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HTP-NLP: A New NLP System for High Throughput Phenotyping

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High Throughput Phenotyping

- Buzz-phrase, floating around the last few years
- Phenotyping: “the algorithmic recognition of any cohort within an EHR for a defined purpose, including case-control cohorts for genome-wide association studies, clinical trials, quality metrics, and clinical decision support”[1]
- High-Throughput: Phenotyping on many records quickly.

[1] Pathak, J., et al.: Normalization and standardization of electronic health records for high-throughput phenotyping: the SHARPn consortium. J Am Med Inform Assoc 20(e2), e341–e348 (2013)

Our Contribution

- Started from examination of the nature of text in medical records
- Two advances:
  - Semantic Indexing
  - Resilience to Non-Grammatical Text

Unstructured EHR Data

- Patient-centric
  - Outside of certain sections, we can assume all text is related to the patient
- Highly conventialized
  - The same phrases are likely to repeat hundreds or thousands of times across a corpus
  - “arrhythmia of the heart”
  - “EKG: normal” (pseudo-sentences)
- Local semantic scope
  - Rarely is understanding >1 sentence required to derive meaning.

Semantic Indexing

- Since there is so much repeated text, repeated processing is wasteful.
- Store each level of analysis in key-value store

Level	Key-Value Store
Discourse	Medical Record -> Sentence / Fragment
Syntax	Sentence -> Word / Phrase (including Polarity / Evidentiality /… markers)
Semantic	Word / Phrase -> Semantically related phrases / synonyms
Analytic	Linguistic semantic content -> Ontological term

- Cohort selection: backtrack from terms -> documents

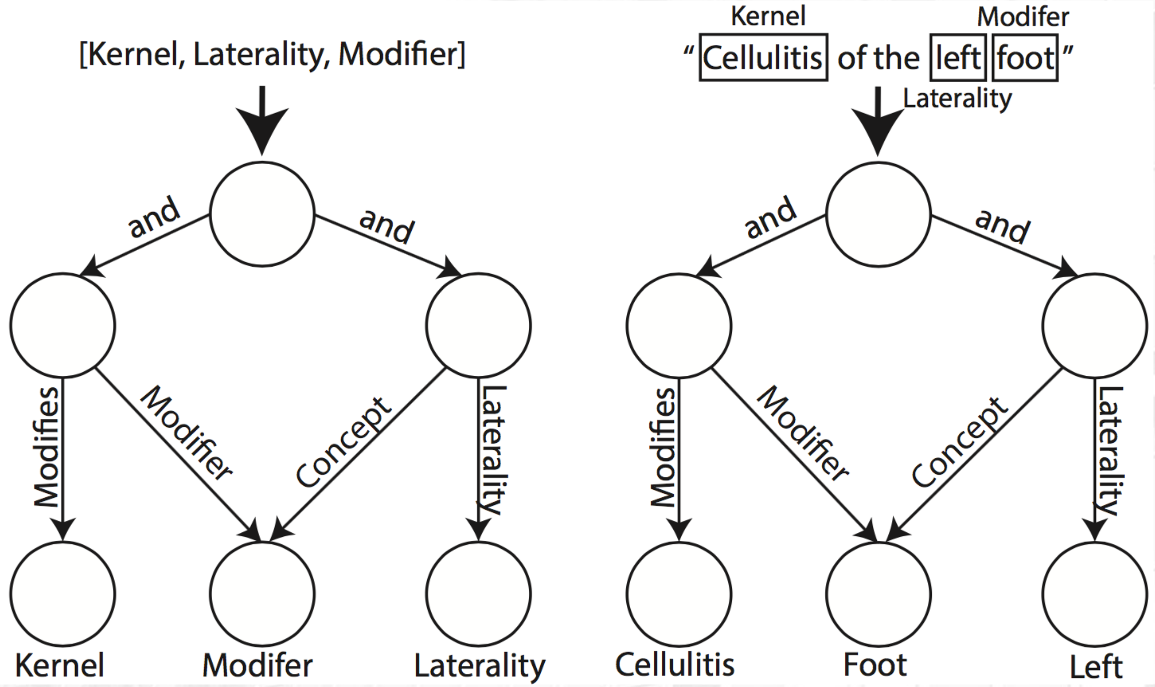
Resilience to Non-Grammatical Text

- Noun-phrase processing can sometimes be done by examining word order alone.
  - Allows for processing ungrammatical text
  - Different surface forms map to the same logical form
  - e.g., *EKG: Normal* vs. *Normal EKG*
- A kind of post-coordination: Compositional Expressions

Compositional Expressions

- Created from the ontological representation of parts of linguistic phrases or sentences.
- Ontology terms (hierarchies) are tagged as being a:
  - kernel – the clinical concept under discussion
  - modifier – changing the meaning of the kernel
  - qualifier – specifying status (e.g., ‘history’)
  - representing laterality – e.g., left or right

Compositional Expression Example



Template graphs for orders of components of CEs are built and matched against

Comparison Testing: Methodology

- Goal: Compare cTAKES vs. HTP-NLP
  - Just speed, no accuracy checks
- Dataset: UBMD Allscripts Database
  - 537,157 encounter notes for 97,964 patients
- Configuration: Single CPU, only components in both cTakes and HTP-NLP tests (no CE extraction)

Comparison Testing: Results

System	Time (minutes)
HTP-NLP	48.3 - 29.3 - linguistic analysis / semantic indexing - 19 - SNOMEC CT / synonym coding
cTAKES	2,299

HTP-NLP was **47.6** times faster than cTAKES in this experiment.

Adding CEs, which cTAKES does not have, roughly doubles processing time.

Conclusion

- The HTP-NLP system improves both portions of the High Throughput Phenotyping ideal
  - Semantic Indexing vastly increases throughput
  - Compositional expressions allow for dealing with non-grammatical text
- We achieved this by designing the system based on an understanding of the input data.

Thank you for your attention!

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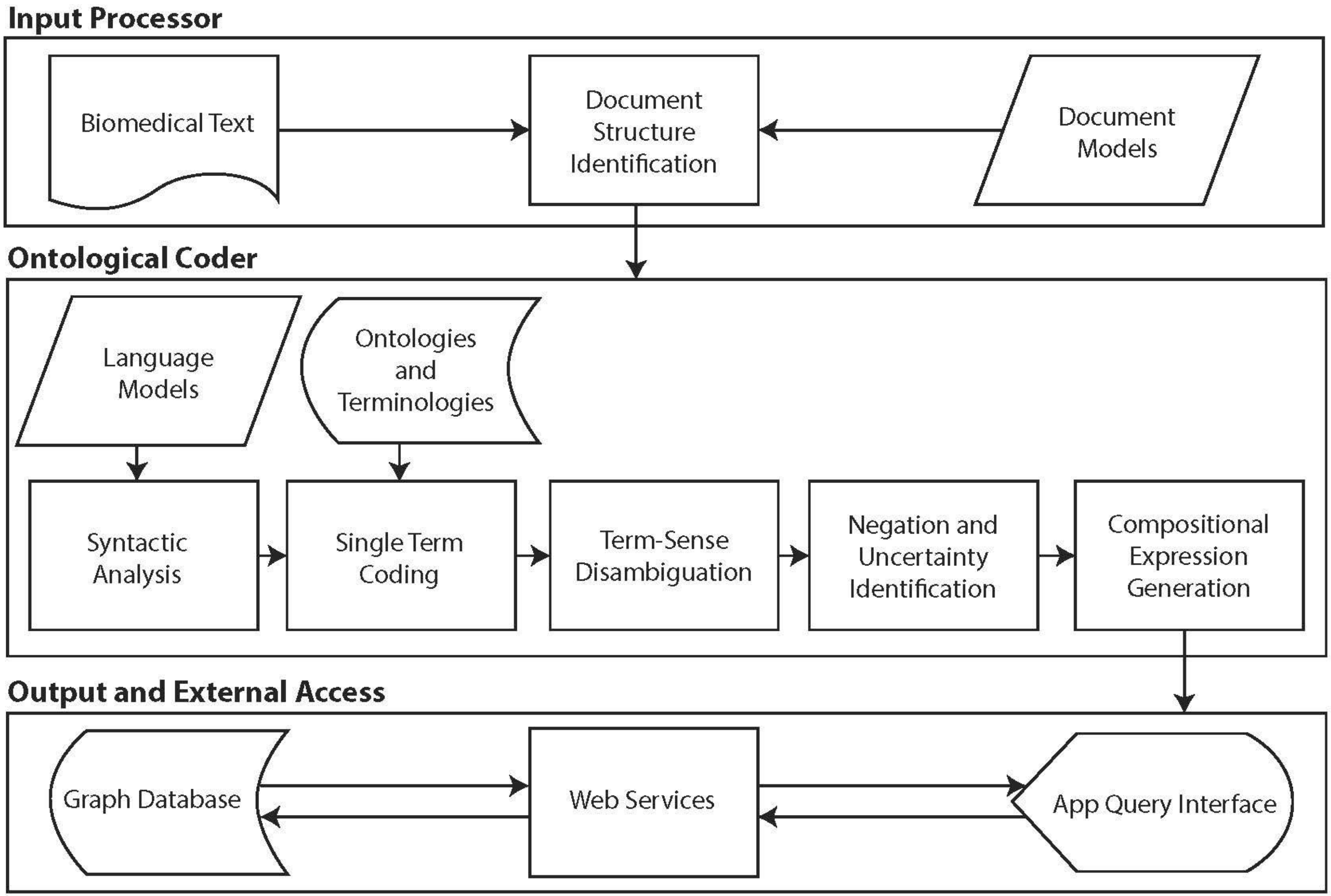
Input Processor
Biomedical Text
Document Structure Identification
Document Models
Ontological Coder
Language Models
Ontologies and Terminologies
Syntactic Analysis
Single Term Coding
Term-Sense Disambiguation
Negation and Uncertainty Identification
Compositional Expression Generation
Output and External Access
Graph Database
Web Services
App Query Interface