InPhOrmed Philosophy

Combining text mining and expert judgment

Colin Allen <colallen@indiana.edu>
Mathias Niepert <mniepert@indiana.edu>
Cameron Buckner <cbuckner@indiana.edu>

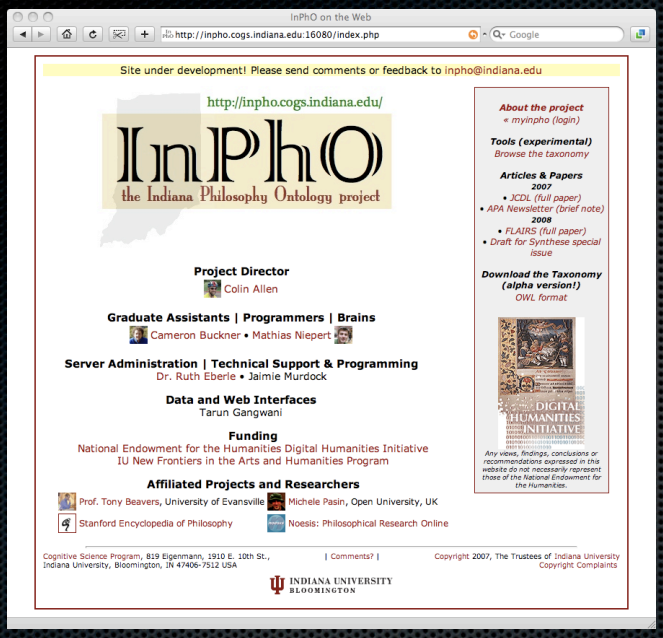


http://inpho.cogs.indiana.edu/

InPhO

the Indiana Philosophy Ontology project

1



Goals

- To build and maintain a “dynamic ontology” for the discipline of philosophy
- To deploy the InPhO in a variety of Digital Philosophy applications.

Digital Tools for the Humanities

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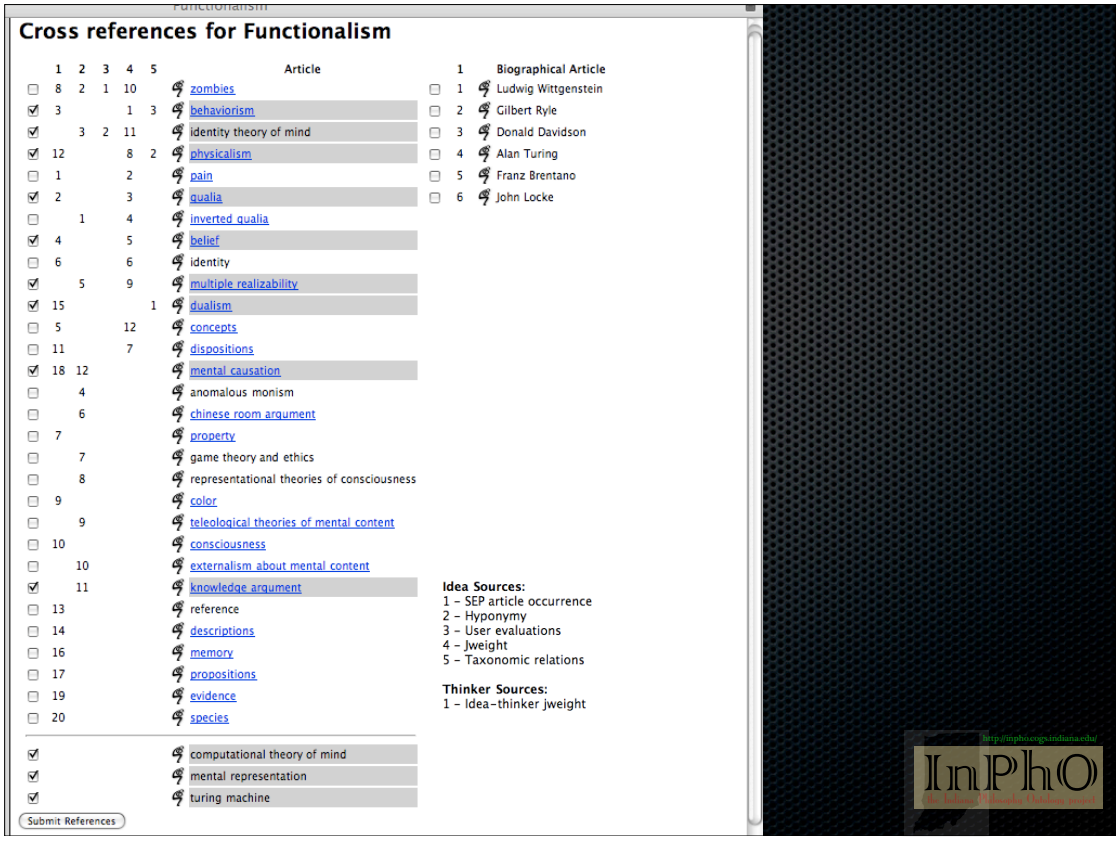
InPhO

2



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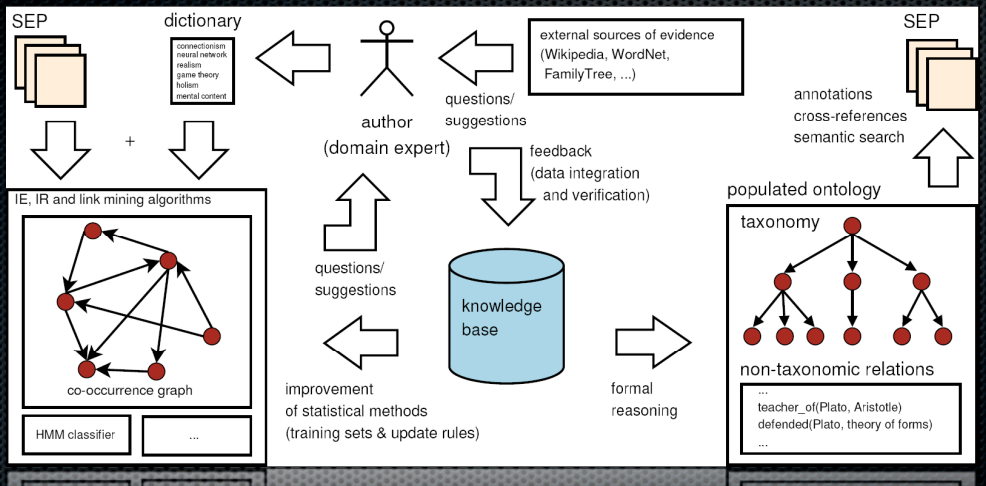
InPhO Architecture Overview



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SEP Data

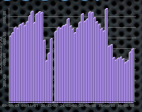
1289 authors (+12)

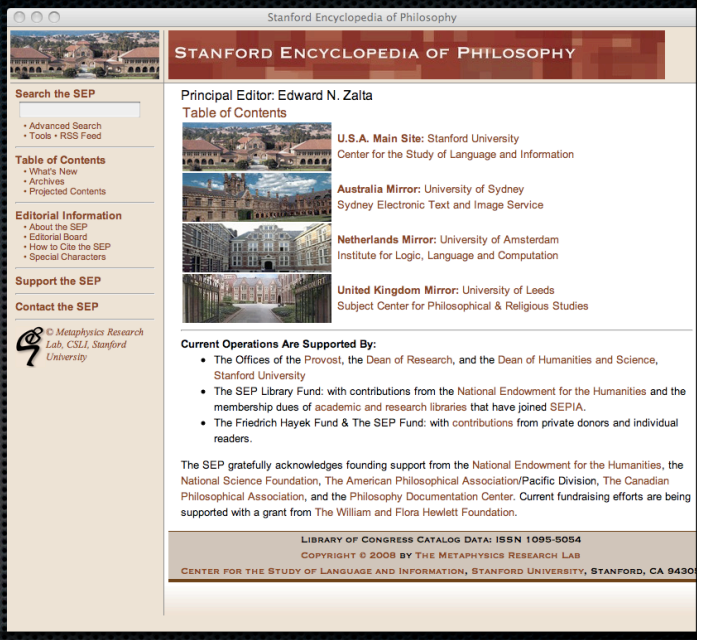
114 subject editors (+1)

1037 published entries (+20)

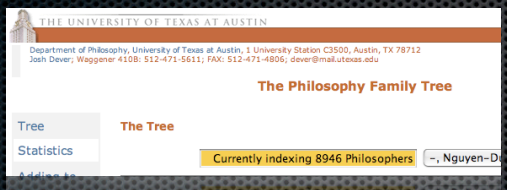
12.05 million words (+250,000)

600-850K articles accessed/week

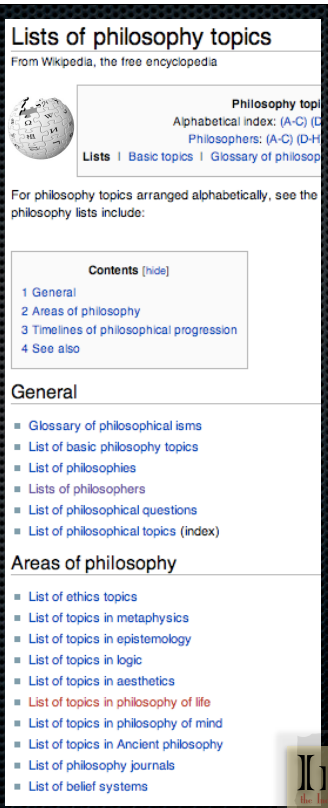




Other data sources



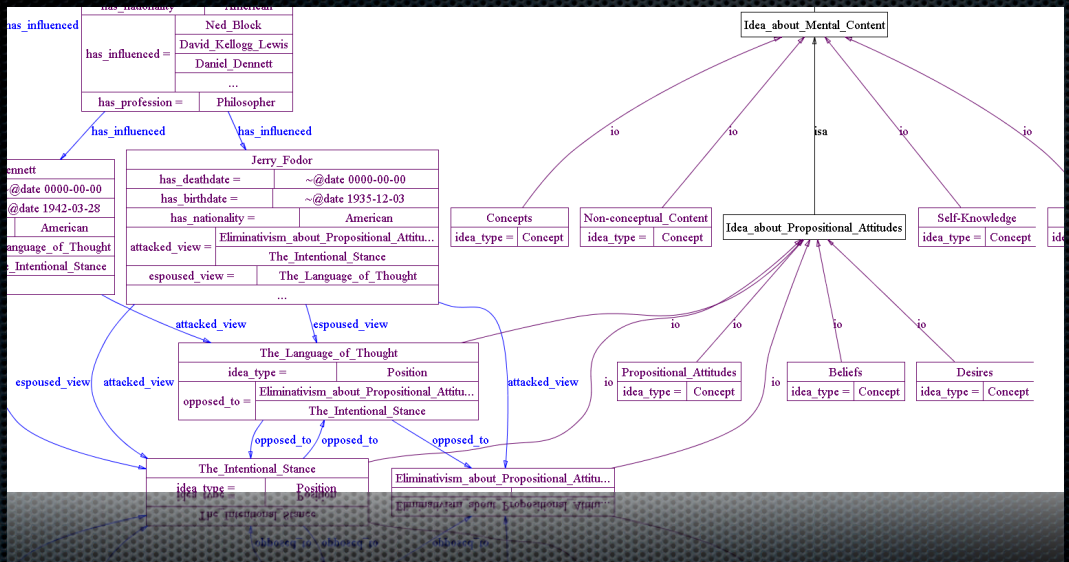
WordNet a lexical database for the English language



Wanted: Structured Data Out

Ontology: formal, machine-readable specification of the types of entities in a domain and relationships between them

Table 1: Initial Property List	
Thinker Properties	Died_on, Born_on , Spoke_language , Nationality
Thinker-Thinker Relations	Teacher_of, Influenced, Criticized, Defended, Dissertation_Advisor_of, Discoursed_with
Idea Properties	Idea_type [concept, position, etc.]
Thinker-Document Relations	Wrote, Edited
Thinker-Organization Relations	Member_of, Studied_at
Thinker-Idea Relations	Worked_on (problem), Created_view, Attacked_view, Espoused_view, Aware_of
Idea-Idea Relations	Opposed_to, Commits_to (idea1 commits one to idea2)
Document-Document Relations	Published_in (article in journal/book)
Document-Idea Relations	Discusses
Ternary Relations	Disagreed_with (ThinkerX disagreed with ThinkerY on IdeaZ)



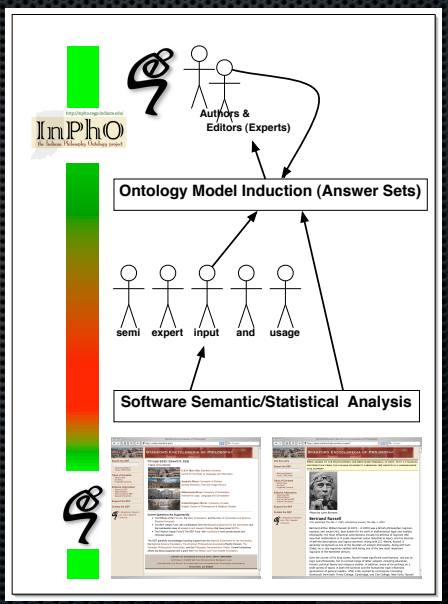
Bridging the Data-Metadata Gap

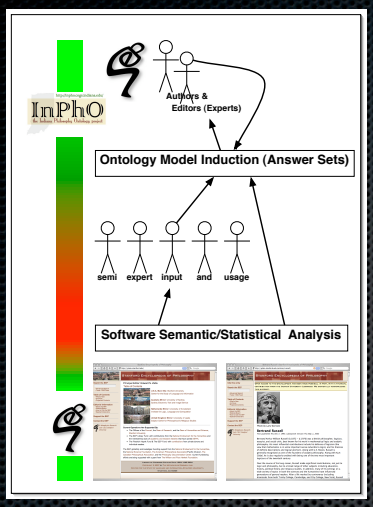
- Two “extremes”:
  - Hire experts to design & maintain an ontology
    - Problems: labor-intensive, expensive, depends on “double” experts
  - Tagging approaches, folksonomies
    - Problems: may not meet academic standards; noisy

Building ontologies: A third way

- Stratified collaboration
  - Expert feedback
    - software
  - General feedback
    - software
  - Expert-written content

The InPhO “layer cake”





- Experts are **busy** people. Experts don't want to be bothered with **garbage**. Experts don't like their **hard work messed up** by amateurs.
- Knowledgeable amateurs often have more **time** and **motivation** to fix things, but they are **rare**. They don't like having their **hard work messed up** by the clueless either.
- Well-intentioned amateurs are **plentiful** and **motivated** to donate their **time**, But they make **mistakes.**
- Software has lots of **time**, has **no motivation problems** but is **clueless**.

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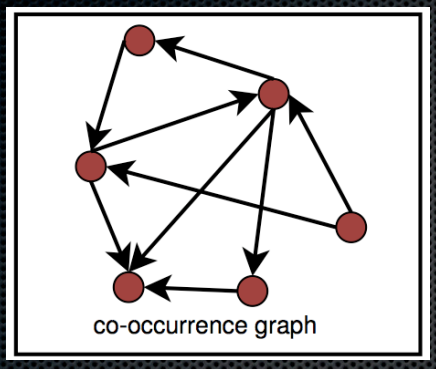
InPhO

Two networks



Software Layer 1

- Is it possible to detect hyper/hyponymy statistically?
  - If *t1* is a hypernym of *t2* then
    - *t1* is semantically similar to *t2*
    - *t1* is more general than *t2* with respect to a taxonomy
  - Probabilistic J-measure widely used to estimate the semantic similarity between two terms:

$$J(i \rightarrow j) = p(i)\left(p(j|i)\log\frac{p(j|i)}{p(j)} + (1-p(j|i))\log\frac{1-p(j|i)}{1-p(j)}\right)$$

Semantic similarity

- We build a directed and weighted co-occurrence graph G = (V , E) in which each node represents a term in our set of keywords. An edge between two terms t_1 and t_2 indicates that the terms co-occur in the encyclopedia at least once and the weight of the edge is a measure of their semantic similarity
- By iterating over all documents in the encyclopedia and counting their term (co-)occurrences we can estimate the probabilities $p(t_i)$, $p(t_j)$, $p(t_i,t_j)$, and thus $p(t_i|t_j)$ for all terms t_i, t_j, with respect to a unit of text.
- Currently we consider a document and a one sentence sliding window as units of text; i.e. two co-occurrence records are created, one for the sentence level and one for the document level. The latter is projected into the former by treating an entire document as one large sentence, giving us more co-occurrences at the cost of possibly including some connected but unrelated terms in our graph.

Hyper/hyponymy

- We hypothesize encyclopedias are "balanced" – terms representing more general categories tend to co-occur with more terms in the encyclopedia's text.
- Normalized node in degree will usually be a good measure for the generality of category, but we anticipate that entropy is an even better approximation of generality because it not only takes into account the in-degree of the node but also how evenly its adjacent nodes are conditionally distributed.
- Node entropy provides a measure for generality that can be used to rank hypernym/hyponym candidates via the "R-measure" (Niepert et al. 2007):

$$R(i \to j) = J(i \to j) \times \frac{H(i) - H(j)}{H_{max}} \qquad H(i) = -\sum_{k \in \{j | (i,j) \in E\}} p(k|i) \log p(k|i)$$

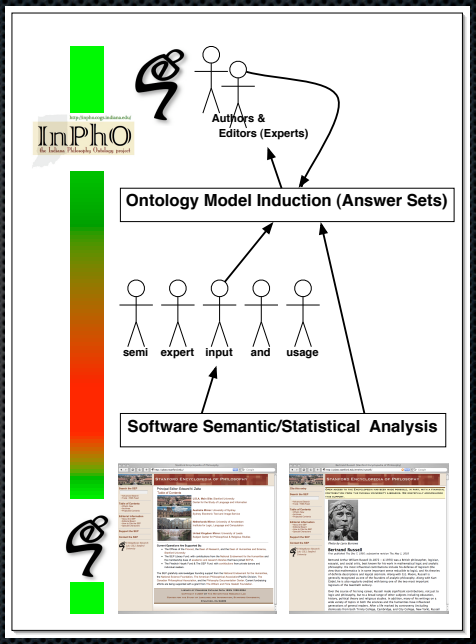
	ID	ante_name	ante_id	cons_name	cons_id	confidence	jweight	weight
	4118455	interpretations of probability	1212	probability or statistics	984	0.462572	0.00314345	0.00055116226184344
	4194454	mind	2194	body	2163	0.0964258	0.0031342	6.21925329774964e-05
	4155520	identity	1581	personal identity and ethics	1666	0.0791403	0.00312541	-0.000765116937470417
	4192979	expression and idiom	875	reference and denotation	876	0.162823	0.00312527	-2.188157133648 15e-05
	4045690	memory	1850	epistemological problems of memory	1299	0.137268	0.00312259	-0.000948000268064484
	3975746	existence	1545	existence of god	2013	0.0504892	0.00311267	-0.000175873536732548
	4192590	belief	921	justification	2195	0.0840042	0.00310113	-4.438581281305 08e-06

Table 2: Top 10 ranked hyponym candidates for the term-node *science* by R-value.

rank	node j	in-deg.	node i	in-deg.	J	H(i)-H(j)	R	$P(i\|j)$
1	cognitive science	409	science	823	0.5046	0.0502	0.0253	1.0
2	computer science	294	science	823	0.2101	0.0653	0.0137	1.0
3	social science	412	science	823	0.4225	0.0283	0.0119	1.0
4	conservation biology	61	science	823	0.0108	0.3308	0.0036	0.2097
5	physics	688	science	823	0.1872	0.0171	0.0032	0.2073
6	laws of nature	460	science	823	0.0424	0.0642	0.0027	0.1796
7	mathematics	633	science	823	0.1575	0.016	0.0025	0.2143
8	biology	522	science	823	0.1127	0.0217	0.0024	0.2323
9	molecular biology	193	science	823	0.016	0.1496	0.0024	0.1789
10	neuroscience	308	science	823	0.0473	0.0491	0.0023	0.3419

Leveraging Expertise

- Simple question interface to gather feedback on statistically generated “hypotheses”
- Automated (nonmonotonic) reasoning to put the pieces together (Answer Set Programming)



This is the page for the node **philosophy of cognitive science**

You can navigate through the idea tree by clicking on the topic node links the left. Clicking on a node expands it into the available subtopics. If no terms appear below, on the right side of this page, then please follow links until some do.

For each term shown below on the left, please indicate its relationship to the topic node selected (i.e., philosophy of cognitive science). You may skip any items you are unsure about. For more information about what you are being asked to do, please click here.

- How should I decide the relatedness or relative generality of two ideas? (see 1-4)
- How hard should I think about idea pairs which seem odd?
- Can I review/revise my feedback?

Page 1 2 3 4 5 6 7 8 9 10 Add your own | Jump to submit button

unrelated ○ ○ ○ ○ ◉ highly related reset [SEP] [Google SEP]

mental imagery | incomparable/either | philosophy of cognitive science

☐ This is not a philosophical idea. ?

unrelated ○ ○ ○ ○ ◉ highly related reset [SEP] [Google SEP]

folk psychology | is more specific than / is more general than / ✓ is as general as / incomparable/either | philosophy of cognitive science

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connectionism | is more specific than | philosophy of cognitive science

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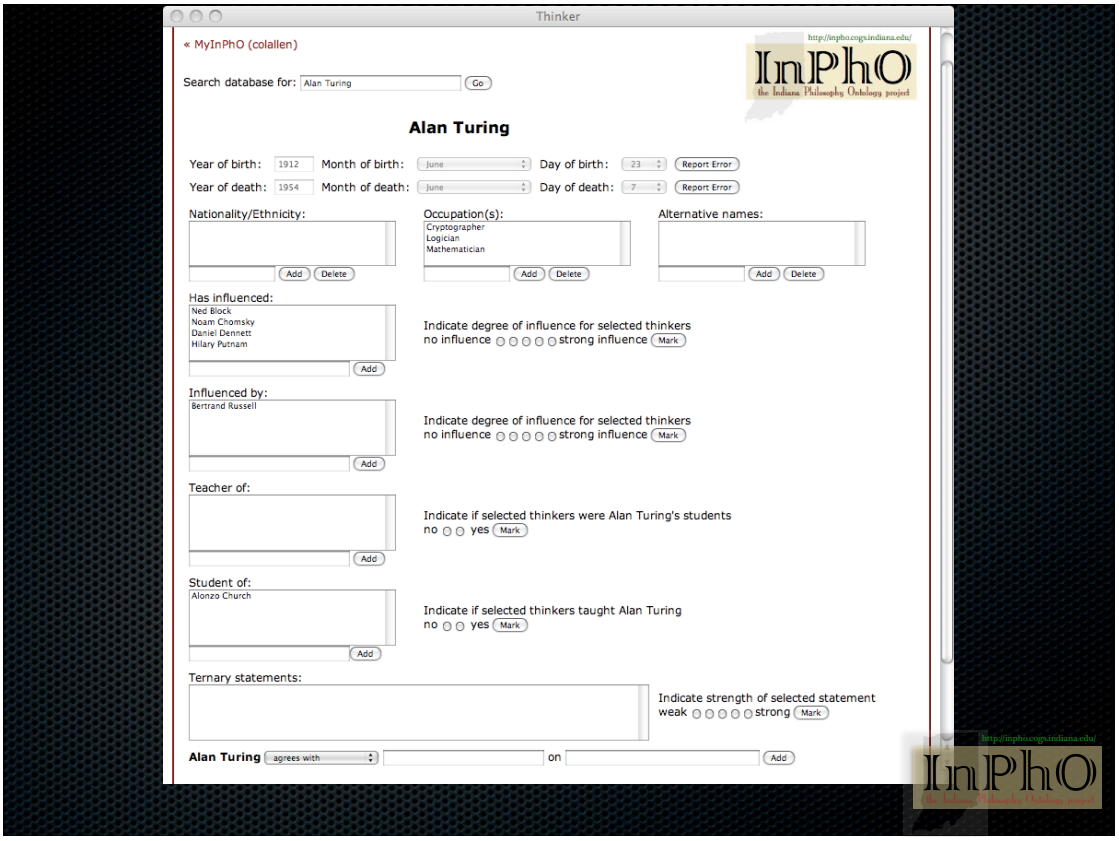

Software 2

- Is it possible to use possibly conflicting evalautions?
  - Yes: Non monotonic reasoning.
  - We use answer-set programming.

$$mg(X,Y) \leftarrow ms(Y,X) \quad (1)$$
$$ms(X,Y) \leftarrow mg(Y,X) \quad (2)$$
$$ic(X,Y) \leftarrow ic(Y,X) \quad (3)$$
$$s_i(X,Y) \leftarrow s_i(Y,X), i \in \{0,...,4\} \quad (4)$$
$$mg(X,Y) \leftarrow mg(X,Z), mg(Z,Y) \quad (5)$$
$$ms(X,Y) \leftarrow ms(X,Z), ms(Z,Y) \quad (6)$$
$$ic(X,Y) \leftarrow ms(X,Y), mg(X,Y), s_i(X,Y), i \in \{3,4\} \quad (7)$$
$$desc(X,Y) \leftarrow isa(X,Y), class(X), class(Y) \quad (8)$$
$$desc(X,Z) \leftarrow desc(X,Y), desc(Y,Z), class(X), \quad (9)$$
$$class(Y), class(Z)$$
$$pins(X,Y) \leftarrow s_i(X,Y), ms(X,Y), not\ class(X), \quad (10)$$
$$class(Y), not\ ic(X,Y),\ i \in \{3,4\}$$
$$plink(X,Y) \leftarrow s_i(Y,X), ms(Y,X), not\ desc(Y,X), \quad (11)$$
$$not\ ic(Y,X), class(X), class(Y),\ i \in \{3,4\}$$
$$plink(X,Y) \leftarrow s_4(X,Y), ic(X,Y), not\ desc(Y,X), class(X) \quad (12)$$
$$nins(X,Y) \leftarrow pins(X,Z), desc(Z,Y), not\ class(X), \quad (13)$$
$$class(Y), class(Z)$$
$$nins(X,Y) \leftarrow pins(X,Z), plink(Y,Z), not\ class(X), \quad (14)$$
$$class(Y), class(Z)$$
$$instance\text{-}of(X,Y) \leftarrow pins(X,Y), not\ nins(X,Y) \quad (15)$$
$$nlink(X,Y) \leftarrow instance\text{-}of(Y,Z), plink(X,Z), class(X), \quad (16)$$
$$not\ class(Y), class(Z)$$
$$nlink(X,Y) \leftarrow instance\text{-}of(Y,Z), desc(Z,X), class(X), \quad (17)$$
$$not\ class(Y), class(Z)$$
$$nlink(X,Y) \leftarrow instance\text{-}of(Y,X), class(X), not\ class(Y) \quad (18)$$
$$nlink(X,Y) \leftarrow plink(X,Z), desc(Y,Z), class(X), \quad (19)$$
$$class(Y), class(Z)$$
$$nlink(X,Y) \leftarrow isa(X,Z), isa(Y,Z), class(X), \quad (20)$$
$$class(Y), class(Z)$$
$$links\text{-}to(X,Y) \leftarrow plink(X,Y), not\ nlink(X,Y)$$

Answer Set Programming

- Three parts:
  - Signature: predicate symbols (e.g., desc) and set of terms (here: terms referring to ideas in Philosophy)
  - Declaration: Set of feedback facts, (e.g., more-specific(Neural Network, Connectionism)) and the facts given by the existing ontological structure (e.g., is-a(Thinking Machines, Artificial Intelligence))
  - Regular Part (set of rules)

Answer Set Programming Conflicting Feedback

- Conflicting feedback is possible!
- Modeled using predicate ic (inconsistent):
  - ic(X, Y) :- ms(X, Y), mg(X, Y).
- Can be used to model “semantic links” between incomparable ideas:
  - plink(X, Y) :- s4(X, Y), ic(X, Y), not desc(X, Y), class(X).

Quality of response

- Is it possible to use feedback according to quality?
  - If *X* is an author or editor at the SEP, then *X* is an expert in subject areas *a*, *b*, ...
  - If *Y* provides feedback in area *a* that is well correlated with experts in *a*, then *Y*'s feedback about edge *E* in *a* may be trusted in the absence of contrary expert feedack.

Managing Expertise

- Is it possible to use feedback according to quality?
  - If *X* is an author or editor at the SEP, then *X* is an expert in subject areas *a*, *b*, ...
  - If *Y* provides feedback in area *a* that is well correlated with experts in *a*, then *Y*'s feedback about edge *E* in *a* may be trusted in the absence of contrary expert feedack.

```
%stratified input predicates are named same as unstratified counterparts but with "i" suffix
rating(0).
rating(1).
rating(2).
rating(3).
rating(4).

%process expert-level-stratified input versions of predicates into those used by program
%inverse
msi(X, Y, A) ← mgi(Y, X, A), rating(A).
mgi(X, Y, A) ← msi(Y, X, A), rating(A).

%similarity symmetry
p4i(X, Y, A) ← p4i(Y, X, A), rating(A).
p3i(X, Y, A) ← p3i(Y, X, A), rating(A).

%incomparable symmetry
ici(X, Y, A) ← ici(Y, X, A), rating(A).

%evidence against similarity ratings if contradicted by those at a higher level
np4(X, Y, A) ← p4i(X, Y, A), p0i(X, Y, B), B>A, rating(A), rating(B).
np4(X, Y, A) ← p4i(X, Y, A), p1i(X, Y, B), B>A, rating(A), rating(B).
np3(X, Y, A) ← p3i(X, Y, A), p0i(X, Y, B), B>A, rating(A), rating(B).
np3(X, Y, A) ← p3i(X, Y, A), p1i(X, Y, B), B>A, rating(A), rating(B).

%if no evidence against the similarity at that level, allow to pass through the "filter"
p4(X, Y) ← p4i(X, Y, A), not np4(X, Y, A), rating(A).
p3(X, Y) ← p3i(X, Y, A), not np3(X, Y, A), rating(A).

%allow lower-level generality evaluations to pass through if not contradicted by a higher level
%mg(X, Y) ← mgi(X, Y, A), rating(A), rating(B), not msi(X, Y, B), B>A.
%ms(X, Y) ← msi(X, Y, A), rating(A), rating(B), not msi(X, Y, B), B>A.

%evidence against the generality ratings at one level if contradicted by those at a higher level
nmg(X, Y, A) ← mgi(X, Y, A), msi(X, Y, B), B>A, rating(A), rating(B).
nms(X, Y, A) ← msi (X, Y, A), mgi(X, Y, B), B>A, rating(A), rating(B).

%if no evidence against the generality at that level, allow to pas
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Representing Philosophy
Three Models

- Wiki — Power to the people! The world is flat!
- Peer reviewed — Experts know best! Mountaintop sanctuaries (SEP, "Formal" Ontology)
- Stratified — From each according to ability! A complex landscape (InPhO)