Unsupervised Sentence Simplification Using Deep Semantics

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INLG, September 2016

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Sentence Simplification

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- preprocessing steps for NLP systems
  - parsers and machine translation systems [Chandrasekar et al., 1996],
  - summarisation [Knight and Marcu, 2000],
  - sentence fusion [Filippova and Strube, 2008] and
  - semantic role labelling [Vickrey and Koller, 2008].

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using an **unsupervised framework** relying only on the **comparable wikipedia corpora**

Outline of the talk

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Sentence Simplification in Literature

- Handcrafted rules capturing syntactic simplification

  [Siddharthan, 2002, Chandrasekar and Srinivas, 1997, Bott et al., 2012, Canning, 2002, Siddharthan, 2011, Siddharthan, 2010]

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- Statistical supervised framework for sentence simplification
  - using aligned sentences from **traditional English** and **Simple English Wikipedia**

  [Zhu et al., 2010, Woodsend and Lapata, 2011, Wubben et al., 2012, Coster and Kauchak, 2011, Siddharthan and Mandya, 2014, Narayan and Gardent, 2014, Xu et al., 2016]

Sentence Simplification in Literature

Monolingual tree-based translation model [Zhu et al., 2010]

- constructed a parallel corpus **PWKP** of 108,016/114,924 complex/simple sentences
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- evaluated on the test set consisting of 100/131 complex/simple sentences.

Sentence Simplification in Literature

Quasi-synchronous grammar and integer linear programming [Woodsend and Lapata, 2011]

- learned a Quasi-synchronous grammar using the **PWKP** corpus [Zhu et al., 2010]
- additional use of the edit history of Simple Wikipedia

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Simplification as monolingual translation
[Coster and Kauchak, 2011, Wubben et al., 2012, Xu et al., 2016]

- learned **statistical machine translation system** considering complex sentences as the source and simple ones as the target

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- does not allow **split**s

Sentence Simplification in Literature

Hybrid symbolic/statistical approach
[Siddharthan and Mandya, 2014] combining

- **hand-crafted syntactic simplification rules**, and
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Hybrid simplification [Narayan and Gardent, 2014] using

- **deep semantic representation** for **splitting** and **deletion**, with
- a **monolingual machine translation** module which handles **reordering** and **substitution**.

Our Simplification Proposal

An **unsupervised framework** relying only on the **comparable wikipedia corpora**

- pipelines three dedicated modules for **lexical simplification**, **sentence splitting** and **sentence compression**

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Exploits **deep semantic representation** for **splitting** and **deletion** probabilities

- Discourse representation structures (**DRS**) assigned by Boxer as input
- facilitates completion (the re-creation of the shared element in the split sentences)
- provide a natural means to avoid deleting obligatory arguments

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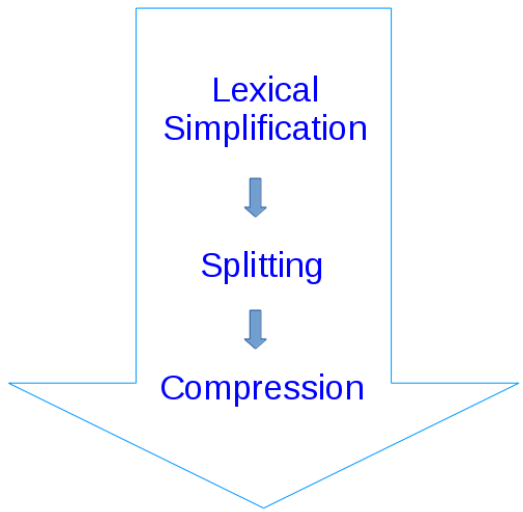

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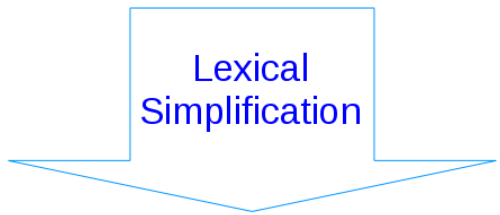

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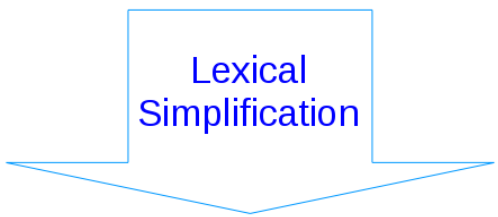

- **Context-aware rules** are learned from **comparable corpora**: English and Simple English Wikipedia [Biran et al., 2011]
- **Viterbi decoding** using highly weighted rules maximising simple sentence probability

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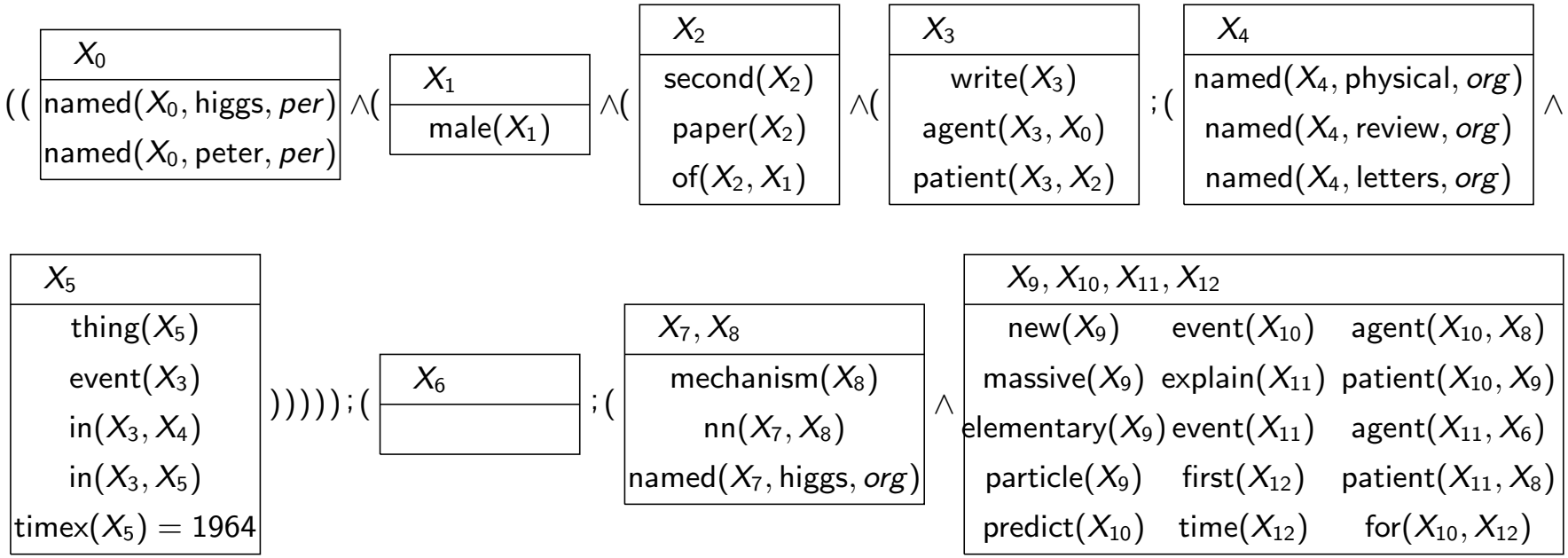
DRS for Semantic Representation



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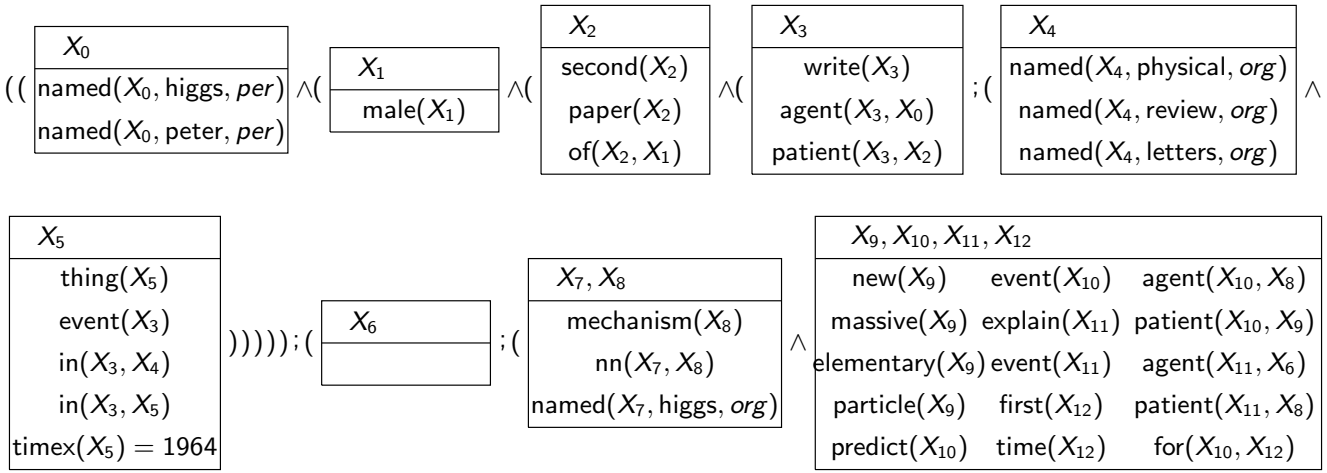

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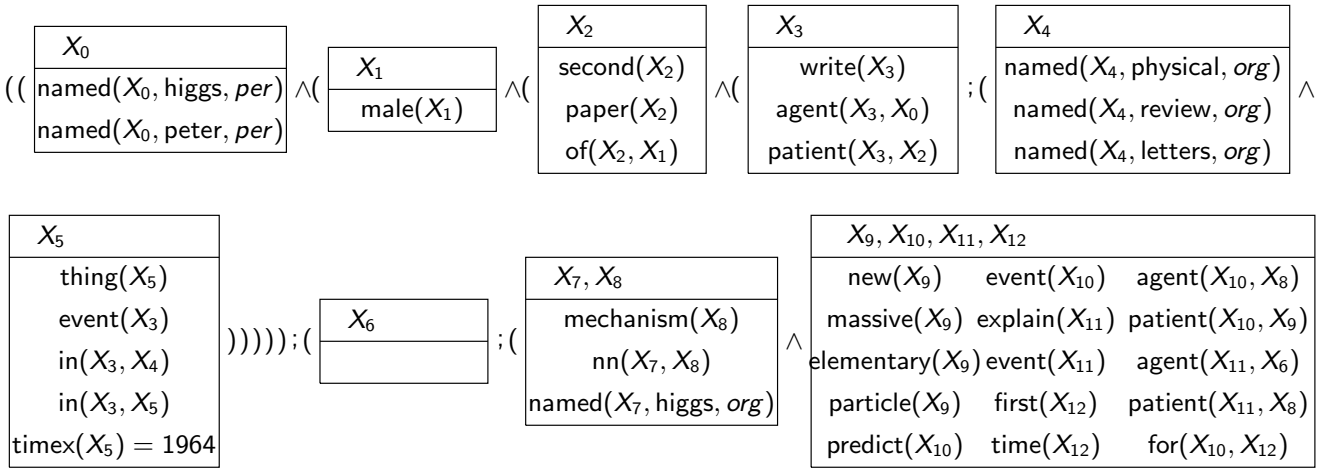

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X_3	5	write/v, **event**
X_4	10, 11, 12	physical/org review/org, letters/org
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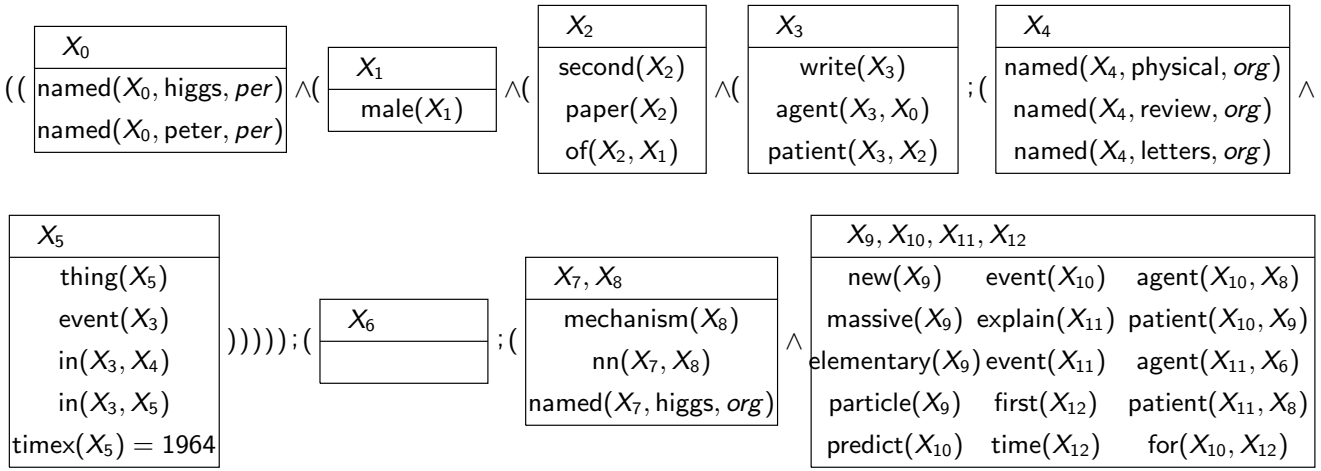

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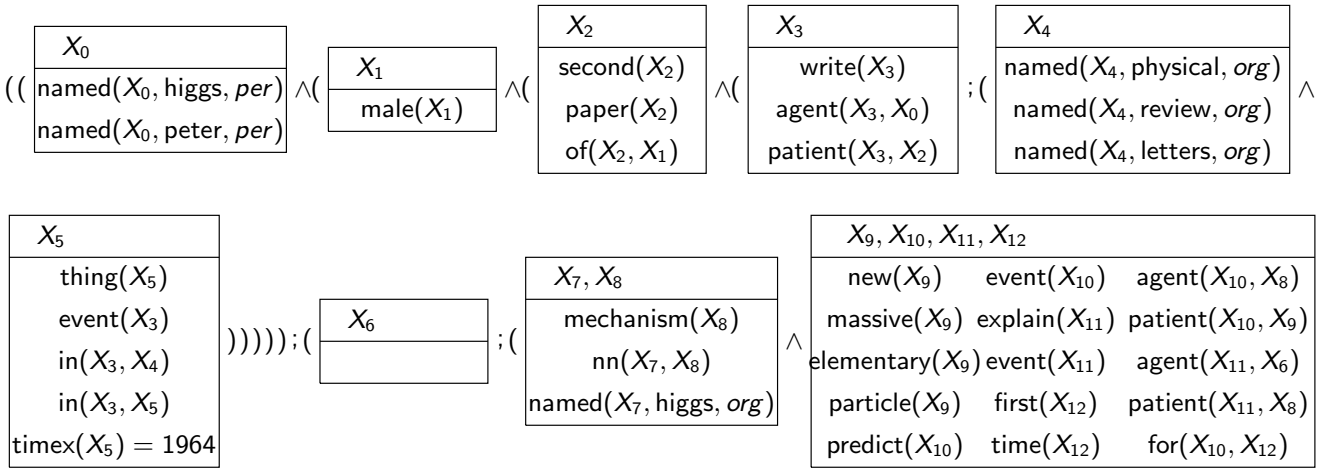

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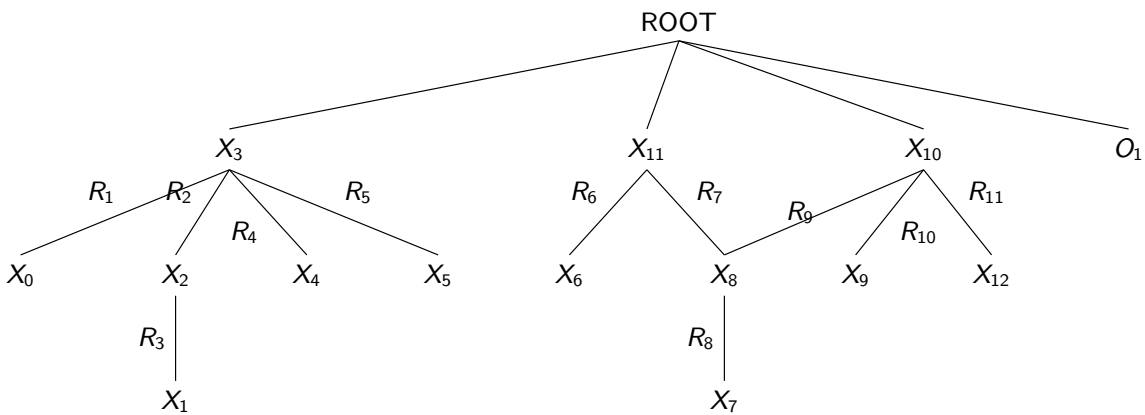

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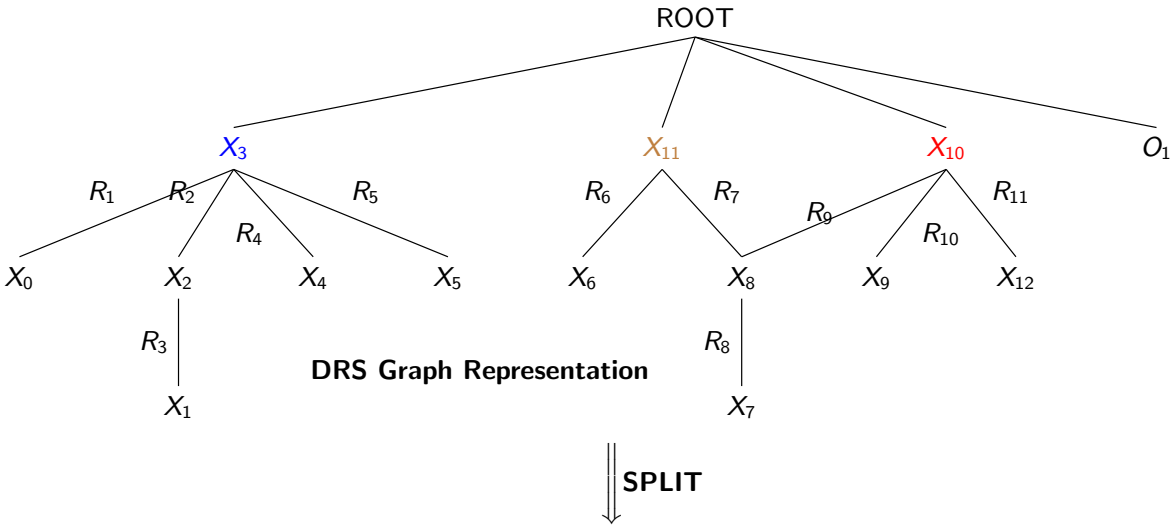
Sentence Splitting



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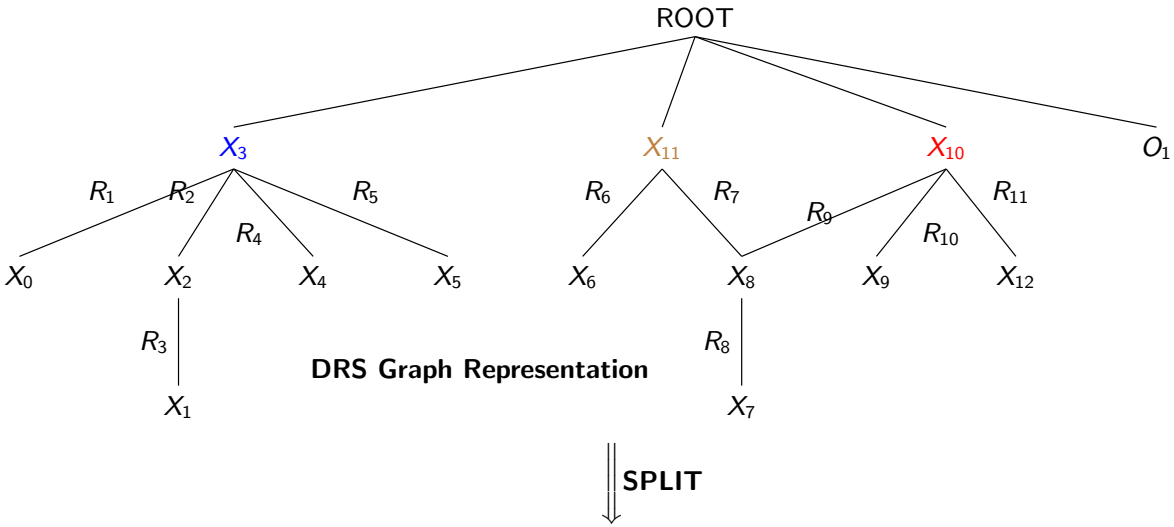

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rel	pos. in S	predicate
R_1	5	$agent, X_3 \rightarrow X_0$
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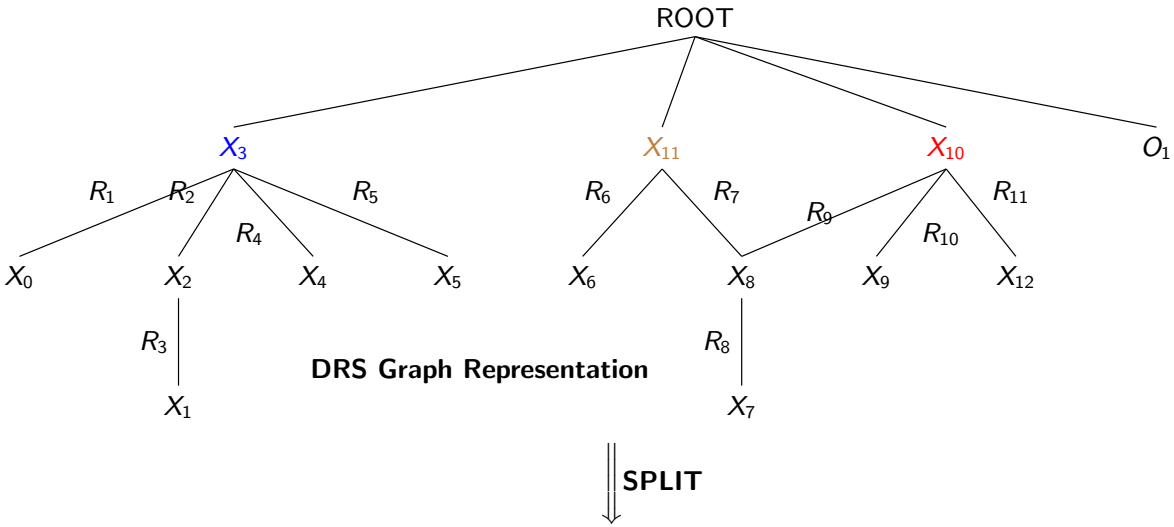
Semantic Patterns in Simple Wikipedia	**prob.**
$\langle$(*agent*, *patient*)$\rangle$	0.059
$\langle$(*agent*, *patient*), (*agent*, *in*, *in*, *patient*)$\rangle$	0.023
$\langle$(*agent*, *patient*), (*agent*, *in*, *in*, *patient*),(*agent*, *for*, *patient*)$\rangle$	0.003

Sentence Splitting



$$S \rightarrow \{s_1, s_2, \ldots, s_n\}$$

$$P_{split} = \frac{1}{n} \sum_{s_i} \alpha_{s_i} \times lm_{s_i} \times SFT_{s_i}$$

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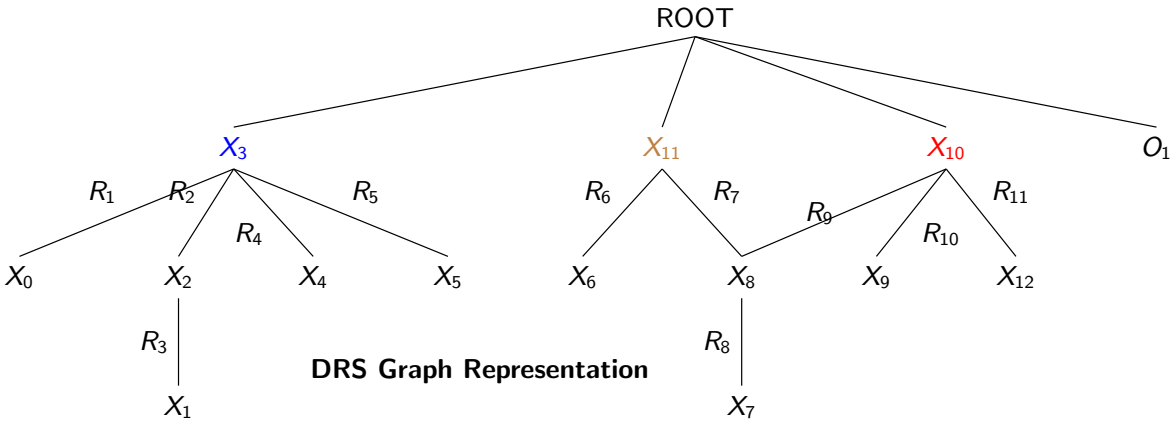

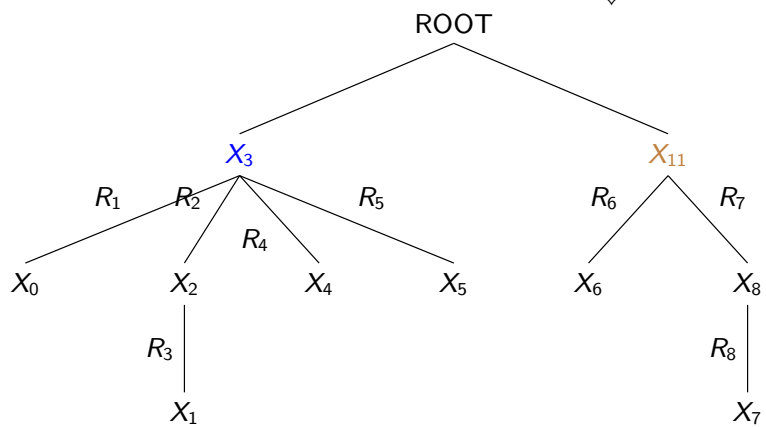

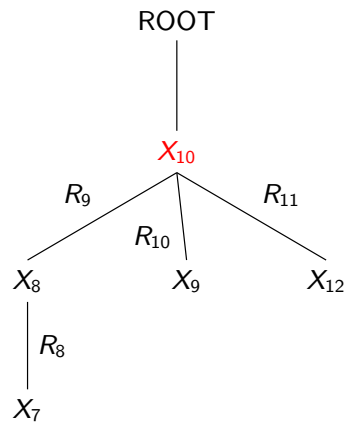

"In 1964 Peter Higgs wrote his second paper in Physical Review Letters explaining Higgs mechanism "

"Higgs mechanism predicted a new massive elementary particle for the first time"

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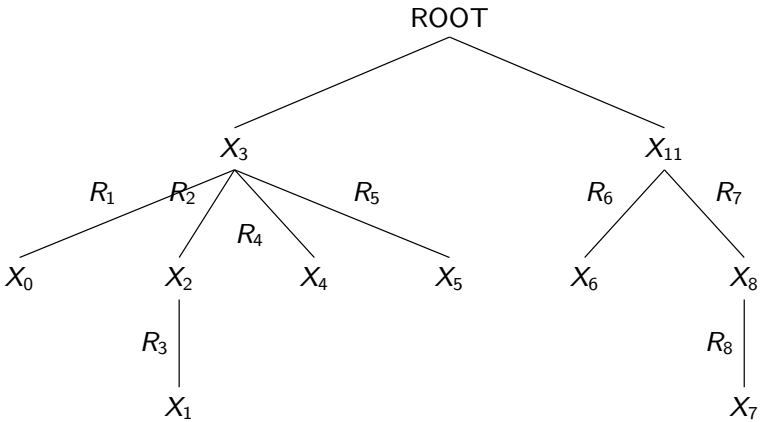

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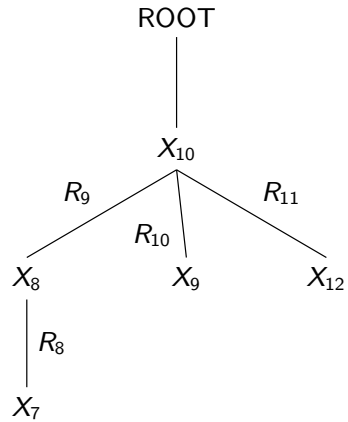

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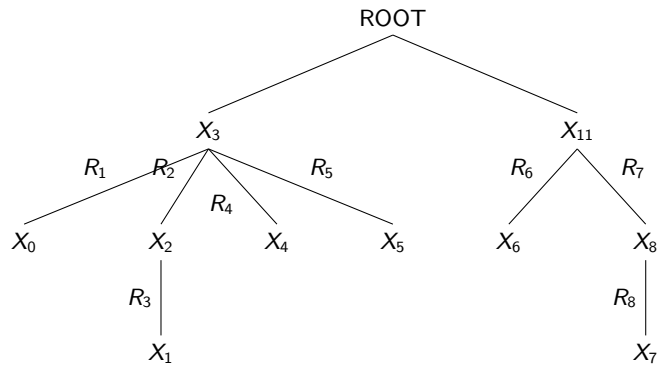

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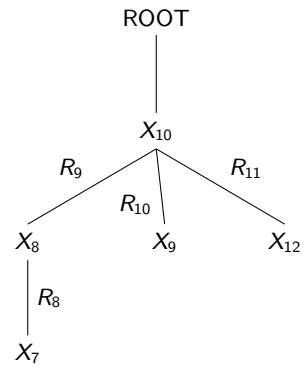

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$$\sum_x x^r_{h,w} \times P(r|h) \times P(w) \quad r \notin \{agent, patient, theme, eq\}$$

$$x^r_{h,w} = \begin{cases} 1, & \text{if } r \text{ is preserved} \\ 0, & \text{otherwise} \end{cases}$$

$P(r|h)$: Conditional probability of relation r given head label h

$P(w)$: Relative frequency of w in Simple Wikipedia

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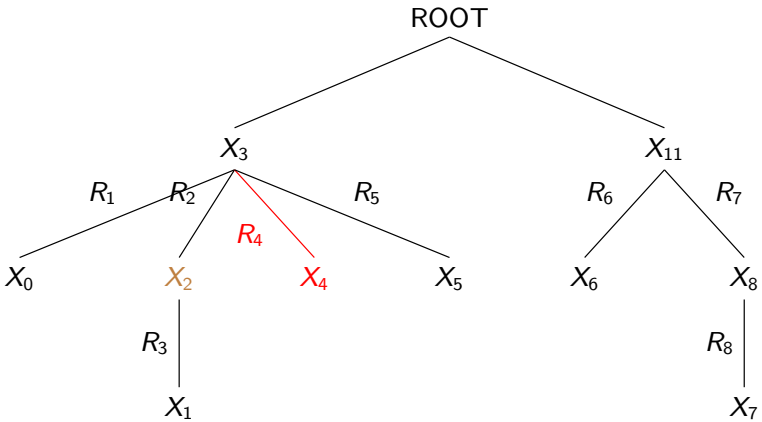
Optimized using ILP, constrained to well-formedness

Sentence Compression



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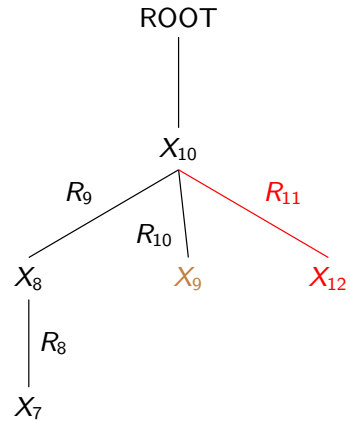

"*Higgs mechanism predicted a new massive elementary particle for the first time*"

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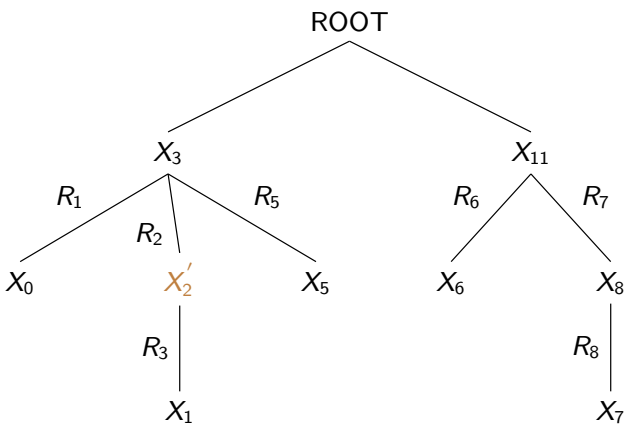

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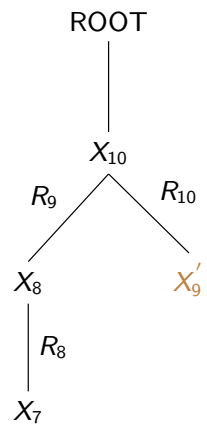

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Sentence Simplification Framework: Summary

In 1964 Peter Higgs published his second paper in Physical Review Letters describing Higgs mechanism which predicted a new massive spin-zero boson for the first time.

⇓ **Context-aware Lexical Simplification**

⇓ **Resource:** Comparable English and Simple Wikipedia

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⇓ **Syntactic Simplification using Deep Semantic Representation**
Sentence Splitting and Compression

⇓ **Resource:** Simple Wikipedia

In 1964 Peter Higgs wrote his paper explaining Higgs mechanism.
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Outline of the talk

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Evaluations

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  - Woodsend's *Quasi-synchronous grammar and integer linear programming* [Woodsend and Lapata, 2011]
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- Evaluation metrics
  - Automatic evaluation metrics: BLEU score, Edit distance, and Split
  - Human evaluation metrics: Simplicity, Fluency, and Adequacy

Automatic evaluation

System	BLEU	Edit distance to complex sentences		Edit distance to simple sentences		Sentences with splits
		LD	No edit	LD	No edit	
GOLD	100	12.24	3	0	100	28
Zhu	37.4	7.87	2	14.64	0	80
Woodsend	42	8.63	24	16.03	2	63
Wubben	41.4	3.33	6	13.57	2	1
Narayan	**53.6**	6.32	4	11.53	3	10
Unsup	38.5	6.75	3	14.29	0	49

Table: BLEU score, Average Levenshtein distance (LD) to complex and simple reference sentences per system ; number of input sentences for which no simplification occur (No edit).

Human evaluation

- 18 randomly selected sentences
- ratings collected from 18 participants
- judgments on a slider scale from 0 to 5 for *simplicity*, *fluency*, and *adequacy*

Systems	Simplicity	Fluency	Adequacy
GOLD	3.62	4.69	3.80
Zhu	2.62	2.56	2.47
Woodsend	1.69	3.15	3.15
Wubben	1.52	3.05	3.38
Narayan	2.30	3.03	3.35
UNSUP	2.83	3.56	2.83

Human evaluation

- Pairwise comparisons and statistical significance
- One way ANOVA with post-hoc Tukey HSD tests

Systems	GOLD	Zhu	Woodsend	Wubben	Narayan
Zhu	◊□△				
Woodsend	◊□▲	◊■▲			
Wubben	◊□▲	◊■△	♦■▲		
Narayan	◊□▲	♦■▲	♦■▲	♦■▲	
Unsup	♦□△	♦□▲	◊■▲	◊■▲	♦■▲

Table: ◊/♦ is/not significantly different (sig. diff.) wrt simplicity. □/■ is/not sig. diff. wrt fluency. △/▲ is/not sig. diff. wrt adequacy. (significance level: $p < 0.05$)

Qualitative Analysis

Complex. This array distributes data across multiple disks, but the array is seen by the computer user and operating system as one single disk.

Zhu. This array sells data across multiple disks but the array is seen. The computer user and operating as one disk. [0]

Woodsend. This array distributes data across several disks. The array is seen by the computer user and operating system as one single disk. [4.85]

Unsup. This array moves data across disks. The array is seen by the computer user and operating system as one disk. [4.83]

Qualitative Analysis

Complex. Here, simulations of evolution using evolutionary algorithms and artificial life started with the work of Nils Aall Barricelli in the 1960s, and was extended by Alex Fraser, who published a series of papers on simulation of artificial selection.

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Woodsend. It has Genetic algorithms. Evolution is using artificial life. This is Nils Aall Barricelli in the 1960s. Here, simulations started with the work. He was extended by Alex Fraser. He published a group of papers on simulation of artificial selection. [0.33]

Unsup. Here, models of evolution using evolutionary algorithms and artificial life started with the work in the 1960s, and was led by Alex Fraser. Alex Fraser wrote a series of papers on model of selection. [5]

Conclusion

We set a benchmark for an **unsupervised approach** to sentence simplification:

- A *deep semantic* based **syntactic simplification**: Better split capabilities
- Competitive with other state-of-the-art supervised methods

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Modular evaluation

System	Levenshtein Edit distance				BLEU Scores with respect to	
	Complex to System		System to Simple			
	LD	No edit	LD	No edit	complex	simple
complex	0	100	12.24	3	100	49.85
LexSimpl	2.07	22	13.00	1	82.05	44.29
Split	2.27	51	13.62	1	89.70	46.15
Deletion	2.39	4	12.34	0	85.15	47.33
LexSimpl-Split	4.43	11	14.39	0	73.20	41.18
LexSimpl-Deletion	4.29	3	13.09	0	69.84	41.91
Split-Deletion	4.63	4	13.42	0	77.82	43.44
LexSimpl-Split-Deletion	6.75	3	14.29	0	63.41	38.47
GOLD (simple)	12.24	3	0	100	49.85	100

Pairwise Split evaluation

System pairs		Average Score (number of split sentences)					
A	B	ALL-A	ALL-B	ONLY-A	BOTH-AB		ONLY-B
					A	B	
	GOLD		3.85(28)	2.15(32)	2.80(17)	3.70(17)	4.05(11)
	Zhu		2.25(80)	1.53(4)	2.45(45)	2.42(45)	2.02(35)
UNSUP	Woodsend	2.37(49)	2.08(63)	2.42(11)	2.36(38)	2.29(38)	1.78(25)
	Wubben		2.73(1)	2.32(48)	4.75(1)	2.73(1)	0(0)
	Narayan		2.09(10)	2.29(41)	2.78(8)	1.79(8)	3.81(2)