Semantic Atomicity and Multilinguality in the Medical Domain: Design Considerations for the **MorphoSaurus** Subword Lexicon

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Context: Subword indexing for multilingual semantic document indexing

Medical sublanguage: large, dynamic, multi-lingual, heterogeneous user community, rich morphology, highly derivative, single-word compounds, expert-layperson language gap

Subwords as atomic sense units

Atomic senses (in a given language and a given domain context) cannot be univocally derived from the sense(s) of its lexical constituents. Atomic senses can inhere in word stems: (*hepat-*), affixes (*anti-*, *hyper*, *-ectomy*, *-logy*), word fragments (*diagnost-*, *hypophys-)*, straight words (*milz*, *spleen*), combinations of words (*yellow fever*, *vitamin C*).

Representation of (sub)word senses

Each sense is represented by one *MID* (MorphoSaurus ID)
D = (lexeme, MID, domain, language)

- Synonymy:*(lex_1; MID_1; dom_1; $lang_1$);(lex_2; MID_1; dom_1; $lang_1$); (lex_3; MID_1; dom_1; $lang_1$)*
  Example*: nephr-, ren-, kidney*
- Translation*: (lex_1; MID_1; dom_1; $lang_1$); (lex_2; MID_1; dom_1; $lang_2$)*
  Example*: nephr-, riñon*
- Ambiguity*: (lex_1; MID_1; dom_1; $lang_1$); (lex_1; MID_2; dom_1; $lang_1$)*
  Example*: head* (body part vs. chief)
- Coincidence:*(lex_1; MID_1; dom_1; $lang_1$); (lex_1; MID_2; dom_1; $lang_2$)*
  Example*: era* (epoch vs. Spanish past of "to be")
- Domain specificity*: (lex_1; MID_1; dom_1; $lang_1$); (lex_1; MID_2; dom_2; $lang_1$)*
  Example*: aspirin* (in dom_2 brand name ≠ substance)

MIDs can be interrelated by two relations:

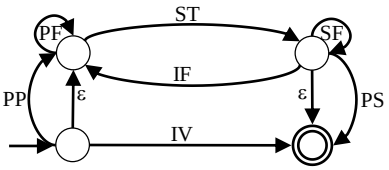
- *Expands* (MID_0; [MID_1; MID_2; :::; MID_3])
  Use: express composed meaning which cannot be suitably expressed by the word composition.
  Example: *Expands*($MID_{urinanalysis}$; [MID_{urine}; $MID_{analysis}$])
- *Has-Sense* (MID_0; {MID_1; MID_2; :::; MID_3})
  Use: treatment of lexical ambiguities.
  Example: *Has-Sense* (MID_{head}; {MID_{caput}; MID_{chief}})

Implementation in MorphoSaurus

Classification and description of lexicon entries in terms of:

- Lexeme classes:
  - Stems (ST), e.g. *hepat*, *enferm*, *diaphys*, *head*
  - Prefixes (PF), *de-*, *re-*, *in-*,
  - Proper Prefixes (PP) cannot be prefixed, e.g. *peri-*, *hemi-*, *down*
  - Infixes (IF), like *-o-*, e.g., in *gastr-o-intestinal*,
  - Sufixes (SF) e.g. *-a*, *-io*, *-ion*, *-tomy*, *-itis* follow a
  - Proper Sufxes (PS) cannot be suffixed, *-ing*, *-ieron*, *-ção*,
  - Invariants (IV), occur isolated e.g. *ion* or *gene*
- Language (English, French, German, Swedish, Spanish, Portuguese)
- MID (equivalence class identifier), only assigned to semantically relevant lexemes
- Inter-MID relations *Expands* and *Has-Sense (see above)*

Word parser



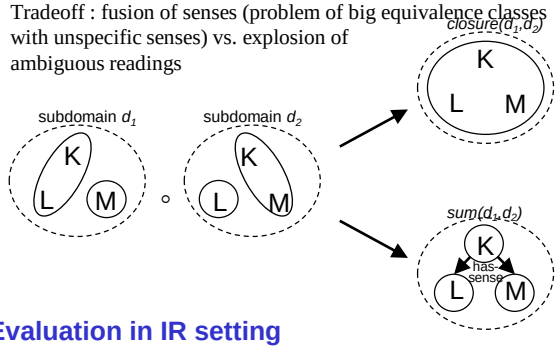
Morphosemantic indexing example

Original Document	Orthographic Normalization	Morphological Segmentation	Semantic Normalization
High TSH values suggest the diagnosis of primary hypothyroidism while a suppressed TSH level suggests hyperthyroidism.	high tsh values suggest the diagnosis of primary hypothyroidism while a suppressed tsh level suggests hyperthyroidism.	high tsh value s suggest the diagnos is of primar y hypo thyroid ism while a suppress ed tsh level suggest s hyper thyroid ism.	**#up# tsh #value#** #suggest# **#diagnost# #primar# #small# #thyre# #suppress# tsh #nivell#** #suggest# **#up# #thyre#** .
Erhöhte TSH-Werte erlauben die Diagnose einer primären Hypothyreose, ein supprimierter TSH-Spiegel spricht dagegen für eine Schilddrüsenüberfunktion.	erhoehte tsh-werte erlauben die diagnose einer primaeren hypothyreose, ein supprimierter tsh-spiegel spricht dagegen fuer eine schilddruesenueberfunktion.	er hoeh te tsh - wert e erlaub en die diagnos e einer primaer en hypo thyre ose, ein supprim iert er tsh - spiegel spricht dagegen fuer eine schilddrues en ueber funktion.	**#up# tsh - #value#** #permit# **#diagnost# #primar# #small# #thyre#** , **#suppress# tsh** - {#mirror# **#nivell#**} #speak# **#thyre# #up#** #function# .
A presença de valores elevados de TSH sugere o diagnóstico de hipotireoidismo primário, enquanto níveis suprimidos de TSH sugerem hipertireoidismo.	a presenca de valores elevados de tsh sugere o diagnostico de hipotireoidismo primario, enquanto niveis suprimidos de tsh sugerem hipertireoidismo.	a presenc a de valor es elevad os de tsh suger e o diagnost ico de hipo tireoid ismo primari o, enquanto niveis suprimid os de tsh suger em hiper tireoid ismo.	#actual# **#value# #up# tsh** #suggest# **#diagnost# #small# #thyre# #primar#** , **#nivell# #suppress# tsh** #suggest# **#up# #thyre#** .

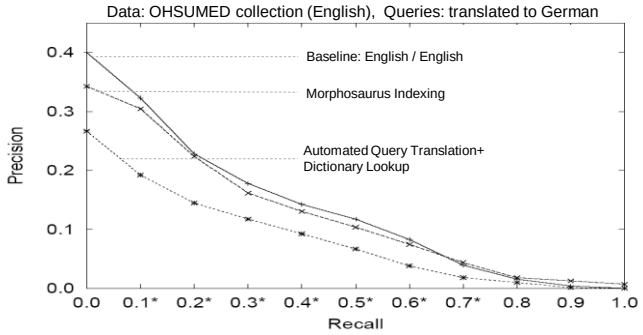
Pragmatics of lexicon building and maintenance

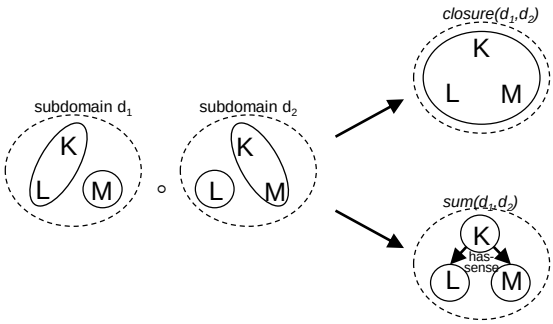
- Delimitation of subwords
  Generation of raw list of morphemes by automated affix stripping.
  - Morpheme candidates are eliminated when utterly short and ccurring as accidental substrings (causing parsing errors), e.g. *ov-*, *gen-*
  - Morpheme combinations are added when composed form has a non-compositional sense, e.g. *bauch|speichel|drüs- de|cubit-*, *neur|os-*
  - Delimitation decisions driven by performance function:
    Precoding of suffix combinations, e.g. *–ibilities*, *-alitäten*
    Prevention of known segmentation errors:
    nephrotomy -> nephr-oto-my (correct: *nephr-o-tomy*)
    addition of *-otomy* solves the problem.

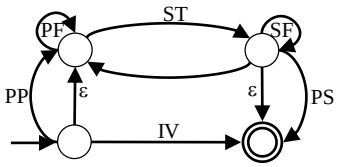
- Grouping of lexemes
  - Creation of equivalence (synonym, translation) classes by incremental fusion of MIDs.
  - Tradeoff : fusion of senses (problem of big equivalence classes with unspecific senses) vs. explosion of ambiguous readings



Evaluation in IR setting




closure(d1,d2)
K
L
M
subdomain d1
K
L
M
∘
subdomain d2
K
L
M
sum(d1,d2)
K
has-sense
L
M


PF
ST
SF
PP
ε
ε
PS
IV

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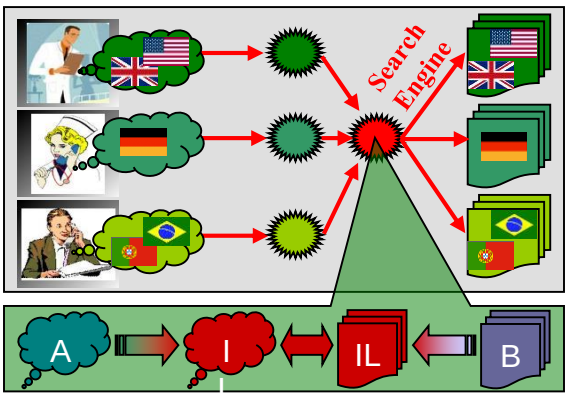
Medical document collections are very large, dynamic, multi-lingual, multi-genre and used by a heterogeneous user community.

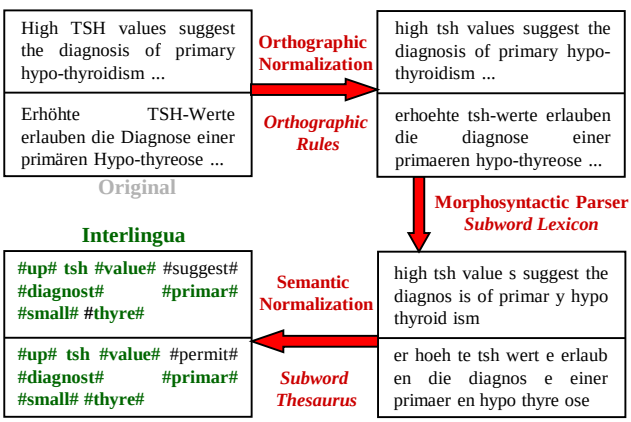
We respond to these challenges for **medical information retrieval** in terms of the **MorphoSaurus system** which is based upon using an **interlingua** representation of both queries and documents.



Interlingual representation: Queries from language A as well as documents from language B are both translated into a language-independent interlingua (IL) on which matching procedures apply.

The Morphosaurus system uses a special type of **dictionary**, with entries consisting of **subwords**, i.e., semantically minimal units. Subwords are grouped into **equivalence classes** which capture **intralingual** as well as **interlingual** synonymy.

A **morphosyntactic parser** extracts subwords and assigns equivalence class identifiers.



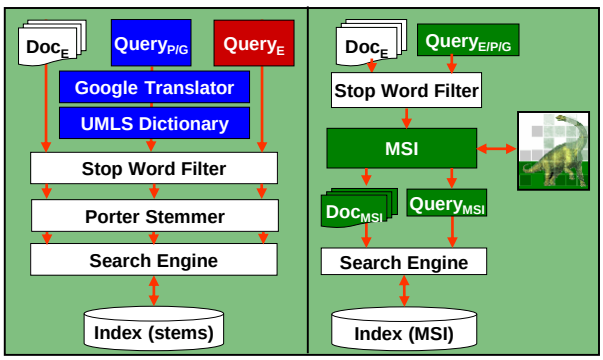
Interlingual **Morpho-semantic Normalization** is achieved by a three-step procedure: orthographic normalization, morphological segmentation and semantic normalization.

Evaluation with the **OHSUMED Corpus** (~233,000 English documents, 106 English queries – translated to German and Portuguese by medical experts)

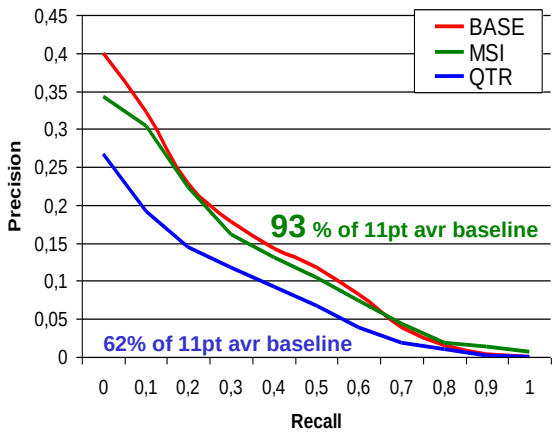
Baseline: monolingual retrieval, $Query_E \leftrightarrow Doc_E$

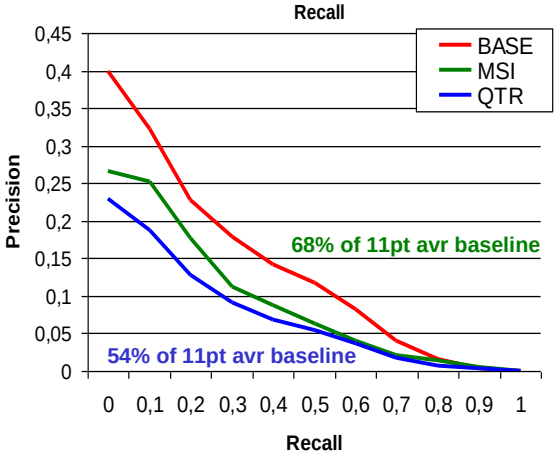
QTR: Query translation - GOOGLE translator & bilingual UMLS dictionary

MSI: Morphosaurus - morpho-semantically indexed queries and documents



Evaluation scenarios: Baseline (left), **query translation** (left), **morpho-semantic indexing (MSI)** (right)





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