

Evaluating Ontological Fit

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The Representation Problem

- What is the best way to encode data?
 - Depends on the data
 - Depends on the purpose
 - Fields
 - Data structures
 - Visualization
 - Statistics
- How do we measure a representation's fitness?
 - Reflects the underlying data
 - Stable across iterations
 - Useful for the end user
- No “Golden Standard” for many domains

Outline

- The Representation Problem
- Digital Humanities
 - The Stanford Encyclopedia of Philosophy (SEP)
 - The Indiana Philosophy Ontology Project (InPhO)
 - The process
 - 1. Data Mining
 - 2. Expert Feedback
 - 3. Machine Reasoning
- Evaluating Ontological Fit
 - The violation score
 - The volatility score
 - Improving InPhO

The Representation Problem

DIGITAL HUMANITIES

Stanford Encyclopedia of Philosophy

Leading digital reference work

13.5 million words

~1200 articles

700,000 weekly hits

<http://plato.stanford.edu>



STANFORD ENCYCLOPEDIA OF PHILOSOPHY

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Epistemology

First published Wed Dec 14, 2005

Defined narrowly, epistemology is the study of knowledge and justified belief. As the study of knowledge, epistemology is concerned with the following questions: What are the necessary and sufficient conditions of knowledge? What are its sources? What is its structure, and what are its limits? As the study of justified belief, epistemology aims to answer questions such as: How we are to understand the concept of justification? What makes justified beliefs justified? Is justification internal or external to one's own mind? Understood more broadly, epistemology is about issues having to do with the creation and dissemination of knowledge in particular areas of inquiry. This article will provide a systematic overview of the problems that the questions above raise and focus in some depth on issues relating to the structure and the limits of knowledge and justification.

- 1. What is Knowledge?
 - 1.1 Knowledge as Justified True Belief
 - 1.2 The Gettier Problem
- 2. What is Justification?
 - 2.1 Deontological and Non-Deontological justification
 - 2.2 Evidence vs. Reliability
 - 2.3 Internal vs. External
 - 2.4 Why Internalism?
 - 2.5 Why Externalism?
- 3 The Structure of Knowledge and Justification

The Indiana Philosophy Ontology Project

Pragmatic attempt to organize the discipline of philosophy through machine learning, augmented by expert verification

~2,200 concepts

~5,000 concept evaluations

~1,750 thinkers

~15,000 thinker evaluations

~1,100 journals

<http://inpho.cogs.indiana.edu>

http://inpho.cogs.indiana.edu

InPhO
the Indiana Philosophy Ontology project

« myinpho (login)

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- ☞ Philosophy [collapse all] [expand all]
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 - african and african-american philosophy
 - arabic and islamic philosophy
 - chinese philosophy
 - ☐ continental philosophy
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 - ☐ feminist philosophy
 - ☐ history of philosophy
 - japanese philosophy
 - judaic philosophy
 - latin american and iberian philosophy
 - ☐ logic
 - ☐ metaphysics
 - philosophy of action
 - ☐ philosophy of language
 - philosophy of law
 - philosophy of mathematics
 - ☐ philosophy of mind
 - philosophy of religion
 - ☐ philosophy of science and the sciences
 - ☐ social and political philosophy

InPhO Taxonomy (β version)

This is the page for the node **Philosophy**

This taxonomy of ideas is the outcome of the first iteration of our cycle of expert-provided structure, statistical analysis of the articles in the [Stanford Encyclopedia of Philosophy](#), and a small amount of human feedback. Iterations of this cycle will be used to develop the taxonomy. The approach is explained in more detail [here](#).

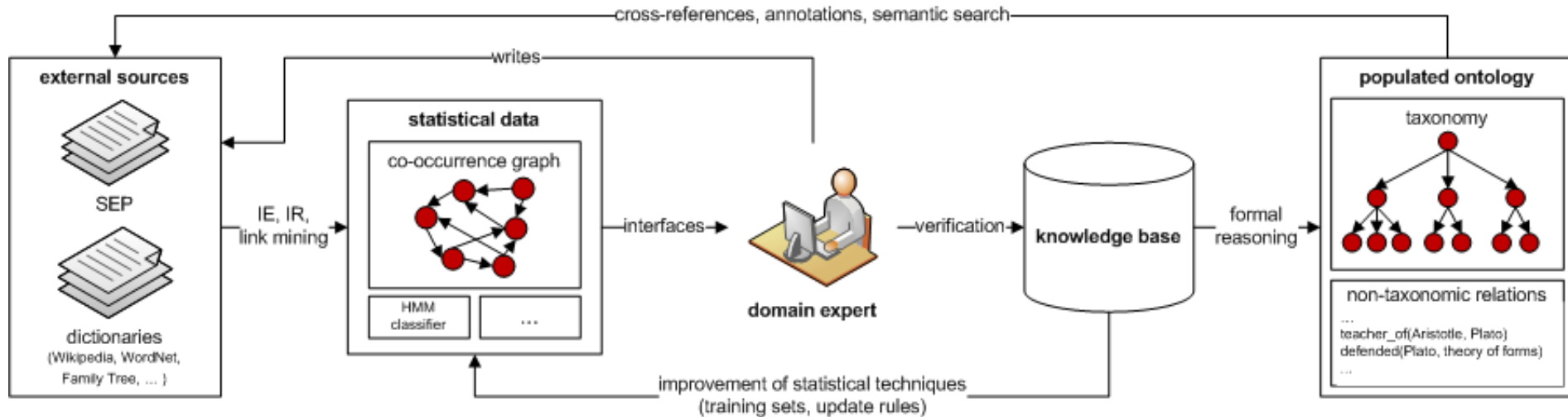
Click on any of the links on the left to explore the topics in the taxonomy. Click ☞ icon to open SEP article on the adjacent term.

Subclasses:	Searches
aesthetics ∪ philosophy of art	☞ SEP inpho SEP Google Scholar
african ∪ african-american philosophy	☞ SEP inpho SEP Google Scholar
arabic and islamic philosophy	☞ SEP inpho SEP Google Scholar
chinese philosophy	☞ SEP inpho SEP Google Scholar
continental philosophy	☞ SEP inpho SEP Google Scholar
☞ epistemology	☞ SEP inpho SEP Google Scholar
ethics	☞ SEP inpho SEP Google Scholar
feminist philosophy	☞ SEP inpho SEP Google Scholar
history of philosophy	☞ SEP inpho SEP Google Scholar
japanese philosophy	☞ SEP inpho SEP Google Scholar
judaic philosophy	☞ SEP inpho SEP Google Scholar
latin american ∪ iberian philosophy	☞ SEP inpho SEP Google Scholar
logic	☞ SEP inpho SEP Google Scholar
☞ metaphysics	☞ SEP inpho SEP Google Scholar
philosophy of action	☞ SEP inpho SEP Google Scholar
philosophy of language	☞ SEP inpho SEP Google Scholar
philosophy of law	☞ SEP inpho SEP Google Scholar
☞ philosophy of mathematics	☞ SEP inpho SEP Google Scholar
philosophy of mind	☞ SEP inpho SEP Google Scholar
☞ philosophy of religion	☞ SEP inpho SEP Google Scholar
philosophy of science and the sciences	☞ SEP inpho SEP Google Scholar
social ∪ political philosophy	☞ SEP inpho SEP Google Scholar

InPhO Goals

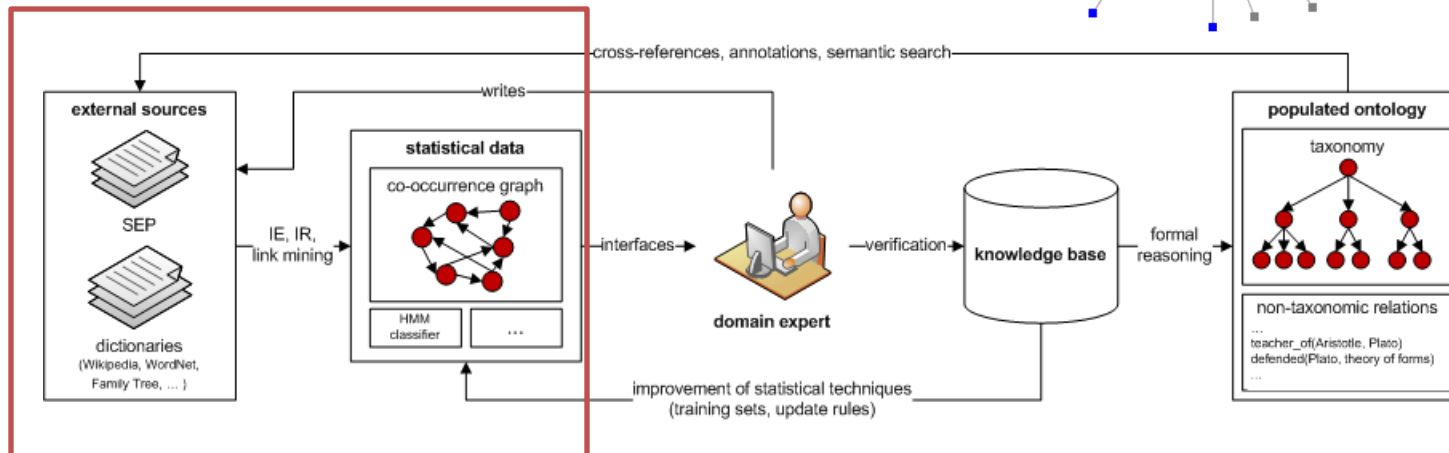
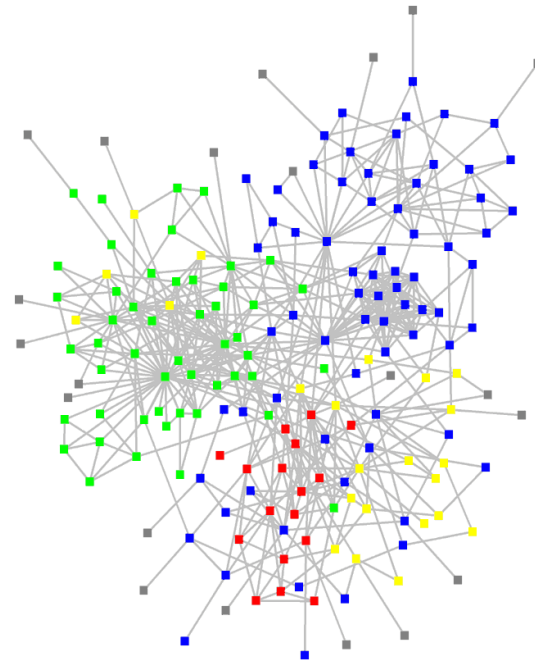
- Ontology – formal representation of concepts in a domain and the relationship between those concepts
- Provide useful tools
 - Cross-referencing
 - Semantic search
 - Document classification
 - Visualizations
- “Guided serendipity”

InPhO Process



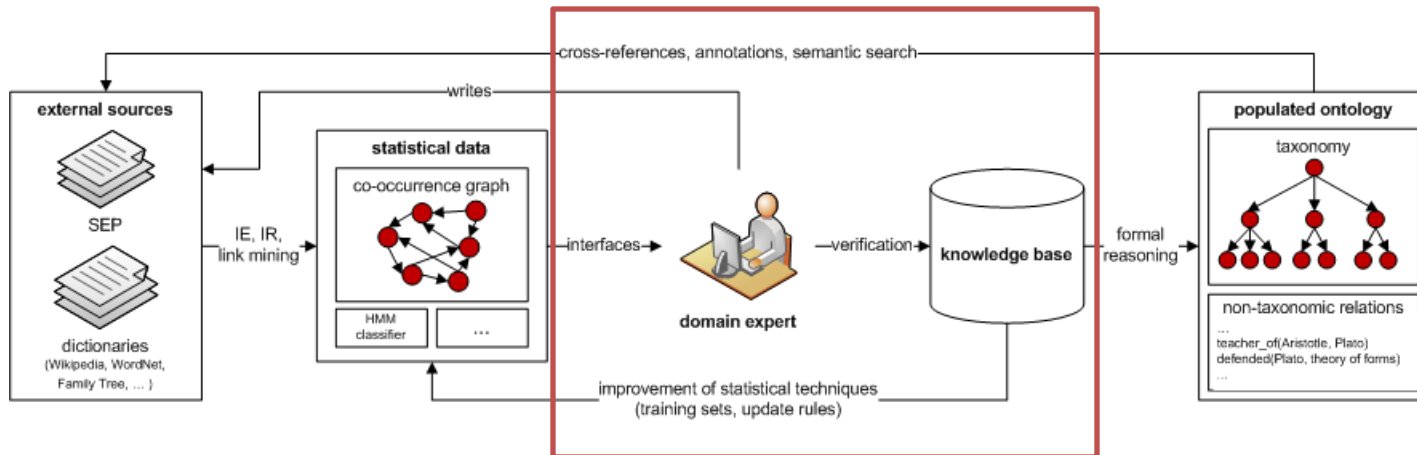
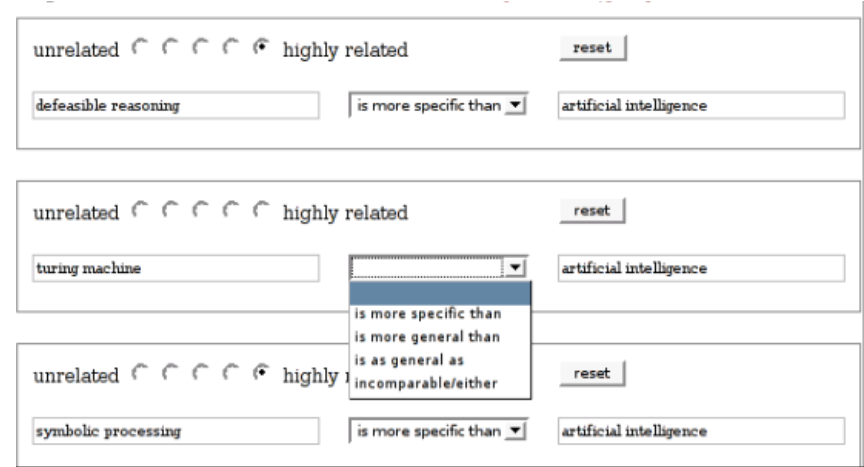
1. Data Mining

- Uses natural language processing (NLP) techniques to generate co-occurrence graph of all concepts in the SEP
- Two statistical measures for each graph edge:
 - Semantic similarity
 - Relative generality (Shannon entropy)
- 1.6 million graph edges
- Further details in Niepert 2007



2. Expert Verification

- Present hypothetical relations to users.
- Users stratified by domain expertise
- Further details: Allen 2008, Niepert 2009, Buckner 2010



3. Machine Reasoning

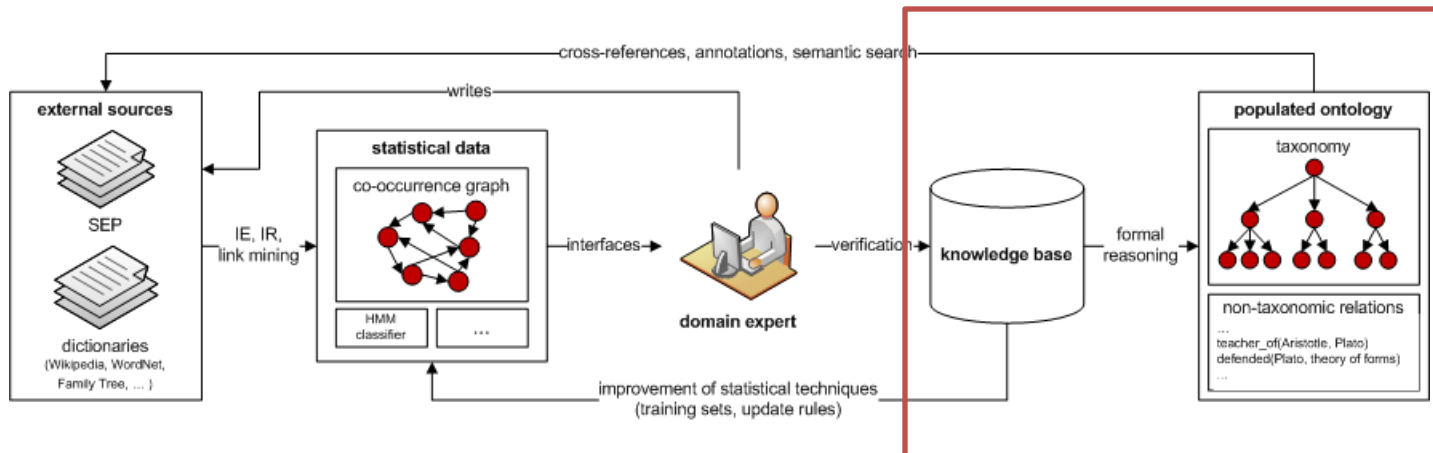
- Input: Verification combined with statistical data
- Answer set programming
- Output: Populated ontology with taxonomic projection
- Further details: Niepert 2008

Sample Rules:

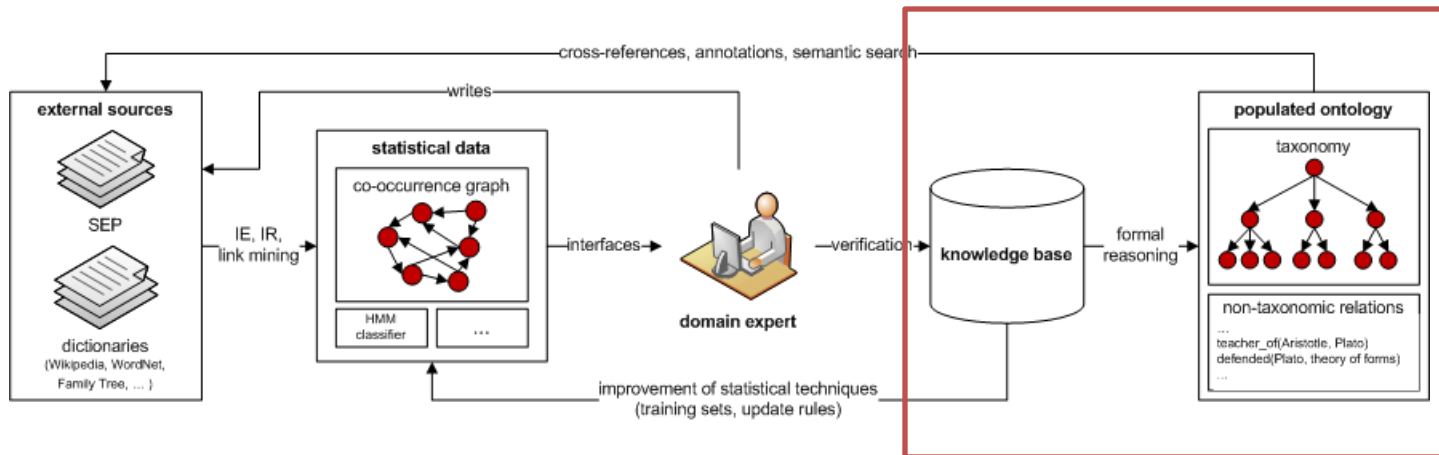
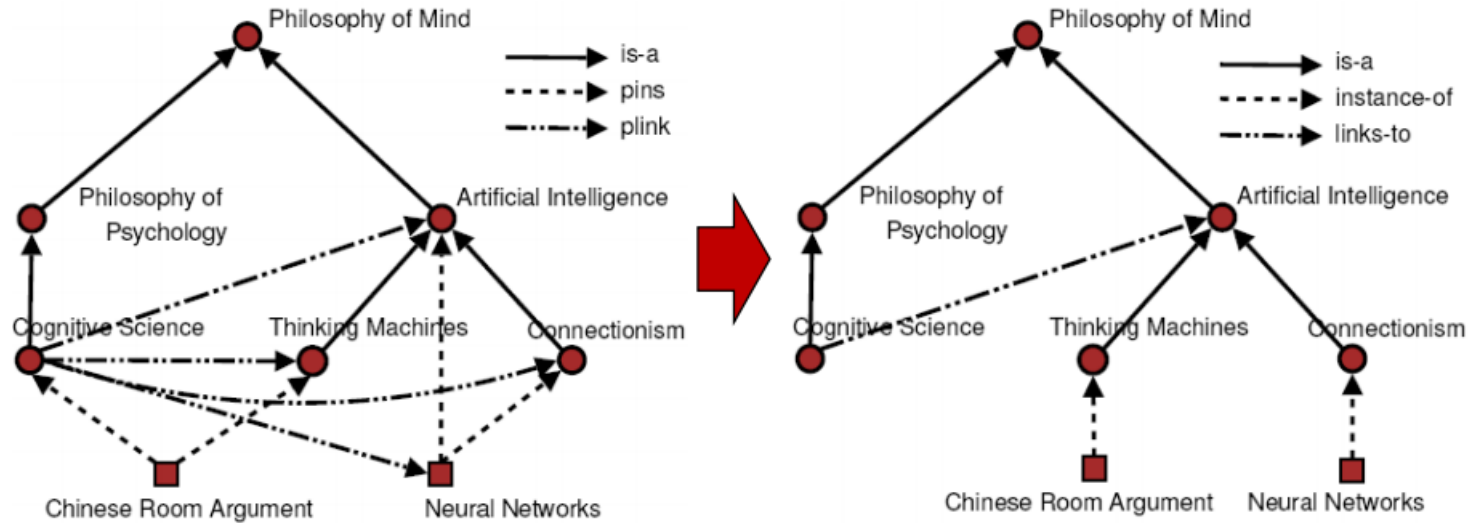
More-specific(X, Y) :- more-general(Y, X)

Possible-instance(X, Y) :- highly-related(X, Y), more-specific(X, Y), class(Y), not class(X).

Inconsistent(X, Y) :- more-specific(X, Y), more-general(X, Y)






















3. Machine Reasoning



API and Tools

Cross references for Computer and Information Ethics

					click SEP icon for entry text link to InPhO taxonomy	1 Biographical Article
1	2	3	4	5	Article	
1		1			 privacy	
	1		3		 philosophy of technology	
2			5		 life	
8			4		 globalization	
6		9			 consequentialism	
9		12			 war	
			2		 philosophy of computer science	
3					 property	
4					 time	
5					 rights	
		6			 artifact	
7					 existence	
		7			 freedom of speech	
		8			 virtue ethics	
10					 identity	
		10			 god	
11					 object	
		11			 artificial intelligence	
12					 democracy	

- Practical usage of data
- Cross-reference engine
 - Captures ~75% of hand-picked references
- Semantic navigation
 - Taxonomy browser
- Online API using the RESTful Web Services paradigm
 - Leverages HTTP protocol
 - Allows SEP integration
 - Use by Noesis domain-specific search

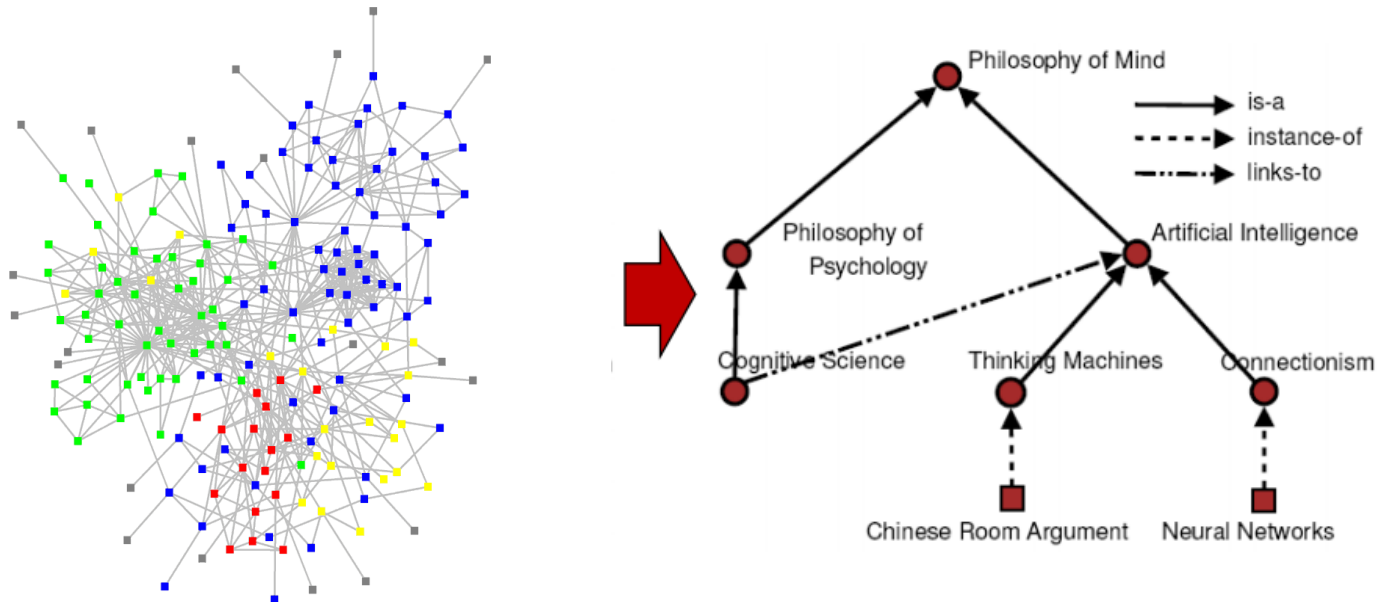
The Representation Problem

Digital Humanities

EVALUATING ONTOLOGICAL FIT

The Representation Problem Revisited

- Fitness measures:
 - Reflects the underlying data (the SEP)
 - Stable across iterations (consistent taxonomic structure)
 - Useful for the end user (promotes serendipity)
- No golden standard for philosophy
- Better representation will be more useful



The Violation Score

- Compares each ruleset's fitness to the corpus
- Only compares the same input
- Iterates over each is-a relation to see if it violates a statistical hypothesis.
 - S-violation: actual distance – predicted distance
 - E-violation: actual depth – predicted depth
- Simple average of two measures:

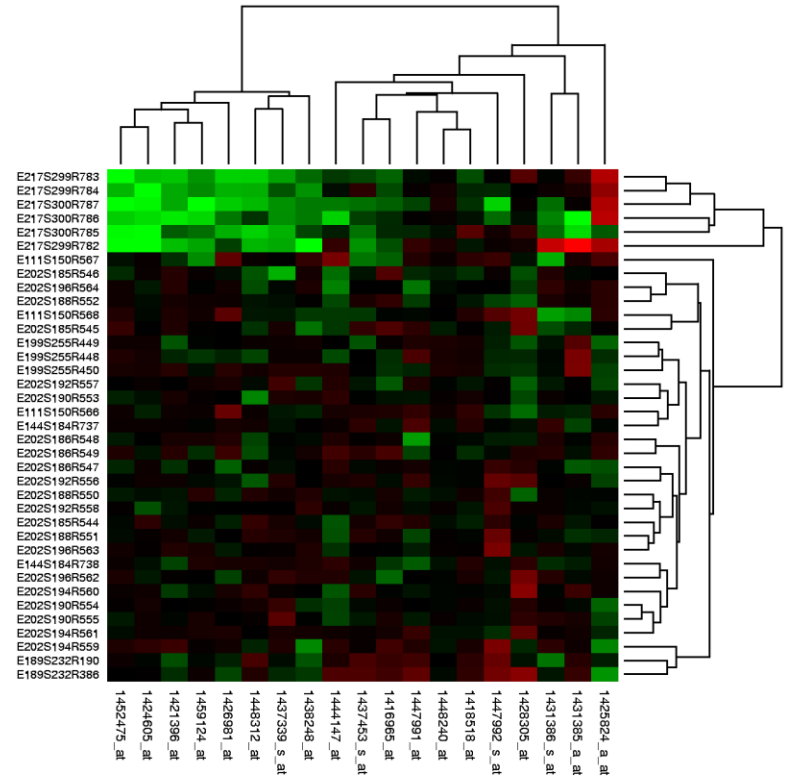
$$V(G, T) = \frac{sv(G, T)}{\text{count}((i, j) \in T)} + \frac{ev(G, T)}{\text{count}(i \in T)}$$

Examining Volatility

- Each instance is declared as $is-a(X, Y)$.
 - Shows movements $is-a(X, Y) \Rightarrow is-a(X, Z)$ and unique $is-a(X, Y)$ for each output set
 - Already useful in showing incremental improvements across iterations
 - $is-a(\text{Hilbert's program, phil. of science}) \Rightarrow is-a(\text{"}, \text{phil. of mathematics})$
 - Experts show higher violation, but qualitative examination shows greater reflection of philosophical structure
 - $is-a(\text{symbolic processing, phil. of computer science})$
 - $is-a(\text{mental state, phil. of mind})$

The Volatility Score

- Measures change in assertion or non-assertion of is-a(X,Y) over time.
- Heat map visualization
 - The more red, the less stability.
 - Also useful for showing areas of controversy



Improving InPhO

Conflicting Feedback

- Users will disagree
 - Naïve method
 - the expert wins
 - New methods
 - preprocessing conflicts through weighted voting
 - each evaluation is a fact in the answer set (computationally intensive)

Dangling Links

- Evidence to support a link(X,Y), but not enough to support ins(Y).
 - Ex) cognitive science, phil. of mind, folk psychology, artificial intelligence, phil of computer science => symbolic processing
- Result of design decisions:
 - `more-specific(X,Z) :-
 more-specific(X,Y),
 more-specific(Y,Z)`
- Weighted Transitivity
 - `more-specific(X,Z,min(A,B)) :-
 more-specific(X,Y,A),
 more-specific(Y,Z,B)`

Improving InPhO

Name	violation	sviolation	eviolation	ins	pairs eval	comparisons	viol/ins
Current Rules	0.684009	0.369258	0.314751	868	462787	12442819	0.000788
Current w/voting	0.685254	0.369813	0.315441	878	467787	12729500	0.00078
Transitivity	0.684908	0.371583	0.313325	976	508687	15597573	0.000702
Transitivity w/voting	0.686428	0.372278	0.31415	999	519162	16262791	0.000687

Recap

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Digital Humanities

Evaluating Ontological Fit

QUESTIONS?