VisLink: Revealing Relationships Amongst Visualizations

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Synsets, one for each sense of that word. Synsets in WordNet are related by many types of relationships, depending on the part of speech (noun, verb, etc.). WordNet contains 28 different types of relationships, but the most widely used part of WordNet is the hyponymy (is-a) partial order. We remove all cycles (they are very rare) by taking a depth-first spanning tree at the user-selected root. In this work we focus on the noun hyponymy (is-a) relationships in English WordNet (v2.1), rooted under the synset [entity] and having 73,736 nodes (synsets) and 75,110 edges. Verb hyponymy is also supported (but the tree is much smaller). The visualizations produced can be generalized to any partial order of a lexicon.

While development on WordNet continues, the interfaces for interacting with WordNet have not progressed to take advantage of advances in the field of information visualization. Currently available interfaces, both textual and graphical, focus on regions of local interest, for example by searching for the relationships for a single synset (ThinkMap, 2005; Bou, 2003; Alcock, 2004). In recent work, we created a working prototype of a visualization suite for WordNet which allows for an overview of the data, as well as the ability to focus on specific synsets of interest and obtain details. After developing these visualizations, we realized that the linguistic structure provided by WordNet could be useful not only for abstract visualization of the network itself, but that by applying other linguistic measures upon the nodes, we could better understand other aspects of language. Of particular interest to many in the information visualization and information retrieval communities is document structure and topic content.

In the following sections we will describe related work in document content visualization and present our interactive, animated, space-filling radial graph visualization of document content and WordNet hyponymy.
(Heer, 2006 [prefuse]) & (Fry, 2004)
Understanding Multiple Relations

- What is the relationship...
  - across different views of the same data?
  - across different relations in the same dataset?
  - across multiple relations and datasets?
VisLink
VisLink Overview

- Any number of 2D visualizations, each on its own plane in 3D space
- Adjacent planes connected by bundled edges
- Shortcuts and constrained widgets aid usability
- Enables powerful inter-visualization queries
Formalizing Multiple Relations Visualizations

Dataset
- Conference Attendee Data

Relation
- Professor / Student

Visualization
- Node-link social network graph
Formalizing Multiple Relations Visualizations

Dataset

Relation

Visualization

$D_A$
Formalizing Multiple Relations Visualizations

- Dataset: $D_A$
- Relation: $R_A(D_A)$
- Visualization

Formalism for Multiple Relationship Visualization Comparison
Formalizing Multiple Relations Visualizations

Dataset

Relation

Visualization

$D_A$

$R_A(D_A)$

$Vis_A \rightarrow R_A(D_A)$
Formalizing Multiple Relations Visualizations

Dataset: $D_A$

Relation: $R_A(D_A)$

Visualization: $Vis_A \rightarrow R_A(D_A)$
Formalizing Multiple Relations Visualizations

Dataset

$D_A$

Relation

$R_A(D_A)$

Relation

$R_B(D_A)$

Visualization

$Vis_A \rightarrow R_A(D_A)$

Formalism for Multiple Relationship Visualization Comparison
Formalizing Multiple Relations Visualizations

Dataset

$D_A$

$R_A(D_A)$

$R_B(D_A)$

Visualization

$\text{Vis}_A \rightarrow R_A(D_A)$

$\text{Vis}_B \rightarrow R_A(D_A)$

Formalism for Multiple Relationship Visualization Comparison
Formalizing Multiple Relations Visualizations

Dataset

$D_A$

$R_A(D_A)$

$R_B(D_A)$

Visualization

$Vis_A \rightarrow R_A(D_A)$

$Vis_B \rightarrow R_A(D_A)$

$Vis_C \rightarrow R_B(D_A)$

Formalism for Multiple Relationship Visualization Comparison
Multiple Relation Visualizations

- Individual Visualizations
- Coordinated Views
- Compound Graphs
- Semantic Substrates
- VisLink

Formalism for Multiple Relationship Visualization Comparison
Individual Visualizations

- Any datasets, relations, and visualizations
- Manually compare
- e.g. different charts in Excel
Coordinated Views

Formalism for Multiple Relationship Visualization Comparison
Coordinated Views

\[ \text{Vis}_A \rightarrow R_A(D_A) \]
Coordinated Views

\[ \text{Vis}_A \rightarrow R_A(D_A) \quad \text{Vis}_A \rightarrow R_B(D_A) \]
Coordinated Views

- Any datasets, relations, and visualizations
- Interactive highlighting
- e.g., Snap-Together Visualization (North & Shneiderman, 2000)

\[ \text{Vis}_A \rightarrow R_A(D_A) \quad \text{Vis}_A \rightarrow R_B(D_A) \]
Compound Graphs
Compound Graphs

\[ \text{Vis}_A \rightarrow R_A(D_A) \]
Compound Graphs

Formalism for Multiple Relationship Visualization Comparison

\[ \text{Vis}_A \rightarrow R_A(D_A) + R_B(D_A) \]
Compound Graphs

- Secondary relation has no **spatial rights**
- e.g., Overlays on Treemaps (Fekete et al., 2003), ArcTrees (Neumann et al., 2005), Hierarchical Edge Bundles (Holten, 2006)

Formalism for Multiple Relationship Visualization Comparison

Use of the powerful spatial dimension to encode data relationships.
Semantic Substrates
Semantic Substrates

$D_A$
Semantic Substrates

Formalism for Multiple Relationship Visualization Comparison
Semantic Substrates

Formalism for Multiple Relationship Visualization Comparison
Semantic Substrates

Formalism for Multiple Relationship Visualization Comparison
Semantic Substrates

$D_{A_1}$  
$D_{A_2}$
Semantic Substrates

\[ \text{Vis}_A \rightarrow R_A(D_{A_1}) \quad \text{Vis}_A \rightarrow R_A(D_{A_2}) \]
Semantic Substrates

\[ \text{Vis}_A \rightarrow R_A(D_{A_1}) \quad \text{Vis}_A \rightarrow R_A(D_{A_2}) \]

Formalism for Multiple Relationship Visualization Comparison
Semantic Substrates

- Single visualization, single relation
- Semantically meaningful data subsets
- Spatial rights for all relations

(Shneiderman and Aris, 2006)
VisLink

Formalism for Multiple Relationship Visualization Comparison
VisLink

\[ Vis_A \rightarrow R_A(D_A) \]
VisLink

\[ \text{Vis}_A \rightarrow R_A(D_A) \quad \text{Vis}_B \rightarrow R_B(D_A) \]
Vis\textsubscript{A} \rightarrow R\textsubscript{A}(D\textsubscript{A}) \hspace{1cm} Vis\textsubscript{B} \rightarrow R\textsubscript{B}(D\textsubscript{A})

Vis\textsubscript{B} \rightarrow R\textsubscript{A}(D\textsubscript{B})
Formalism for Multiple Relationship Visualization Comparison

\[ \text{Vis}_A \rightarrow R_A(D_A) \quad \text{Vis}_B \rightarrow R_B(D_A) \]

\[ \text{Vis}_{A+B} \rightarrow T(R_A(D_A), R_B(D_A)) \]
VisLink

Formalism for Multiple Relationship Visualization Comparison

\[ \text{Vis}_{A+B} \rightarrow T(R_A(D_A), R_B(D_A)) \]

- Visualize second order relations between visualizations
- Across any datasets, relations, visualizations for which a relation can be defined
- All component visualizations retain spatial rights
VisLink & Semantic Substrates

Formalism for Multiple Relationship Visualization Comparison
VisLink & Semantic Substrates

- Single visualization technique
- Semantic subsets of data provide added meaning

Formalism for Multiple Relationship Visualization Comparison
VisLink & Semantic Substrates

• Any number of different relations and visualizations
• Second order relations revealed in inter-plane edges

Formalism for Multiple Relationship Visualization Comparison
Equivalency & Extension

Formalism for Multiple Relationship Visualization Comparison
VisLink Case Study: Lexical Data

- WordNet IS-A hierarchy \( (R_A) \) using radial tree (Vis$_A$)
- Similarity clustering \( (R_B) \) using force-directed layout (Vis$_B$)

VisLink Visualization
Edge Detail

- Bundled: one-to-many edges
- Smooth: Chaiken corner cutting
- Transparent: bundles more opaque
- Directed: orange-to-green
Always equivalent to 2D:
- Planes are virtual displays
- Mouse events transformed and passed to underlying visualization
- Equivalent to 2D viewing mode
Interplane Edges
Zoom

VisLink Visualization
Constrained Widget Interaction
3D Navigation
Spreading Activation

- Nodes have a **level of activation**, indicated by **transparency** of orange node background.
- Full activation through:
  - Selecting a node on a plane
  - Node matches search query
- Activation propagates through interplane edges, **reflecting** between planes with exponential drop-off.
- Enables inter-visualization queries.
- Edge transparency relative to source node activation.
Inter-Plane Query Example

1: alphabetic clusters

2: synonym sets

Q: Synonyms in the alphabetic view?

No synonym information
No alphabetic organization
Inter-Plane Query Example

1. Select a word on plane 1
2. Edges propagate to synonym sets on plane 2
3. Reflected edges propagate back, revealing synonyms in alphabetic clusters

1: similarity clusters  
2: synonym sets
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1: similarity clusters 2: synonym sets
Edge Reflection and Inter-Plane Queries
Linking Existing Visualizations
Linking Existing Visualizations
Implementation

- Prefuse visualization toolkit (Heer et al., 2005)
  - Existing visualizations can be incorporated without changes
  - Interplane edges defined by (plane, node) index pairs
- Java OpenGL
Perceptual Considerations

- Not all layouts equal
- Colour interactions with edges and visualizations
- 3D perspective bias
Future Work

- Application to additional analytic scenarios
- Investigation of 3D edge bundling, edge lenses
- Animation of spreading activation
- Evaluation against existing multiple view techniques
- Rich query language to filter visualization planes
Summary

- Formalism to describe multi-relation visualizations
- New way to reveal relationships amongst visualizations
- Reuse of the powerful spatial visual dimension
- Full 2D interactivity for constituent visualizations
- Techniques to simplify 3D navigation
- Visualization bridging through inter-representational queries and spreading activation
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