Transforming Complex Sentences into a Semantic Hierarchy

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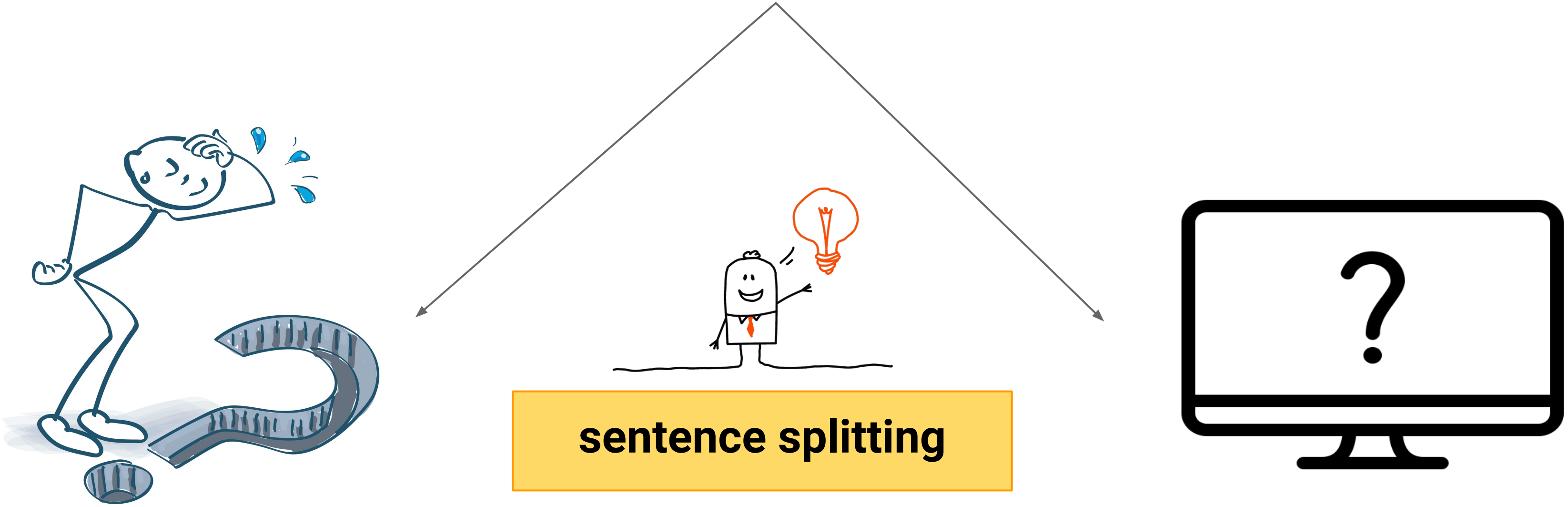
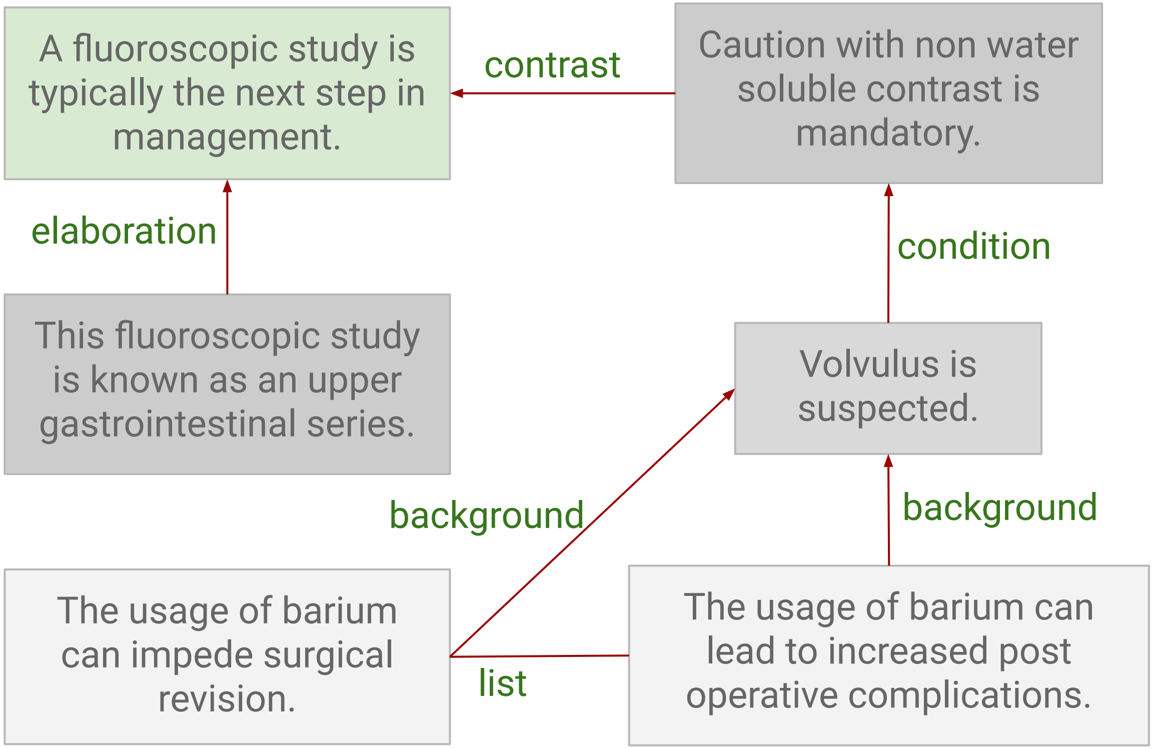
Text Simplification

“A fluoroscopic study known as an upper gastrointestinal series is typically the next step in management, although if volvulus is suspected, caution with non water soluble contrast is mandatory as the usage of barium can impede surgical revision and lead to increased post operative complications.”



sentence splitting

Semantic Hierarchy



A fluoroscopic study is typically the next step in management.

Caution with non water soluble contrast is mandatory.

This fluoroscopic study is known as an upper gastrointestinal series.

Volvulus is suspected.

The usage of barium can impede surgical revision.

The usage of barium can lead to increased post operative complications.

(1) sentence splitting

(2a) contextual hierarchy

(2b) rhetorical relations

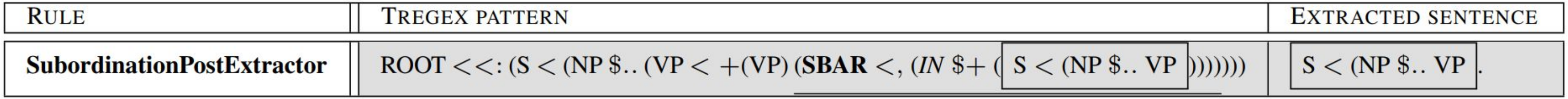
minimal propositions

preservation of coherence structure

Discourse-aware Sentence Simplification

- Recursive transformation stage
- **35 hand-crafted grammar rules**
- Encode syntactic and lexical features

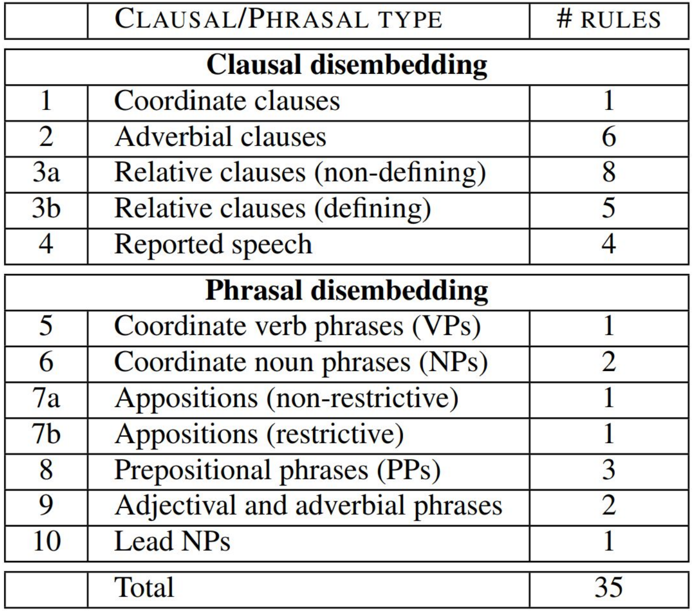
(1) How to **split up and rephrase** the input?
(2) How to set up a **semantic hierarchy**?



RULE	TREGEX PATTERN	EXTRACTED SENTENCE
SubordinationPostExtractor	ROOT <<: (S < (NP \$.. (VP < +(VP) (**SBAR** <, (*IN* \$+ (S < (NP \$.. VP)))))))	S < (NP \$.. VP .

(1) Sentence Splitting

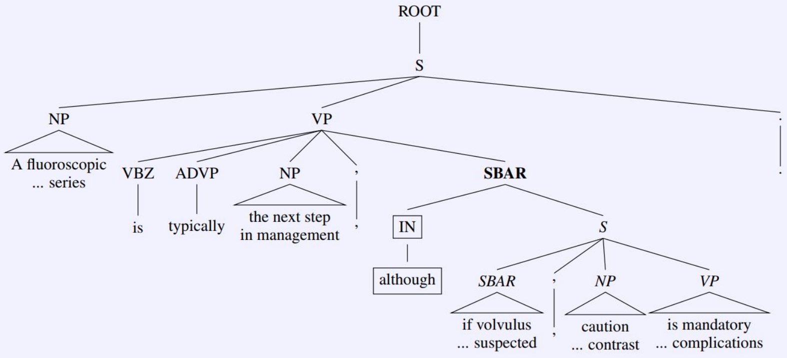
- Rules encode both the **splitting points** and **rephrasing procedure**



	CLAUSAL/PHRASAL TYPE	# RULES
	Clausal disembedding	
1	Coordinate clauses	1
2	Adverbial clauses	6
3a	Relative clauses (non-defining)	8
3b	Relative clauses (defining)	5
4	Reported speech	4
	Phrasal disembedding	
5	Coordinate verb phrases (VPs)	1
6	Coordinate noun phrases (NPs)	2
7a	Appositions (non-restrictive)	1
7b	Appositions (restrictive)	1
8	Prepositional phrases (PPs)	3
9	Adjectival and adverbial phrases	2
10	Lead NPs	1
	Total	35

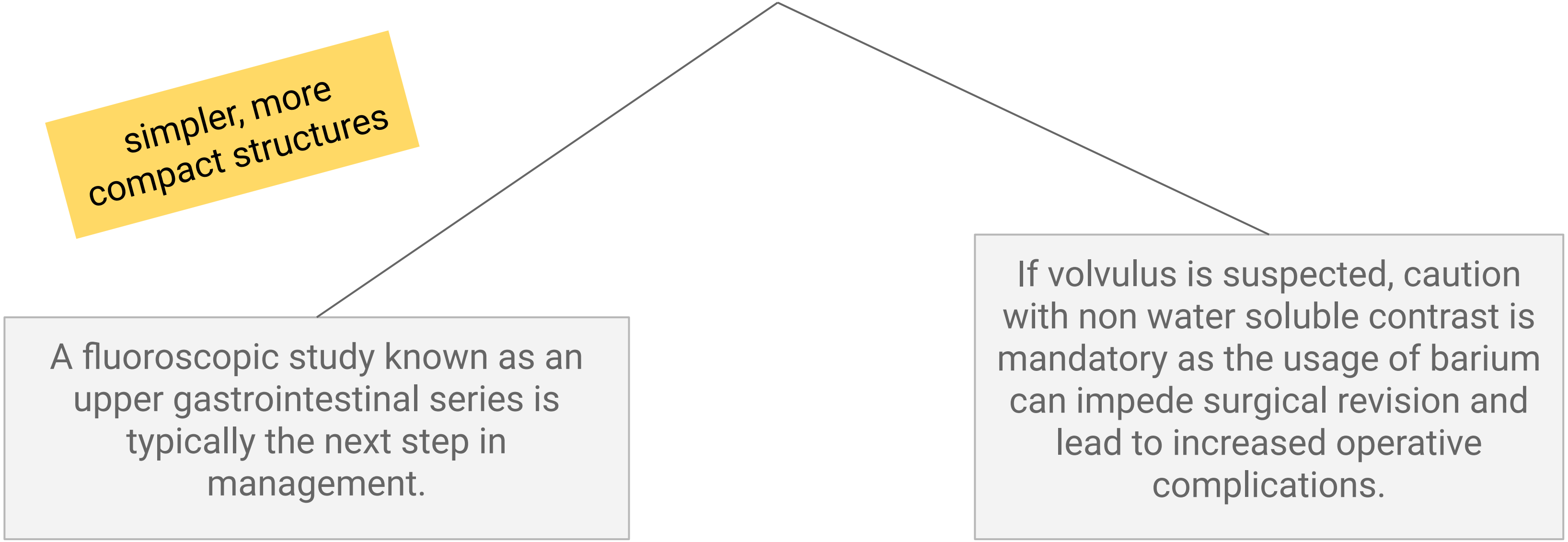
Example: SUBORDINATIONPOSTEXTRACTOR

Matched Pattern:


ROOT
S
NP
A fluoroscopic ... series
VP
VBZ
is
ADVP
typically
NP
the next step in management
,
SBAR
IN
although
S
SBAR
if volvulus ... suspected
,
NP
caution ... contrast
VP
is mandatory ... complications
.

(1) Sentence Splitting: Example

"A fluoroscopic study known as an upper gastrointestinal series is typically the next step in management, although if volvulus is suspected, caution with non water soluble contrast is mandatory as the usage of barium can impede surgical revision and lead to increased post operative complications."



simpler, more compact structures

A fluoroscopic study known as an upper gastrointestinal series is typically the next step in management.

If volvulus is suspected, caution with non water soluble contrast is mandatory as the usage of barium can impede surgical revision and lead to increased operative complications.

(2a) Constituency Type Classification

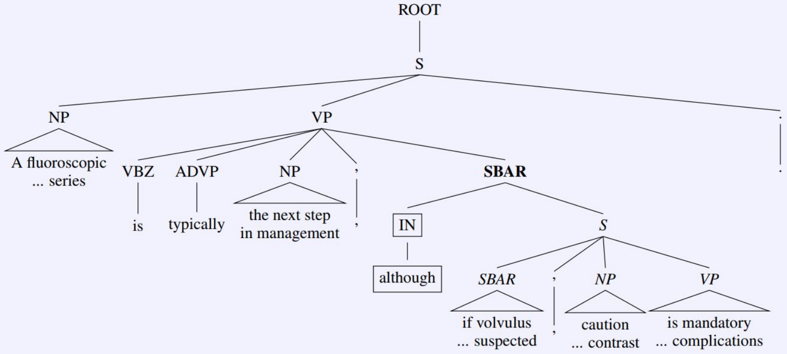
- Establishes a **contextual hierarchy** between the split sentences (based on syntax)
- Adopts the concept of nuclearity from **RST**

coordinations:
CORE

subordinations:
CONTEXT

Example: SubordinationPostExtractor

Matched Pattern: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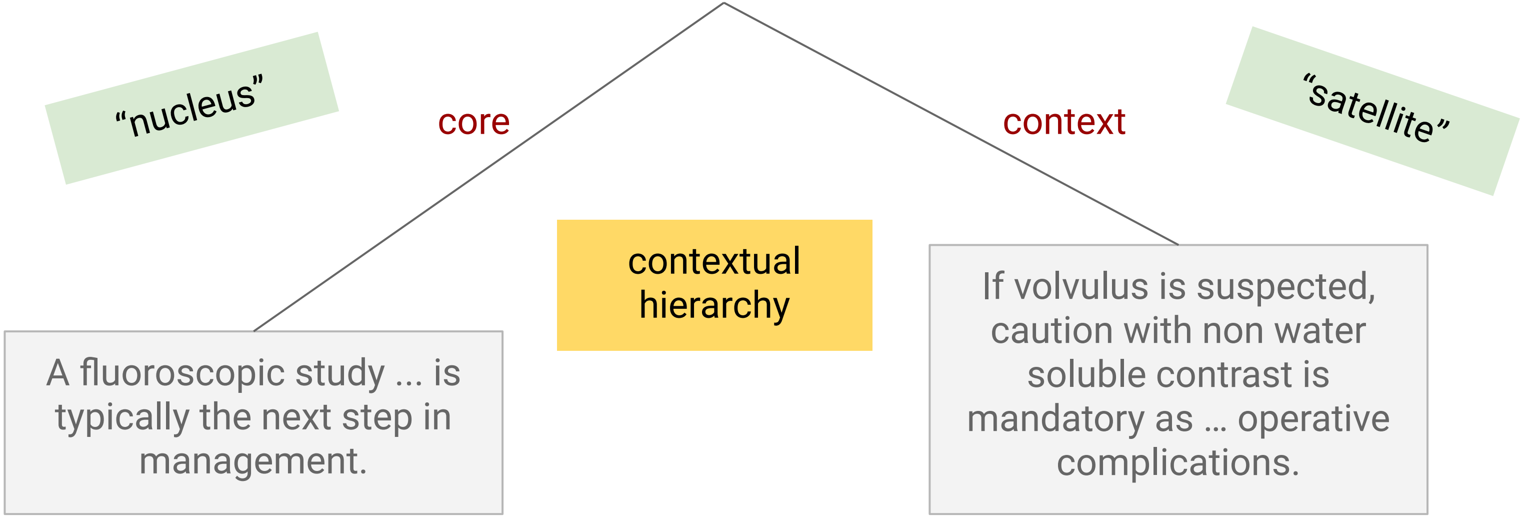
(2a) Constituency Type Classification: Example

“A fluoroscopic study known as an upper gastrointestinal series is typically the next step in management, although if volvulus is suspected, caution with non water soluble contrast is mandatory as the usage of barium can impede surgical revision and lead to increased post operative complications.”



“nucleus”

core

context

“satellite”

contextual hierarchy

A fluoroscopic study ... is typically the next step in management.

If volvulus is suspected, caution with non water soluble contrast is mandatory as … operative complications.

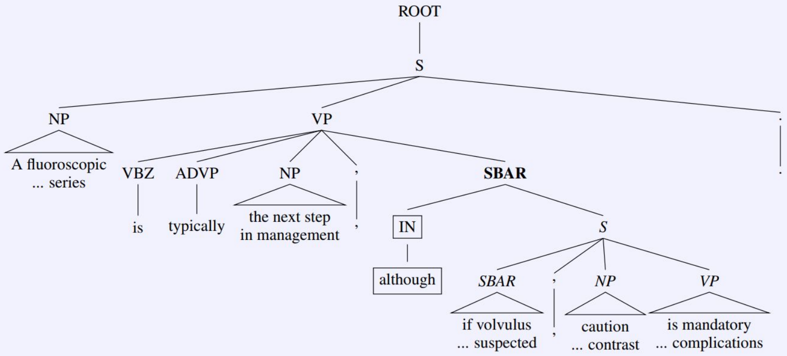
(2b) Rhetorical Relation Identification

- Identifies and classifies **rhetorical relations** that hold between a pair of split sentences
- Based on syntactic and lexical features

mapping of **rhetorical cue words**

Example: SubordinationPostExtractor

Matched Pattern: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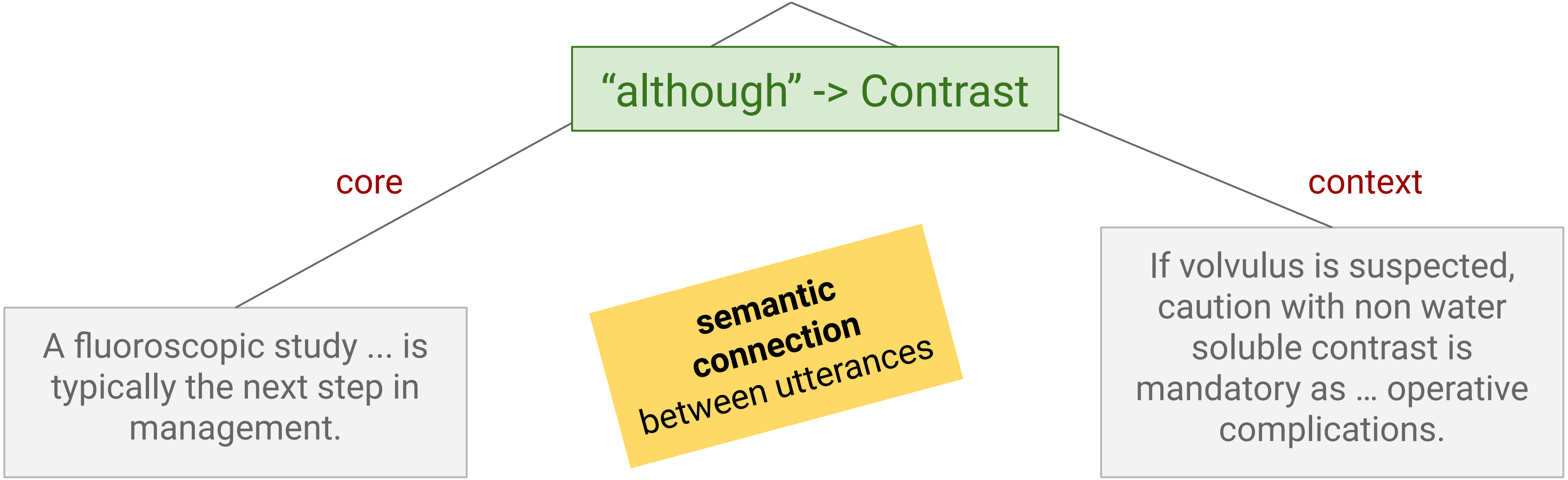
(2b) Rhetorical Relation Identification: Example

“A fluoroscopic study known as an upper gastrointestinal series is typically the next step in management, although if volvulus is suspected, caution with non water soluble contrast is mandatory as the usage of barium can impede surgical revision and lead to increased post operative complications.”



“although” -> Contrast

core

context

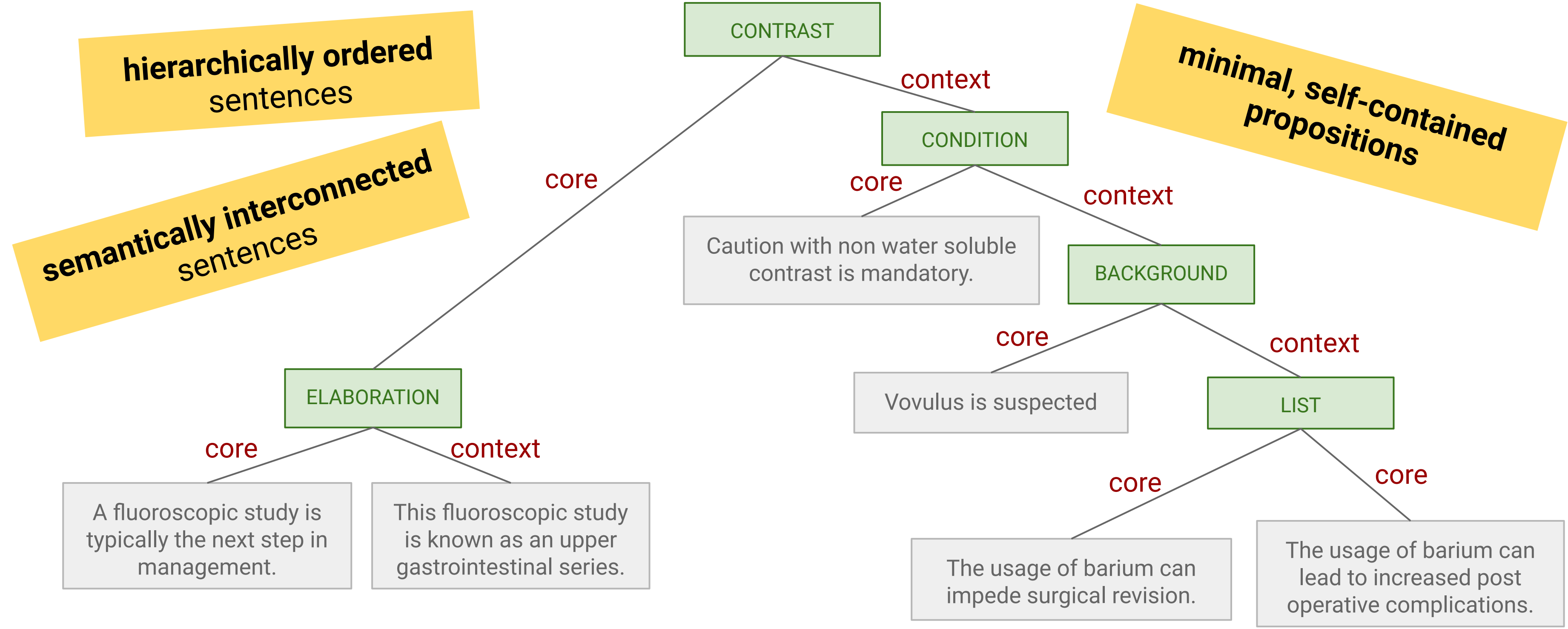
A fluoroscopic study ... is typically the next step in management.

semantic connection between utterances

If volvulus is suspected, caution with non water soluble contrast is mandatory as ... operative complications.

Discourse Tree

- **Recursive** simplification of leaf nodes in a **top-down** fashion until no more rule matches


hierarchically ordered
sentences
semantically interconnected
sentences
minimal, self-contained
propositions
CONTRAST
core
context
CONDITION
core
Caution with non water soluble contrast is mandatory.
context
BACKGROUND
core
Vovulus is suspected
context
LIST
core
The usage of barium can impede surgical revision.
core
The usage of barium can lead to increased post operative complications.
ELABORATION
core
A fluoroscopic study is typically the next step in management.
context
This fluoroscopic study is known as an upper gastrointestinal series.

Evaluation: Baselines

- Focus on **splitting subtask**
- Comparison with state-of-the-art syntactic TS systems that **explicitly model splitting operations**

syntax-driven **rule-based** approaches:

1. RegenT (Siddharthan and Mandya, 2014)
2. YATS (Ferrés et al., 2016)

manual definition of a set of grammar rules based on syntactic information

decomposition of a sentence into its **main semantic constituents**

approaches based on **semantic parsing**:

3. Hybrid (Narayan and Gardent, 2014)
4. DSS (Sulem et al., 2018)

data-driven approaches:

5. Seq2Seq (Botha et al., 2018)

model **learns simplification rewrites** from examples of aligned complex source and simplified target sentences

Evaluation: Corpora

Wikilarge
(359 test sentences)
(Xu et al., 2016)

WikiSplit
(5000 test sentences)
(Botha et al., 2018)

Newsela
(1077 test sentences)
(Xu et al., 2015)

The Arizona Daily Star
TWO KILLED, 15 IN
IN PIONEER
Arizona Daily
"TO MY VALENTINE"
DRINK A TOAST TO THE STATE
FAIREST OF ALL—ARIZONA
O'Connor confirmed unanimously
Arizona woman gains Supreme Court bench
Goldwater leads charge for nominee

Evaluation: Basic Statistics

- Average **sentence length** of the simplified sentences
- Average **number of simplified sentences** per complex input
- Percentage of sentences that are **copied** from the source
- Average **Levenshtein distance** from the input

How **conservative** are the systems?

Wikilarge	#T/S	#S/C	%SAME	LD$_{SC}$
Complex	22.06	1.03	100	0.00
Simple reference	20.19	1.14	**0.00**	7.14
DisSim	**11.01**	**2.82**	**0.00**	11.90
DSS	12.91	1.87	**0.00**	8.14
Hybrid	13.44	1.03	**0.00**	**13.04**
YATS	18.83	1.40	18.66	4.44
RegenT	18.20	1.45	41.50	3.77

Evaluation: Syntactic Complexity

- SAMSA: high correlation with **simplicity** and **grammaticality** (Sulem et al., 2018)
- SAMSA$_{abl}$: high correlation with **meaning preservation** (Sulem et al., 2018)

SAMSA is **maximized** when each split sentence represents exactly 1 semantic unit in the input.

Wikilarge	SAMSA	SAMSA$_{abl}$
Complex	0.59	0.96
Simple reference	0.48	0.78
DisSim	**0.67**	0.84
DSS	0.64	0.75
Hybrid	0.47	0.76
YATS	0.56	0.80
RegenT	0.61	**0.85**

Evaluation: Human Annotation

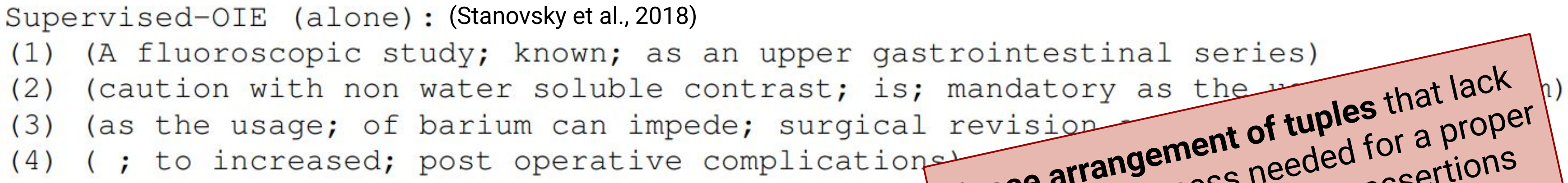
- **Grammaticality**: Is the output fluent and grammatical? (1 - 5)
- **Meaning preservation**: Does the output preserve the meaning of the input? (1 - 5)
- **Structural simplicity**: Is the output simpler than the input, ignoring the complexity of the words? (-2 - 2)

- 50 randomly sampled sentences
- 2 annotators

Wikilarge	**G**	**M**	**S**	**avg.**
Simple reference	4.70	4.56	-0.2	3.02
DisSim	4.36	4.50	**1.30**	**3.39**
DSS	3.44	3.68	0.06	2.39
Hybrid	3.16	2.60	0.86	2.21
YATS	4.40	**4.60**	0.22	3.07
RegenT	**4.64**	4.56	0.28	3.16

Extrinsic Evaluation: Open IE

- **Open IE**: turn unstructured information into a structured representation in the form of **relational tuples**



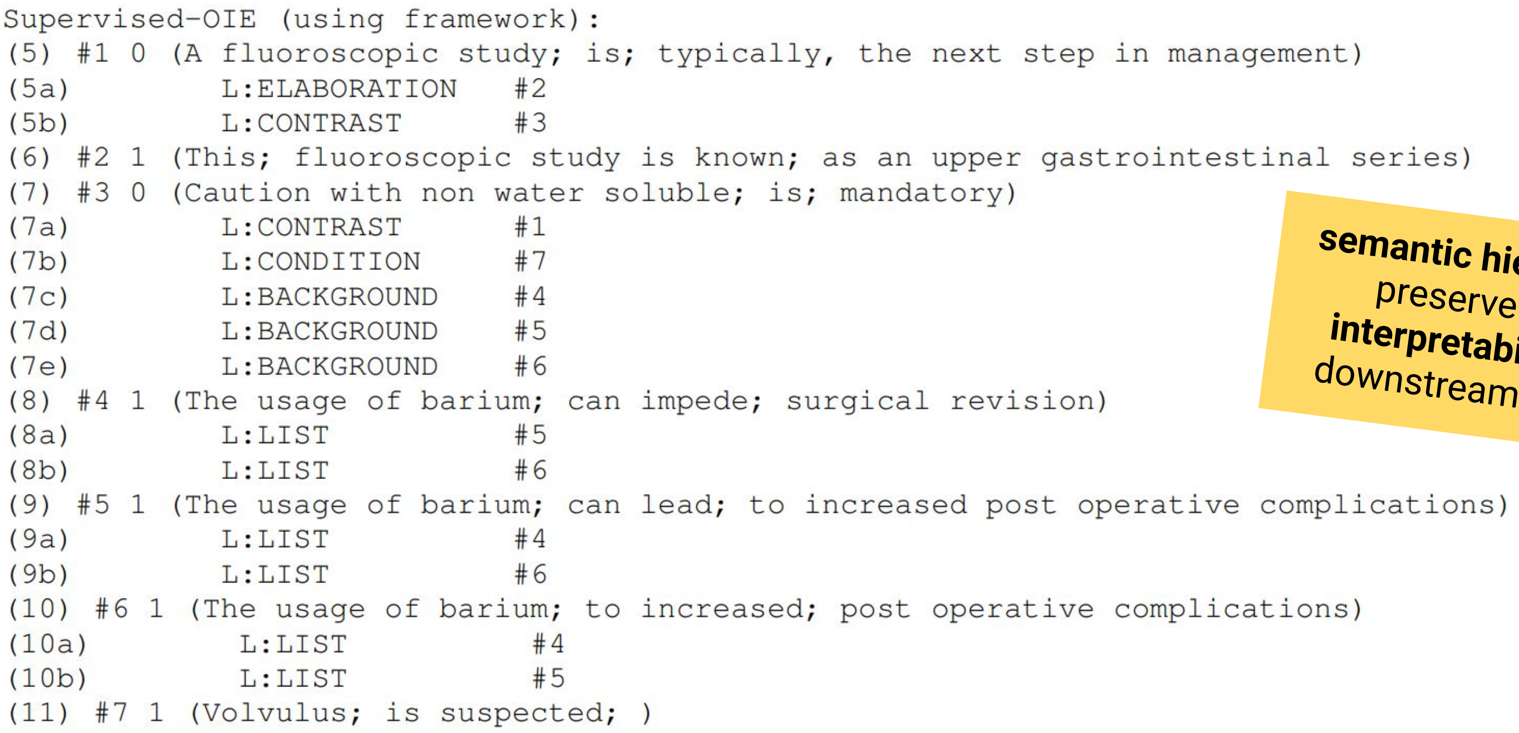
```
Supervised-OIE (alone):
(1) (A fluoroscopic study; known; as an upper gastrointestinal series)
(2) (caution with non water soluble contrast; is; mandatory as the u                    n)
(3) (as the usage; of barium can impede; surgical revision o
(4) ( ; to increased; post operative complications)
```

(Stanovsky et al., 2018)

loose arrangement of tuples that lack the expressiveness needed for a proper interpretation of complex assertions

- **Integration of DisSim as a preprocessing step** into state-of-the-art Open IE approaches
  - enrich extractions with **contextual information**
  - allows to restore the semantic relationship between a set of propositions

Extrinsic Evaluation: Open IE

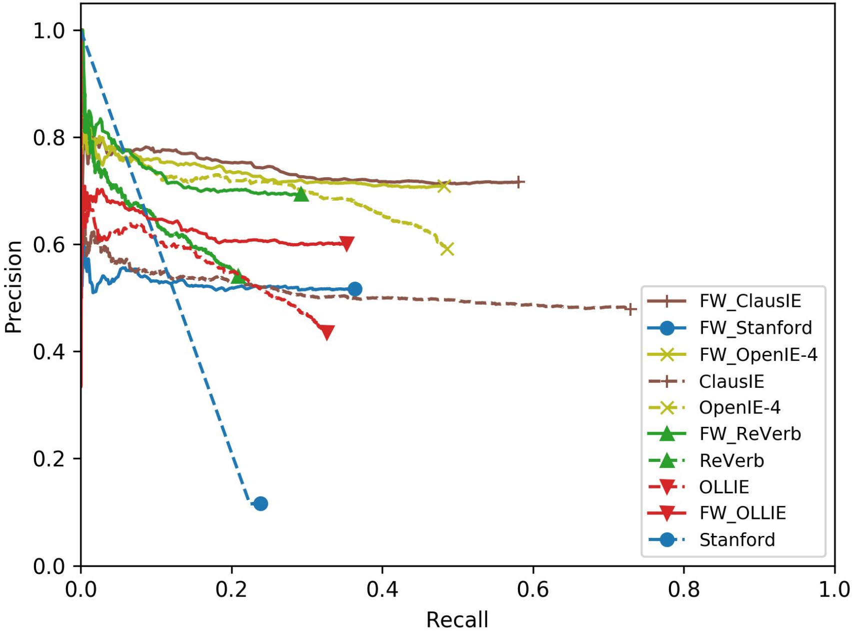


```
Supervised-OIE (using framework):
(5) #1 0 (A fluoroscopic study; is; typically, the next step in management)
(5a)        L:ELABORATION   #2
(5b)        L:CONTRAST      #3
(6) #2 1 (This; fluoroscopic study is known; as an upper gastrointestinal series)
(7) #3 0 (Caution with non water soluble; is; mandatory)
(7a)        L:CONTRAST      #1
(7b)        L:CONDITION     #7
(7c)        L:BACKGROUND    #4
(7d)        L:BACKGROUND    #5
(7e)        L:BACKGROUND    #6
(8) #4 1 (The usage of barium; can impede; surgical revision)
(8a)        L:LIST          #5
(8b)        L:LIST          #6
(9) #5 1 (The usage of barium; can lead; to increased post operative complications)
(9a)        L:LIST          #4
(9b)        L:LIST          #6
(10) #6 1 (The usage of barium; to increased; post operative complications)
(10a)        L:LIST          #4
(10b)        L:LIST          #5
(11) #7 1 (Volvulus; is suspected; )
```

semantic hierarchy: preserve the **interpretability** in downstream tasks

Extrinsic Evaluation: Open IE

- **Minimality**: improve performance of state-of-the-art Open IE approaches in terms of **precision and recall**

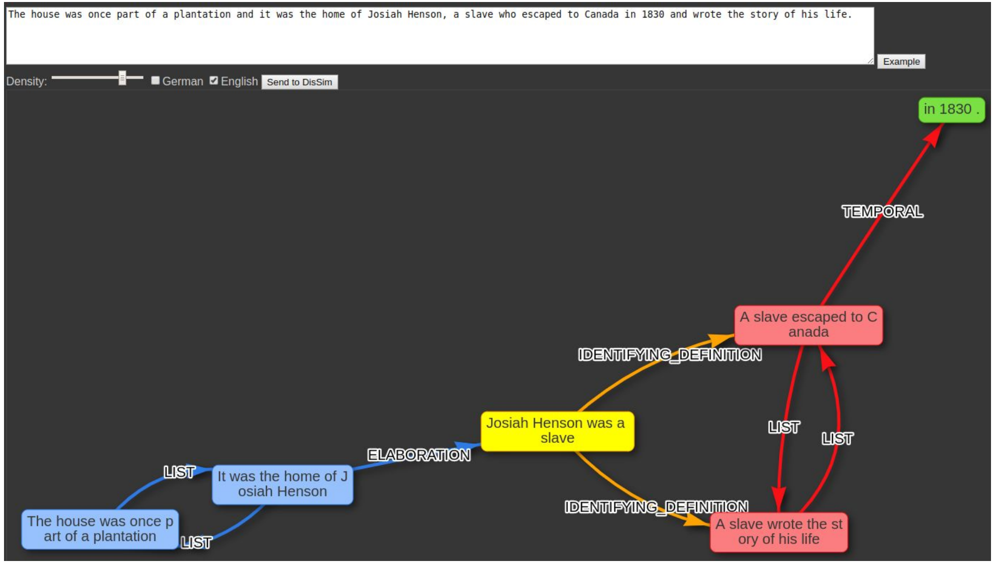


System	Precision	Recall	AUC
Stanford Open IE (Angeli et al., 2015)	**+346%**	**+52%**	**+597%**
ReVerb (Fader et al., 2011)	+28%	+40%	+57%
OLLIE (Mausam et al., 2012)	+38%	+8%	+20%
ClausIE (Del Corro and Gemulla, 2013)	+50%	-20%	+15%
OpenIE-4 (Mausam, 2016)	+20%	-1%	+3%

Cetto et al., 2018

Conclusion

- Transformation of complex sentences into a set of hierarchically ordered and semantically interconnected sentences that present a simplified syntax
  - **minimal semantic units**
  - **semantic hierarchy**
- DisSim **outperforms the state of the art** in syntactic TS
  - fine-grained output with high level of grammaticality and meaning preservation
  - improvement of 5%, 4% and 6% in SAMSA against the second best-performing approach
  - domain independence
- Application as a **preprocessing step**:
  - improves the performance of downstream applications in precision and recall
  - enriches their output with important contextual information



The house was once part of a plantation and it was the home of Josiah Henson, a slave who escaped to Canada in 1830 and wrote the story of his life.

Density: □ German ☑ English

The house was once p art of a plantation

It was the home of J osiah Henson

Josiah Henson was a slave

A slave escaped to C anada

A slave wrote the st ory of his life

in 1830 .

Code: https://github.com/Lambda-3/DiscourseSimplification