A Modular Degree-of-Interest Specification for the Visual Analysis of Large Dynamic Networks

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Motivation

Goal:
tracking temporal changes in a large dynamic network

Challenge:
find and show the most important elements / changes according to different analysis goals

DBLP co-authorship network
Existing Approaches

- **DoI functions** often used to differentiate between
  - relevant elements $\rightarrow$ high DoI values
  - their context $\rightarrow$ low DoI values

- first specified for **static hierarchies** [Furnas 1986]
- extensions for **multiple attributes**
  - general networks [Hüsken & Ziegler 2007, Crnovrsanin et al 2011]
  - dynamic graphs [van Ham and Perer 2009]
  - [Reitz et al 2009]

$\rightarrow$ each given as an individual **weighted monolithic** DoI function
- other fields already follow more flexible DoI approaches [Doleisch et al 2003]
Modular DoI Specification for Dynamic Networks

goal: identify the most important elements (nodes & edges) according to different analysis goals

• elements featuring specific characteristics
  • (clicked) focus elements
  • certain attribute values
  • certain structural properties
  • certain temporal changes

• important elements by association in
  • structure
  • time

• flexible composition of all the above
our approach: a modular specification of DoI functions based on functional components

- **specification** components for characteristics
  - (clicked) focus elements
  - certain attribute values
  - certain structural properties
  - certain temporal changes

- **propagation** components for associations
  - structural propagation
  - temporal propagation

- **transformation and combination** components for flexible composition

\[
\begin{align*}
\text{spec}(x_i) &= \text{inter}(\text{comp}(x_i)) \\
\text{comp}(x_i) : x_i &\mapsto \mathbb{R} \\
\text{comp}(x_i) : \text{attr}(x_i) &\mapsto \mathbb{R} \\
\text{comp}(x_i) : V(x_i) \times E(x_i) &\mapsto \mathbb{R} \\
\text{comp}(x_i) : \text{attr}(x_{i-p}) \times \ldots \times \text{attr}(x_i) \times \ldots \times \text{attr}(x_{i+f}) &\mapsto \mathbb{R}
\end{align*}
\]

\[
\begin{align*}
\text{props}(\text{doi}(y_i), x_i) &= \max_{y_i \in V_i \cup E_i} \frac{\text{drop}(\text{doi}(y_i), \text{dist}_{\text{attr}}(x_i, y_i))}{|T|} \\
\text{prop}_{t}(\text{doi}(x_j), x_i) &= \max_{j=1} \frac{\text{drop}(\text{doi}(x_j), t_j - t_i)}{T}
\end{align*}
\]

\[
\begin{align*}
\text{trans} : [0\ldots1] &\mapsto [0\ldots1] \\
\text{comb} : [0\ldots1]^T &\mapsto [0\ldots1]
\end{align*}
\]
representations for each functional component

- **diverse set** of representations for characteristics
- **list views** for focus elements
- **histograms** for attribute values
  structural properties
  temporal changes (not shown)

- **curve views** for associations
  structural propagation
  temporal propagation (not shown)

- **interactive hierarchical nesting** for flexible composition of the DoI function

\[
doi(x_i) = \text{prop}_s(\max(\{\text{select}_{0.85}(y_i), \text{sum}(\{\text{inter}_1(\text{norm}(\text{publications}(x_i))), \text{inter}_2(\text{norm}(\text{node\_degree}(x_i)))\}))\})
\]
Utilizing DoI values for Visualizing Dynamic Networks

structure

- **node-link** representation
- emphasis of important elements by
  - DoI-based abstraction
  - DoI-based layout
  - DoI-based color-coding
  - DoI-based labeling

meta nodes

subgraph size

density

time

- **animation**
  - DoI-based pinning weights

- **stacked graph** representation
  - DoI-based aggregation
Visual Analysis Setup combining both DoI Interface and Visualization

**linked** views provide visual feedback for the investigation of the user selection in detail
Real World Scenario (2)

**dataset:** DBLP co-authorship network

- 21 time points (1990-2011)
- 914,492 nodes (authors)
- 3,802,317 edges (co-authorship)

**common goal:** identification and visualization of **top authors**

- high number of **published papers**
- high number of **coauthors** → many edges (node degree)

→ derive DoI function
Real World Scenario (2)  

common goal: identification of top authors
Real World Scenario (3)

namesakes?

- utilize histograms of specification components to identify similarities
- utilize visual cues given by hovering over elements
Real World Scenario (4) namesake characteristics
Real World Scenario (5) - top authors \ namesakes
Contribution

- a **multi-faceted, modular** DoI specification for **dynamic networks**
  - focus elements
  - attributes
  - structure
  - time
  - interactive hierarchical composition
  - temporal
  - structural propagation

- utilized for visualization of their **structural** and **temporal** facet
  - abstraction
  - layout
  - color-coding
  - labeling
  - pinning weights
  - aggregation

Future Work

- better support for specifying multi-dimensional characteristics

![Diagrams showing attribute and structure transition](images)
Thank you!

Questions?

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