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SEMPER: Semantic Search for Patient Self-Management

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Switzerland

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Outline

1. What SEMPER is about
2. The Need for Semantic Search
3. Ontology Learning with ai-one™ Hoffleisch Neural Nets
4. Evaluation of Ontology Learning
5. Future Work: Information Extraction with ai-one™
6. Outlook

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SEMPER: Fact Sheet

Motivation:

- increase in chronic diseases causes growing health costs
- support and education for self-care is essential for compliance and long-term behavioural change
- new media have great potential in an integrated health care approach, esp. for personalised monitoring and information access

Application scenarios:

- work-related health problems
- alcohol-related problems

Goals:

- empowering patients
- Web-based platform for patient self-management

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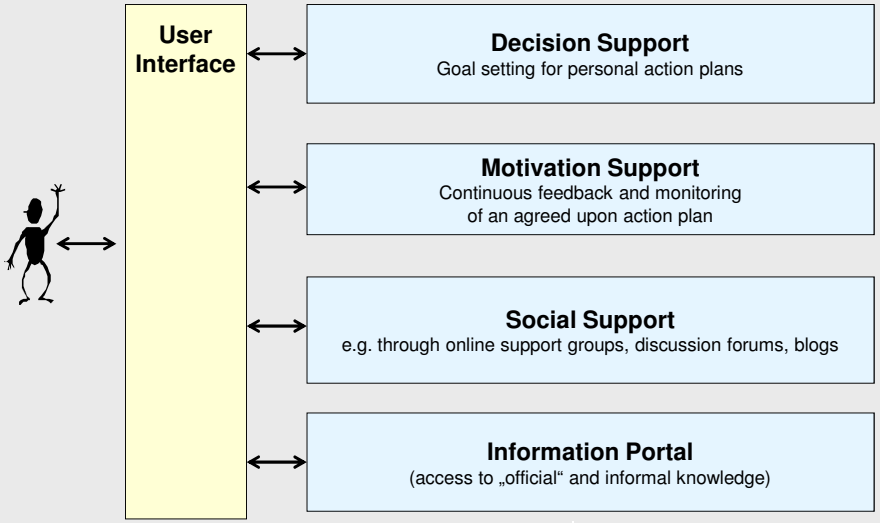
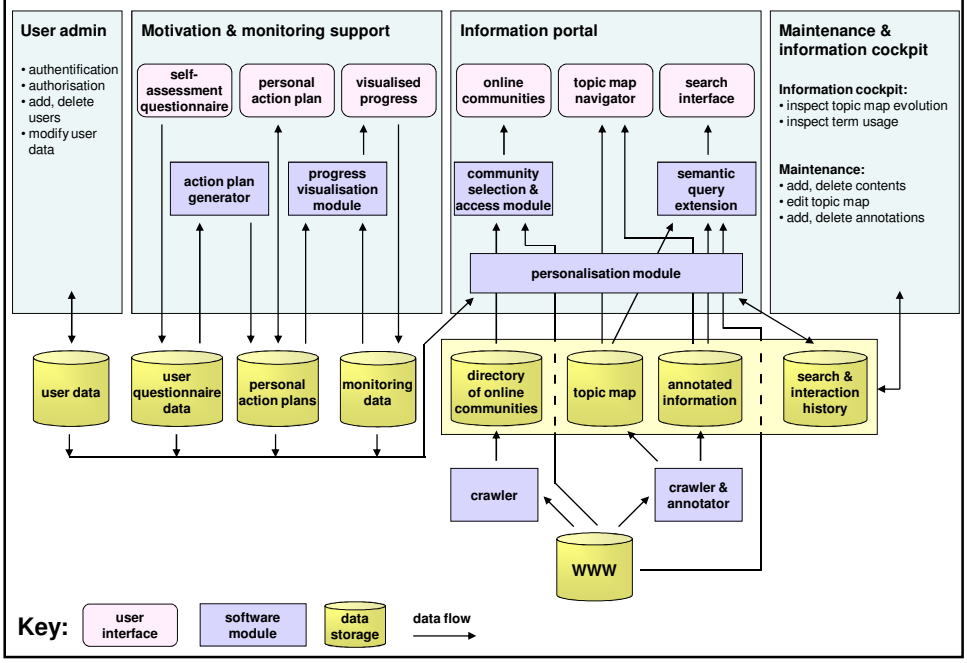
Functional Modules of the Self-Management System



SEMPER: System Architecture



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Motivation and Monitoring Support

Work-related disorders

Ergonomic check of workplace with natural language dialogue or juxtaposing real and ideal images of workplace

Compliance by means of group pressure and incentives offered by employer

Alcohol dependency

Self-help tool with self-assessment and self-management only for anonoymous visitors

Online community support for after-care of ex-patients

Success stories

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Community Support

Benefits of virtual support groups:

- Participation independent of time and space → suitable for people living in remote areas or people homebound due to illness, age or handicap
- Anonymity is often desirable for exchange on stigmatised (health) problems
- Online communities are an untapped knowledge resource

Virtual support groups are integrated into the search function

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Semantic Information Portal

3 Types of Information Sources:

1. Internal:
   high-quality information provided by organisations and experts,
   e.g. specific clinical pictures, case histories, activities/actions to reduce or eliminate symptoms
2. External from community sites:
   Information gathered from discussion forums, blogs etc.
3. External from the Web:
   from relevant information sources on the Web

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Why Semantic Search?

- Huge gap between information needs of patients and their transformation into appropriate queries
- People often don't know what they are looking for
- Popular terms vs. subject-specific terminology (esp. in the medical domain)

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Problems with Standard Text Retrieval (1)

treatment of a sore throat | Search

Are there any home remedies for a sore throat?
...
Salt water gargles, hard candies, sprays and lozenges can provide temporary pain relief.
...

...
A humidifier may be helpful in relieving symptoms, especially in sore throats caused by mouth breathing and dry air.
...

. . .

Antibiotics are prescribed for pharyngitis caused by bacteria. These drugs are effective in killing bacteria, and certain other organisms, but not viruses.
...

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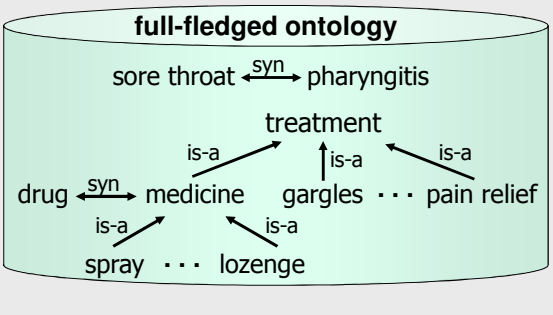
Query Extension through Background Knowledge (1)

treatment of a sore throat | Search

automatic query extension



(treatment OR medicine OR drug OR gargles OR …) AND
(sore throat OR pharyngitis)

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Problems with Standard Text Retrieval (2)

lifestyle “back pain” Search

…
However, if you are overweight or obese, chances are you have, or will have, back pain.
…

…
There is a strong connection between stress and back pain.
…

. . .

…
studies show that there is a direct relationship between smoking cigarettes and having back problems.
…

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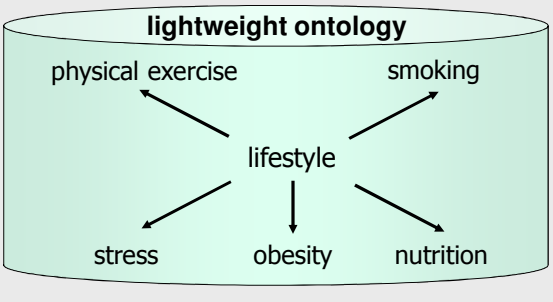
Query Extension through Background Knowledge (2)

lifestyle “back pain” Search

automatic query extension



(lifestyle OR physical exercise OR stress OR smoking OR obesity OR …) AND “back pain”

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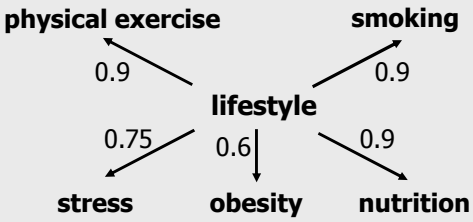
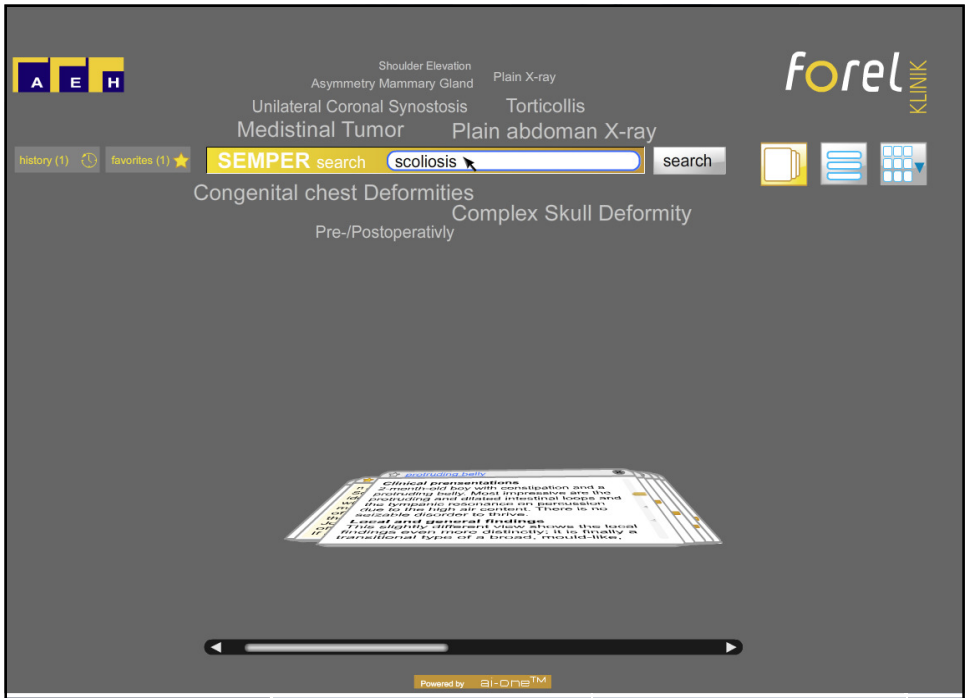
Lightweight Ontologies: Association Strength



→ Lightweight ontologies are also called associative networks



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Navigate the Search Results

lifestyle “back pain” Search

automatic query extension

- lifestyle
  - physical exercise
    - Physical exercise against back pain
    - Back pain – more daily exercise
    - Relieving back pain with yoga
    - Back pain: Exercise instead of bed rest
  - nutrition
  - smoking
  - stress
  - overweight

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Where Do the Ontologies Come From?

Possible solutions:

- manual construction: in most cases too costly or impossible
- ontology learning: difficult for full-fledged ontologies
- sharing / reuse of ontologies: limited possibilities
- folksonomies: more a supplement than a solution

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Where Do the Ontologies Come From?

Possible solutions:

- manual construction: in most cases too costly or impossible
- ontology learning: we do it for lightweight ontologies
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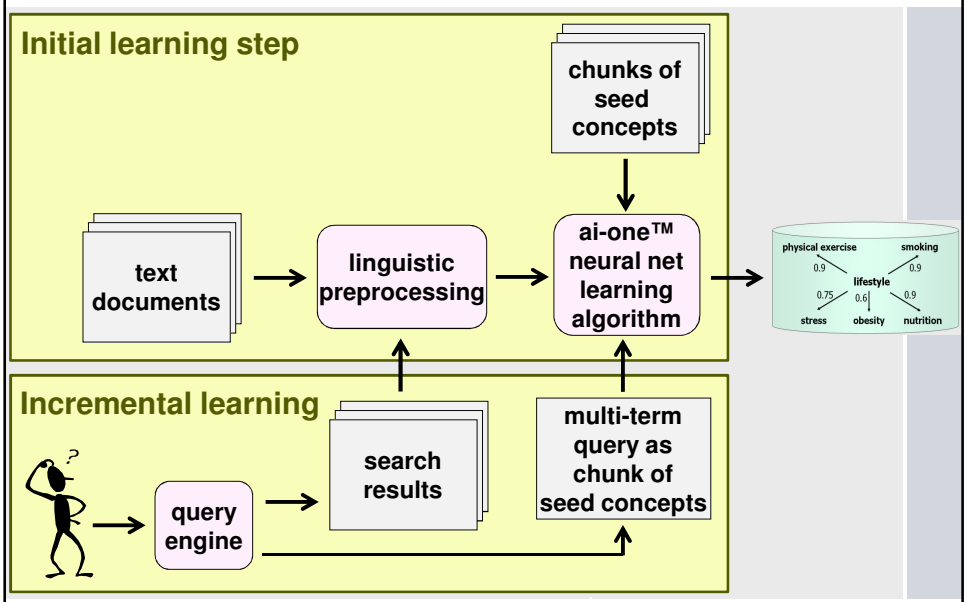
Learning Scenario



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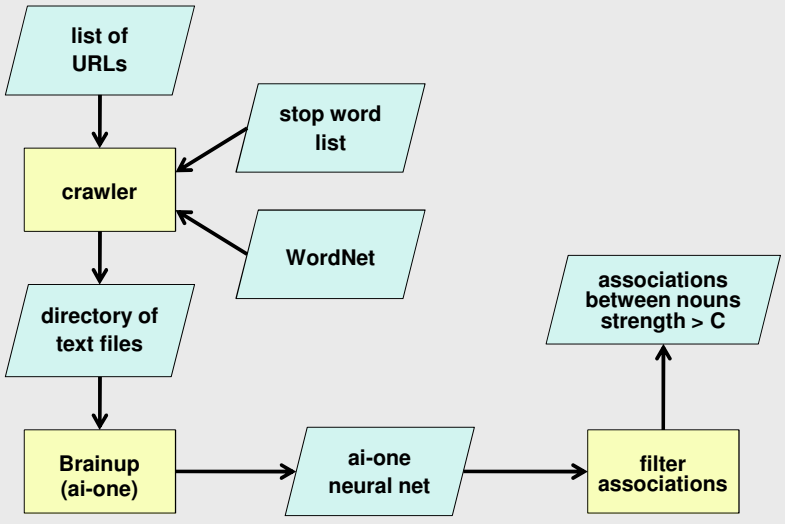
Workflow for Ontology Creation



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ai-one™: Hoffleisch Neural Networks

Characteristics:

- biologically inspired: neurons with axons, synapses, dendrites
- stimulation by binary spikes, no thresholds
- stimuli are encoded as distribution of spikes over time
- reinforce traversed connections
- weaken non-traversed connections
- create new connections as a reaction to stimuli
- no predefined topology or neighbourhood function

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ai-one™: Hoffleisch Neural Networks

Providing a notion of relevance by overlapping chunks of concepts:

$chunk_1$ = { back pain, stress relief, physical exercise, posture, ergonomic workplace }

$chunk_2$ = { obesity, nutrition, physical exercise, self esteem}

life philosophy

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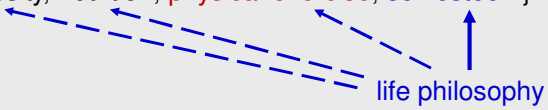

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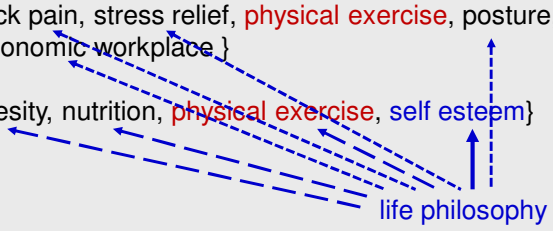

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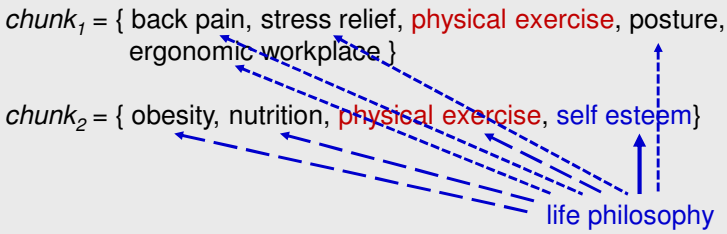

- higher-order term co-occurrences: sub-sentences & chunks
- chunks are hypergraphs
- chunks introduce background knowledge

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Evaluation of Ontology Learning with ai-one™

Comparison with cosine measure from vector space model on a tf-idf document term matrix:

$$tf_{ij} = \frac{n_{ij}}{\sum_k n_{kj}}$$

$$idf_i = log \frac{|D|}{|\{d \in D \mid t_i \in d\}|}$$

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Evaluation of Ontology Learning with ai-one™ (1)

query term	*c* = 0.8						*c* = 0.9					
	ai-one™			cos/tf-idf			ai-one™			cos/tf-idf		
	R	T	R/T	R	T	R/T	R	T	R/T	R	T	R/T
alcohol dependency	42	64	0.66	4	6	0.66	40	57	0.7	1	2	0.5
alcohol problem	44	64	0.69	7	16	0.44	10	16	0.63	1	4	0.25
prevention	13	20	0.65	0	0	0	12	17	0.7	0	0	0
. . .	…	…	…	…	…	…	…	…	…	…	…	…
therapy	79	116	0.68	9	13	0.69	71	104	0.68	0	0	0
treatment facility	6	8	0.75	10	48	0.21	4	6	0.67	10	46	0.22
withdrawal symptoms	29	32	0.9	15	34	0.44	28	31	0.9	6	9	0.67
average		60.9	0.73		38.3	0.47		46.6	0.73		30.8	0.41

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Evaluation of Ontology Learning with ai-one™ (2)

Advantages of ai-one™ over other approaches:

- incremental learning
- works already on a small number of input texts
- asymmetric (directed) associations
- computationally tractable

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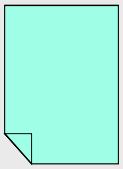
Information Extraction with ai-one™

Hidden Relationships in a Search Formulation

Ibuprofen “side effect” Search

has



wanted:
documents about
the drug Ibuprofen and
the side effects it has

not wanted:
documents where
the drug Ibuprofen and
the word „side effect“
are mentioned

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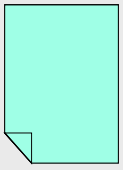
Information Extraction with ai-one™

Hidden Relationships in a Search Formulation

Ibuprofen “Morbus Bechterew” Search

treats



wanted:
documents about
the drug Ibuprofen and its use for
treating the disease Morbus Bechterew

not wanted:
documents where
the drug Ibuprofen and
the disease Morbus Bechterew
are mentioned

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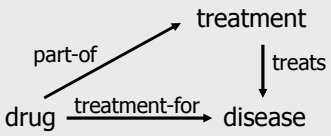
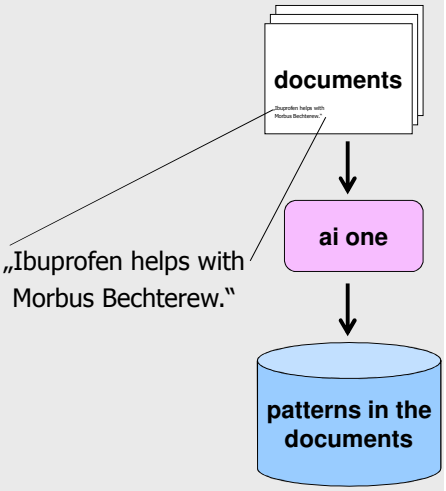
Information Extraction with ai-one™

Automatic Ontology Population after a Training Phase

Manually created ontology:





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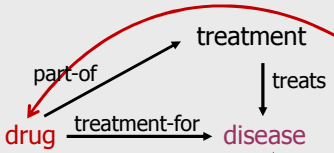

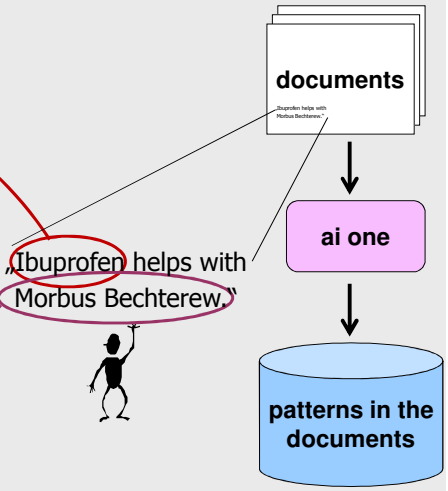

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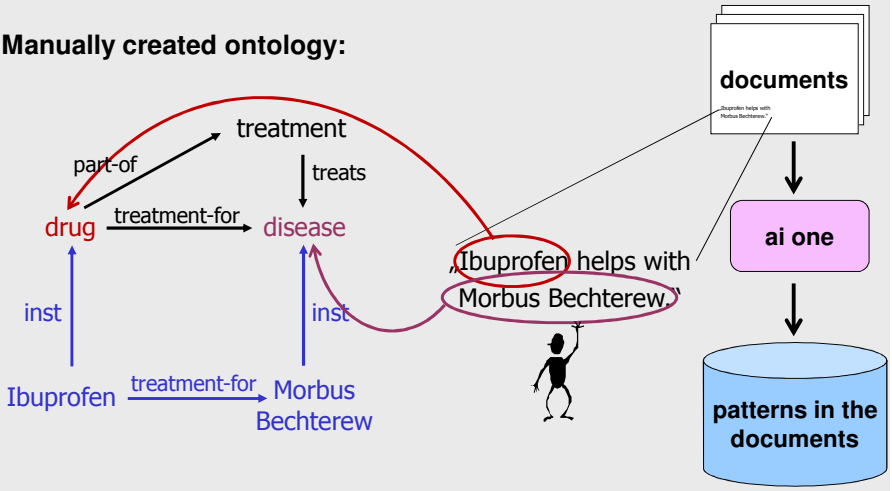

→ **Learning general patterns for certain kinds of statements !**

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Information Extraction with ai-one™

Automatic Ontology Population after a Training Phase

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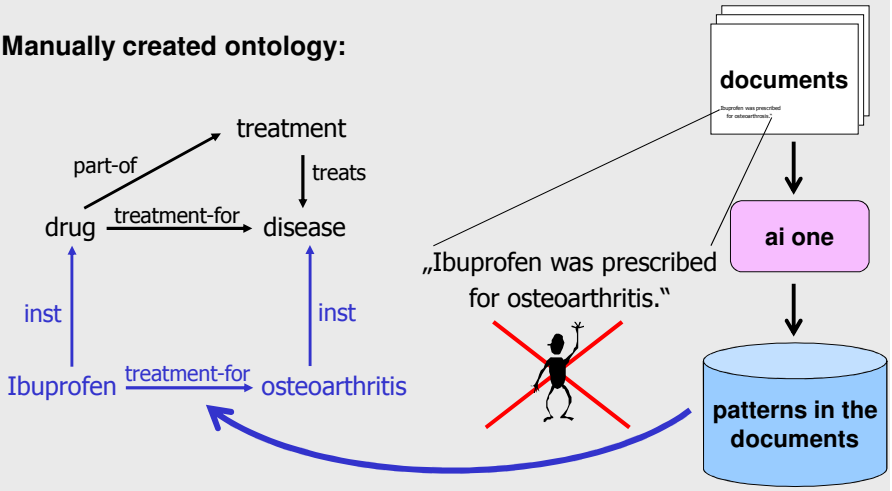

→ **No fact acquisition, only relationships!**

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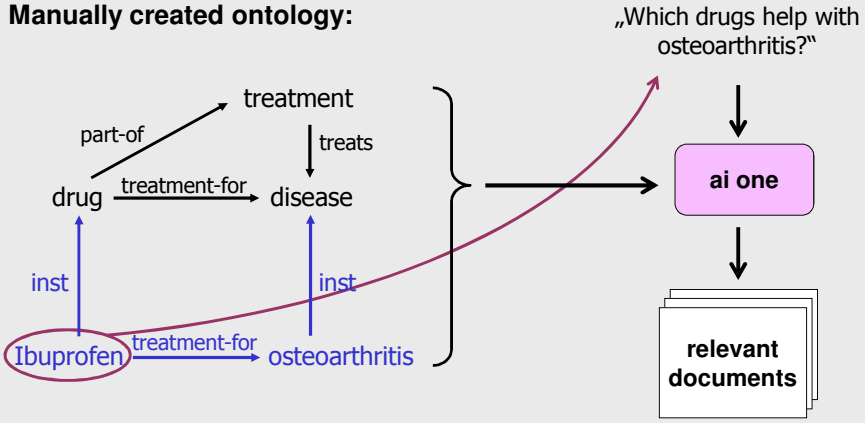
Information Extraction with ai-one™

Semantic Search

Manually created ontology:



→ No fact retrieval, only document (passage) retrieval!

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Outlook

Semantic Search:

- integrate thesauri/ontologies as further background knowledge
- examine effects of text type, text length, number of texts
- use ai-one™ in supervised learning for information extraction

SEMPER overall:

- draw up guidelines for data protection and information security
- address concerns about information quality
- integrate further application partners into the platform