Syntax-Based Translation: The Good, The Bad, and How to Win Big

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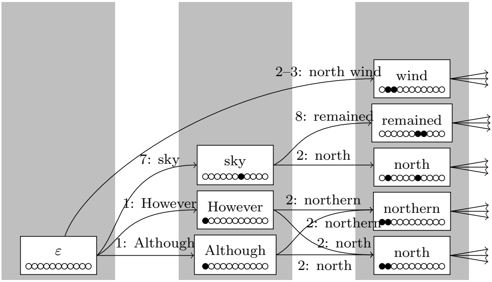
with thanks to Ondřej Bojar
(and apologies to Richard P. Gabriel)

- Why do we care about syntax-based MT?
- How does it work?
- What are the open problems?

Disclaimer
Fast-moving field, we only scratch the surface

虽然	北	风	呼啸	，	但	天空	依然	十分	清澈	。
Although	*north*	*wind*	*howls*	*,*	*but*	*sky*	*still*	*extremely*	*limpid*	*.*
1	2	3	4	5	6	7	8	9	10	11



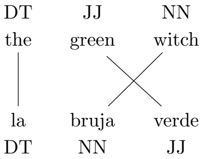
Phrase-based models are good, but not perfect

- computing all possible reorderings is NP-complete
- can't generalize
- can't model long-distance dependencies
- can't model grammaticality

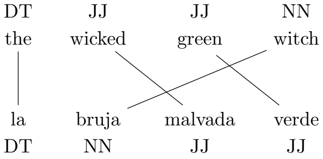
The Good

Syntax-based models aim to solve these problems

- polynomial complexity
- can generalize
- can model long-distance dependencies
- can model grammaticality



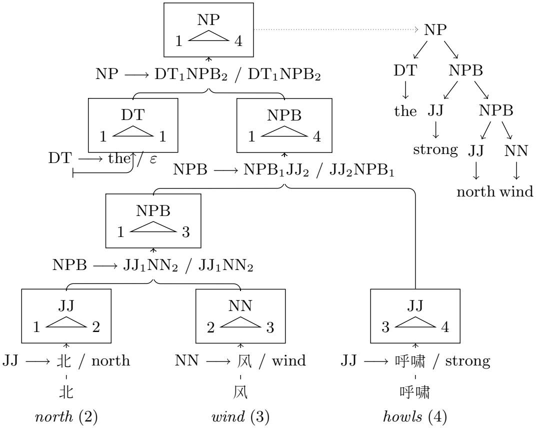
$$\mathrm{NP} \longrightarrow \mathrm{DT}_1\mathrm{JJ}_2\mathrm{NN}_3/\mathrm{DT}_1\mathrm{NN}_3\mathrm{JJ}_1$$



$$\mathrm{NP} \longrightarrow \mathrm{DT}_1\mathrm{JJ}_2\mathrm{JJ}_3\mathrm{NN}_4/\mathrm{DT}_1\mathrm{NN}_4\mathrm{JJ}_2\mathrm{JJ}_3$$

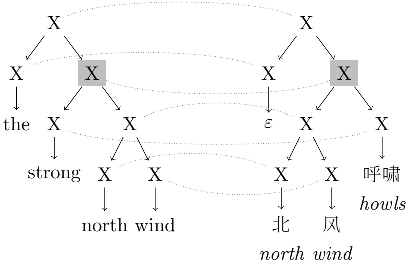
Problem Stack decoding doesn't apply

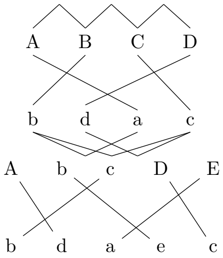
Idea Decoding is parsing



Problem Phrase-based decoding with full reordering has exponential complexity.

Idea Use binary-bracketing SCFG for polynomial complexity.



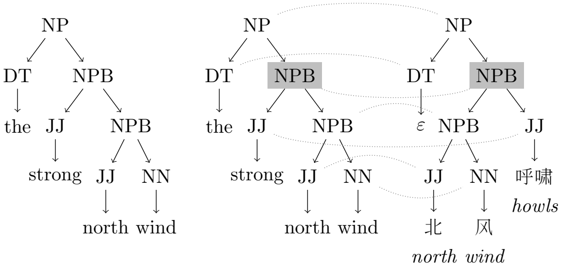


not possible with binary SCFG

not possible with 4-ary SCFG

Problem Phrase-based cannot model grammaticality.

Idea Constrain SCFG to target-side syntax.


NP
DT
NPB
the
JJ
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strong
JJ
NN
north
wind
NP
DT
NPB
the
JJ
NPB
strong
JJ
NN
north
wind
NP
DT
NPB
ε
NPB
JJ
JJ
NN
呼啸
howls
北
风
north wind

The Bad

It doesn't really work.

- Bracketing grammar doesn't capture all alignments.
- Tree isomorphism at production level is too strict.

Where do we go next?

- More theory?
- More articulated models?

Modeling translational equivalence using wieghted finite state transducers is like approximating a high-order polynomial with line segments... the relatively low expressive power of weighted finite state transducers limits the quality of SMT systems.

–Burbank *et al.* 2005

But language is hierarchical.

–anonymous MT researcher

I think phrases are a passing fad.

–anonymous MT researcher

This type of difficulty has happened in other research areas.

See: “Lisp: Good News, Bad News, How to Win Big”, presented at the EUROPAL conference by Richard P. Gabriel in 1989.

Lisp = syntax-based models
Unix and C++ = phrase-based models

Simplicity the design must be simple, both in implementation and interface. It is more important for the interface to be simple than the implementation.

Correctness the design must be correct in all observable aspects. Incorrectness is simply not allowed.

Consist gn is
mplete
portant

The Right Thing

Completeness the design must cover as many important situations as is practical. All reasonably expected cases must be covered. Simplicity is not allowed to overly reduce completeness.

Worse is Better

Simplicity the design must be simple. Simplicity is the most important consideration in a design.

Correctness the design must be correct in all observable aspects. It is slightly better to be simple than correct.

Consistency the design must not be overly inconsistent. It is [illegible] at deal [illegible] ntroduce [illegible]

Completeness the design must cover as many important situations as is practical. Completeness can be sacrificed in favor of any other quality. In fact, completeness must sacrificed whenever implementation simplicity is jeopardized.

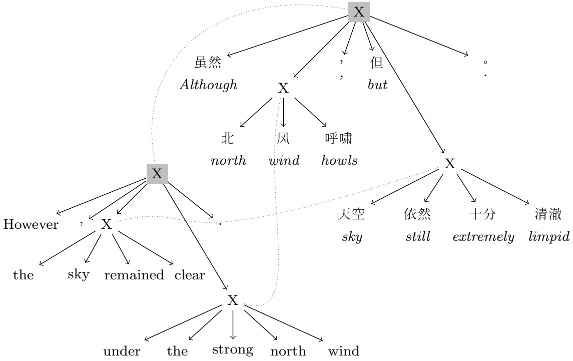
> The good news is that in 1995 we will have a good operating system and programming language. The bad news is that they will be Unix and C++.
>
> –Richard Gabriel

In 2018, will we have a good translation system based on phrases?

How to Win Big

Observation Phrase-based models good at local reordering.

Idea Use phrases to reorder phrases.



Observation Phrase-based models good, but not grammatical.

Idea Add syntax, but keep the phrases.

Current status

- Syntax-based models competitive with phrase-based
  - Slightly better for Chinese-English
  - Slightly worse for Arabic-English
  - Open question for European languages
  - Language models make a bigger difference
- Not as fast as advertised
  - With 5-gram language model – $O(n^{11})$
  - Easy tricks in phrase-based models not applicable
  - Work on clever search algorithms
- Parsing progress – 1997: 88.1%, 2007: 92.4%

Many, many more angles

- Different formal models with different properties
  - Dependency grammar
  - Synchronous tree substitution grammar
  - Synchronous tree adjoining grammar
- Parsing: source, target, or both?

See handout for some further reading