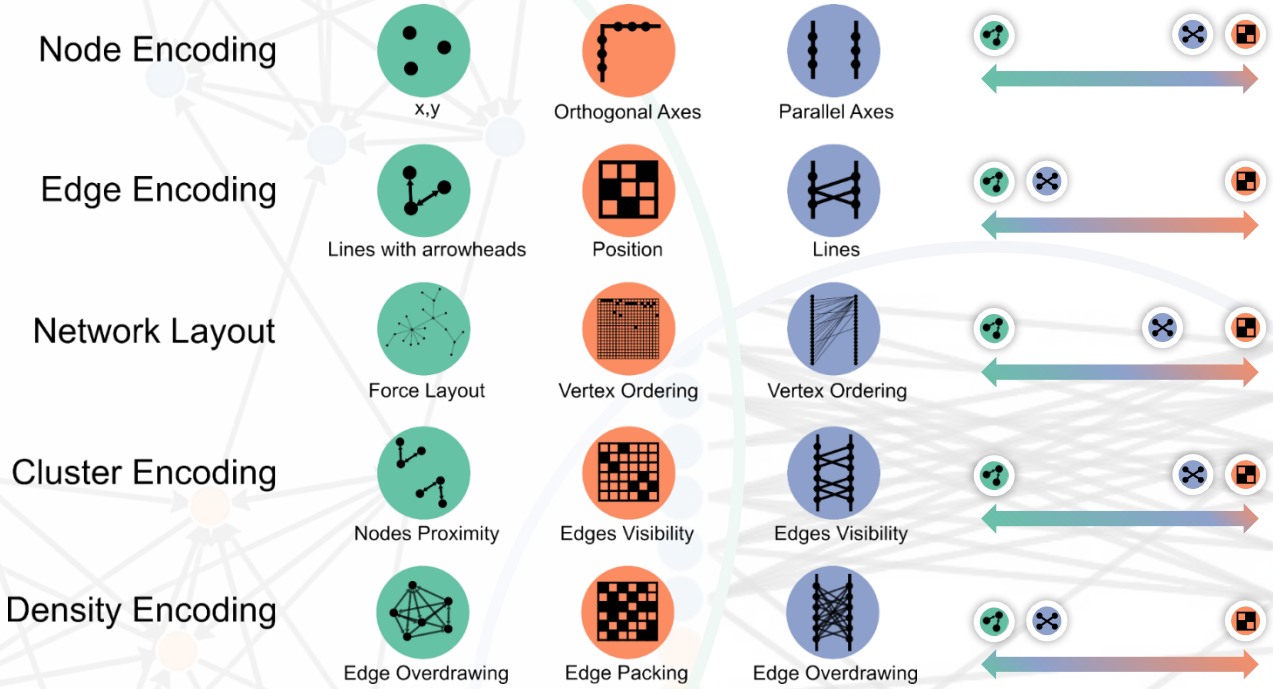


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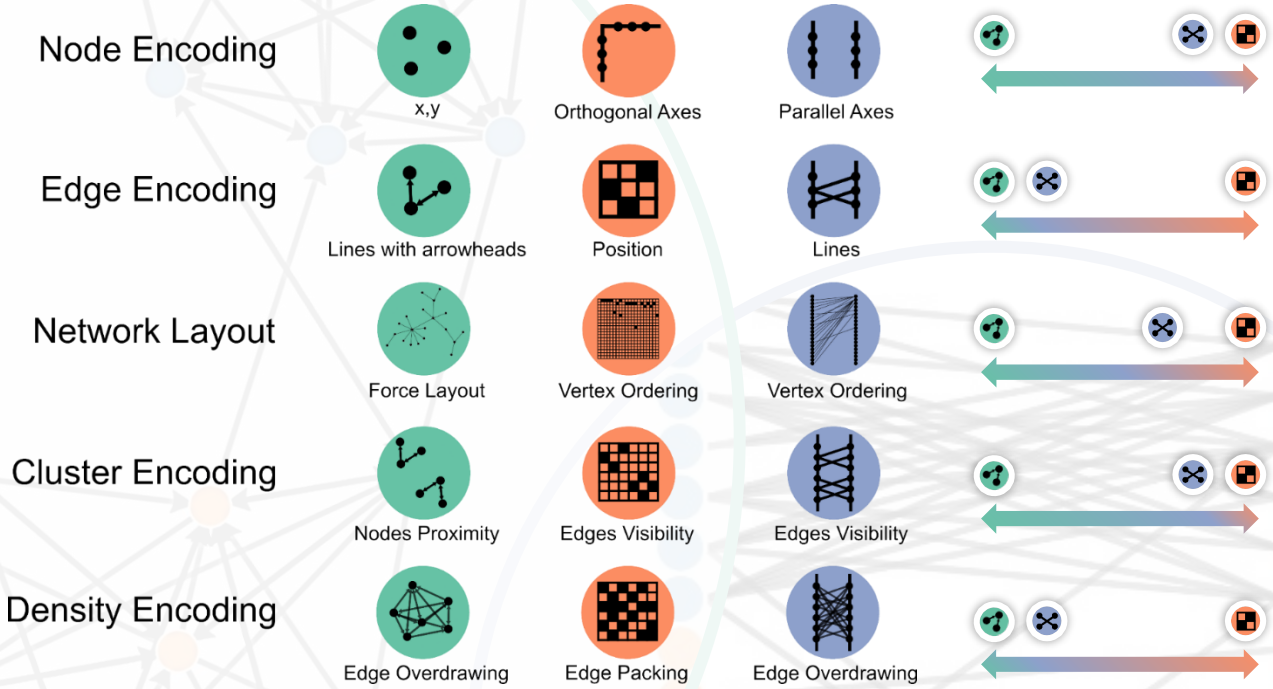


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**Edge Packing > Edge Overdrawing**

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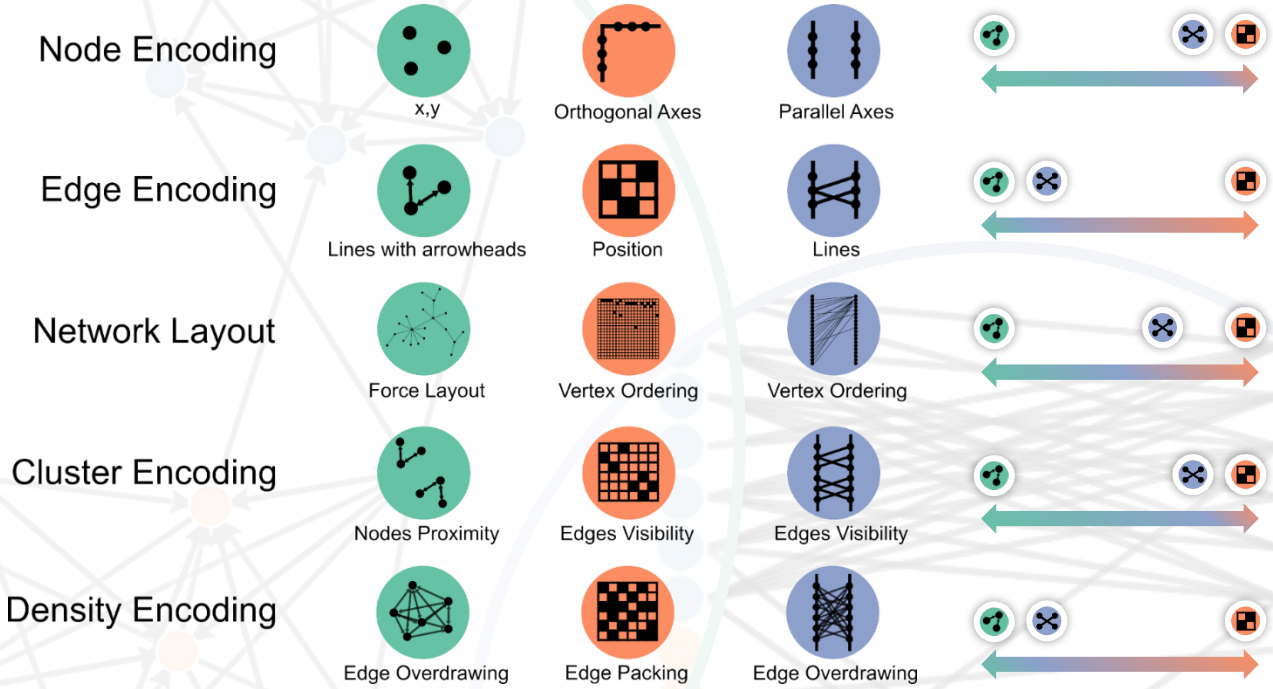


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**Network Layout > Edge Encoding**

**Vertex Ordering > Force Layout**

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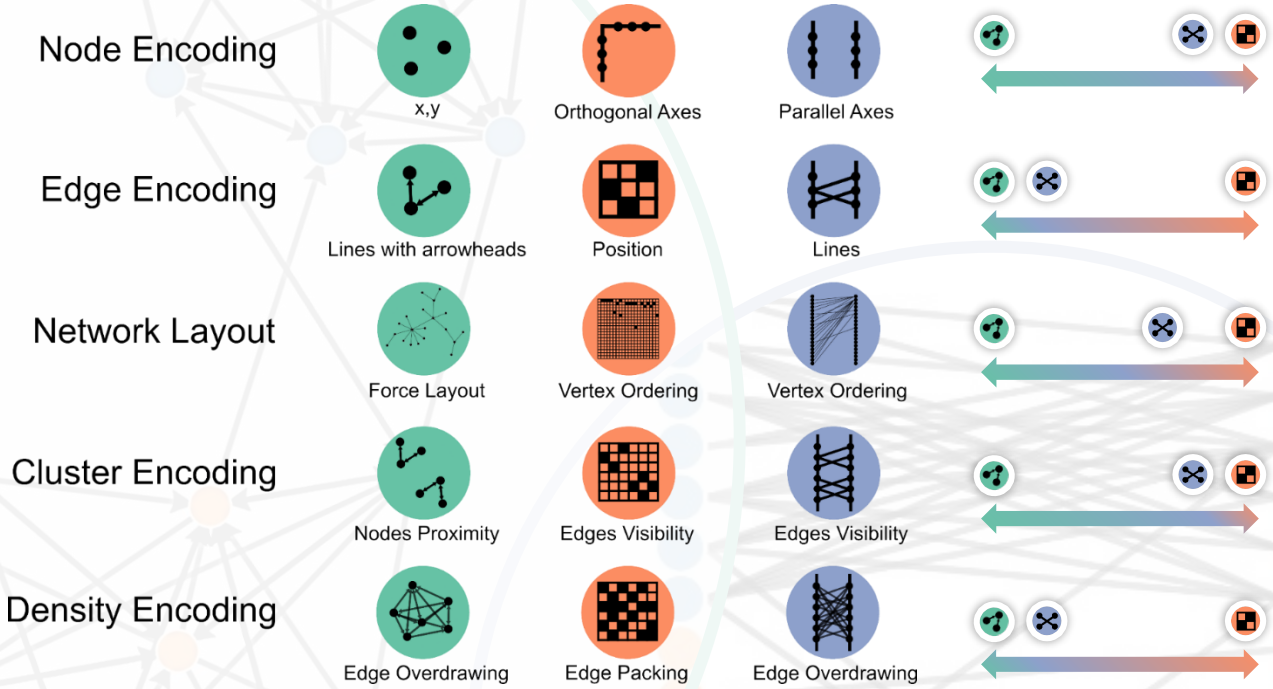
**Edge Packing > Edge Overdrawing**

# NL vs. AM vs. BP

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Thanks to:







IntCDC CLUSTER OF EXCELLENCE

SFB-TRR 161 Quantitative Methods for Visual Computing

University of Stuttgart


Paper, study website, source code, and supplemental materials