Models of Synchronous Grammar Induction for SMT

Workshop 2010

The Center for Speech and Language Processing
Johns Hopkins University

June 21, 2010

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Statistical machine translation

Urdu → English

اس حملہ کے بعد بڑی تعداد میں مقامی باشندوں نے علاقوں کو خالی کردیا ہے .

↓

- Statistical machine translation: Learn how to translate from parallel corpora.

Statistical machine translation:

Urdu → English

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↓

After this incident, a large number of local residents fled from these areas.

- Statistical machine translation: Learn how to translate from parallel corpora

Statistical machine translation: Before

Urdu → English

اس حملہ کے بعد بڑی تعداد میں مقامی باشندوں نے علاقوں کو خالی کردیا ہے .

↓

In this attack a large number of local residents has should vacate areas.

- Current state-of-the-art translation models struggle with language pairs which exhibit large differences in structure.

Statistical machine translation: After

Urdu → English

اس حملہ کے بعد بڑی تعداد میں مقامی باشندوں نے علاقوں کو خالی کردیا ہے ۔

↓

After this attack, a large number of local residents have to vacate the areas.

- In this workshop we've made some small steps towards better translations for difficult language pairs.

Statistical machine translation: limitations

Structural divergence between languages:

English	**Who wrote this letter?**
Arabic	من الذي كتب هذه الرسالة؟ (function-word) (who) (wrote) (this) (the-letter)
Chinese	这封信是谁写的？ (this) (letter) (be) (who) (write) (come-from) (function-word)

Statistical machine translation: limitations

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Statistical machine translation: limitations

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Statistical machine translation: limitations

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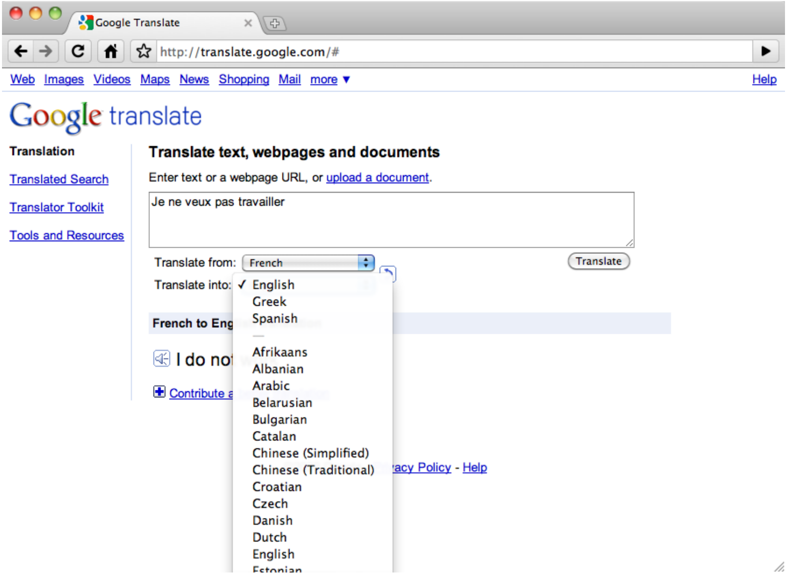
- Phrasal translation equivalences (existing models)
- **Constituent reordering (this workshop!)**
- Morphology (Next year?)

Statistical machine translation: successes



Google Translate

http://translate.google.com/#

Translate text, webpages and documents

Enter text or a webpage URL, or upload a document.

Je ne veux pas travailler

Translate from: French

Translate into: ✓ English

French to Eng

I do no

Contribute a

Workshop overview

Input:

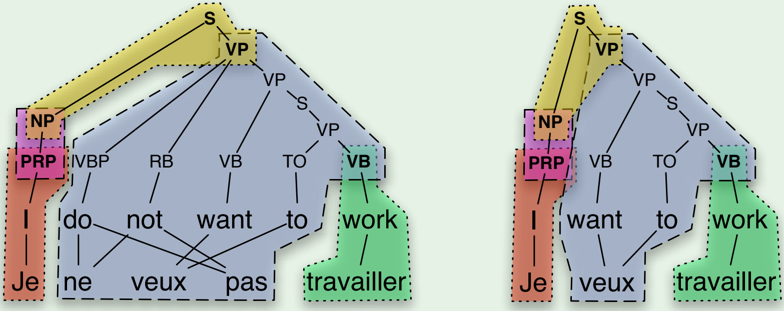
- Existing procedures for synchronous grammar extraction

Output:

- New unsupervised models for large scale synchronous grammar extraction,
- A comparison and analysis of the existing and proposed models,
- Extended decoders (cdec/Joshua) capable of working efficiently with these models.

Models of translation

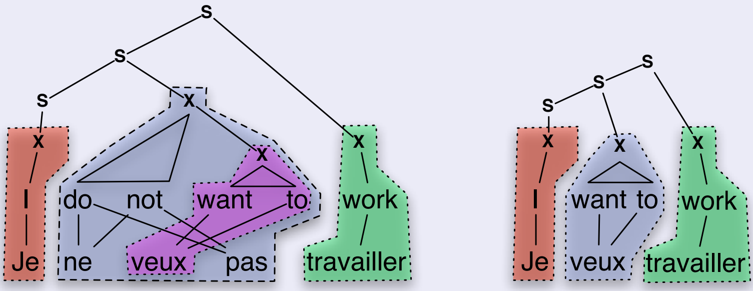
Supervised SCFG: Syntactic Tree-to-String



- Strong model of sentence structure.
- Reliant on a treebank to train the parser.

Models of translation

Unlabelled SCFG: Hiero



- Only requires the parallel corpus.
- But weak model of sentence structure.

Using syntax in Machine Translation:

Synchronous Context Free Grammar (SCFG)

$$S \rightarrow \langle X_{\boxed{1}},\ X_{\boxed{1}} \rangle$$

$$X \rightarrow \langle X_{\boxed{1}}\ X_{\boxed{2}},\ X_{\boxed{2}}\ X_{\boxed{1}} \rangle$$

$$X \rightarrow \langle \mathit{Sie},\ \mathit{She} \rangle$$

$$X \rightarrow \langle \mathit{eine\ Tasse\ Kaffee},\ \mathit{a\ cup\ of\ coffee} \rangle$$

$$X \rightarrow \langle X_{\boxed{1}}\ X_{\boxed{2}},\ X_{\boxed{1}}\ X_{\boxed{2}} \rangle$$

$$X \rightarrow \langle \mathit{will},\ \mathit{wants\ to} \rangle$$

$$X \rightarrow \langle \mathit{trinken},\ \mathit{drink} \rangle$$

Example Derivation

$$S \Rightarrow \langle X_{\boxed{1}},\ X_{\boxed{1}} \rangle \quad \Rightarrow \langle X_{\boxed{2}}\ X_{\boxed{3}},\ X_{\boxed{2}}\ X_{\boxed{3}} \rangle$$

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Example Derivation

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Using syntax in Machine Translation:

Synchronous Context Free Grammar (SCFG)

$S \longrightarrow \langle X_{\boxed{1}},\ X_{\boxed{1}} \rangle$

$X \longrightarrow \langle X_{\boxed{1}}\ X_{\boxed{2}},\ X_{\boxed{2}}\ X_{\boxed{1}} \rangle$

$X \longrightarrow \langle Sie,\ She \rangle$

$X \longrightarrow \langle eine\ Tasse\ Kaffee,\ a\ cup\ of\ coffee \rangle$

$X \longrightarrow \langle X_{\boxed{1}}\ X_{\boxed{2}},\ X_{\boxed{1}}\ X_{\boxed{2}} \rangle$

$X \longrightarrow \langle will,\ wants\ to \rangle$

$X \longrightarrow \langle trinken,\ drink \rangle$

Example Derivation

$S \Rightarrow \langle X_{\boxed{1}},\ X_{\boxed{1}} \rangle \quad \Rightarrow \langle X_{\boxed{2}}\ X_{\boxed{3}},\ X_{\boxed{2}}\ X_{\boxed{3}} \rangle$

$\Rightarrow \langle Sie\ X_{\boxed{3}},\ She\ X_{\boxed{3}} \rangle \quad \Rightarrow \langle Sie\ X_{\boxed{4}}\ X_{\boxed{5}},\ She\ X_{\boxed{4}}\ X_{\boxed{5}} \rangle$

$\Rightarrow \langle Sie\ will\ X_{\boxed{5}},\ She\ wants\ to\ X_{\boxed{5}} \rangle \quad \Rightarrow \langle Sie\ will\ X_{\boxed{6}} X_{\boxed{7}},\ She\ wants\ to\ X_{\boxed{7}} X_{\boxed{6}} \rangle$

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$$S \rightarrow \langle X_{\boxed{1}},\; X_{\boxed{1}} \rangle$$

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$$X \rightarrow \langle \mathit{Sie},\; \mathit{She} \rangle$$

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$$X \rightarrow \langle X_{\boxed{1}}\, X_{\boxed{2}},\; X_{\boxed{1}}\, X_{\boxed{2}} \rangle$$

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Models of translation

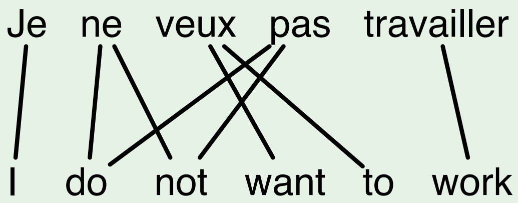
Phrase extraction:

Je ne veux pas travailler

I do not want to work

Models of translation

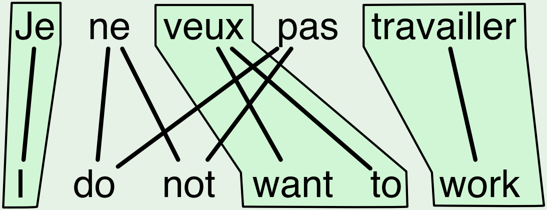
Phrase extraction:



- Use a word-based translation model to annotate the parallel corpus with word-alignments

Models of translation

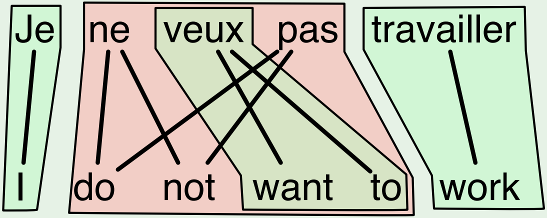
Phrase extraction:



- ⟨ Je, I ⟩, ⟨ veux, want to ⟩, ⟨ travailler, work ⟩

Models of translation

Phrase extraction:



- ⟨ Je, I ⟩, ⟨ veux, want to ⟩, ⟨ travailler, work ⟩, ⟨ ne veux pas, do not want to ⟩

Models of translation

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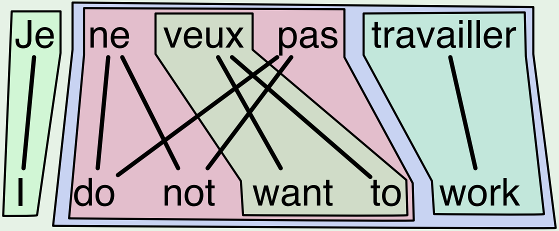
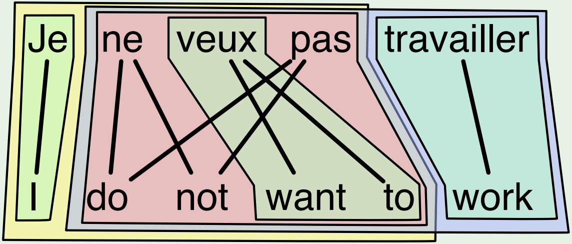


- ⟨ Je, I ⟩, ⟨ veux, want to ⟩, ⟨ travailler, work ⟩, ⟨ ne veux pas, do not want to ⟩, ⟨ ne veux pas travailler, do not want to work ⟩

Models of translation

Phrase extraction:



- ⟨ Je, I ⟩, ⟨ veux, want to ⟩, ⟨ travailler, work ⟩, ⟨ ne veux pas, do not want to ⟩, ⟨ ne veux pas travailler, do not want to work ⟩, ⟨ Je ne veux pas, I do not want to ⟩

Models of translation

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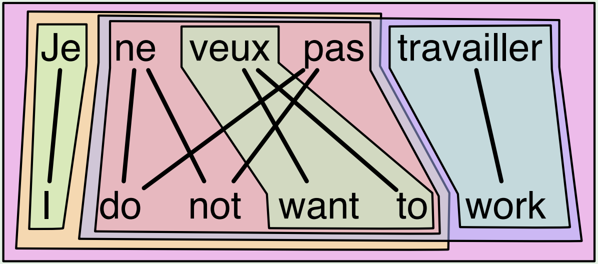
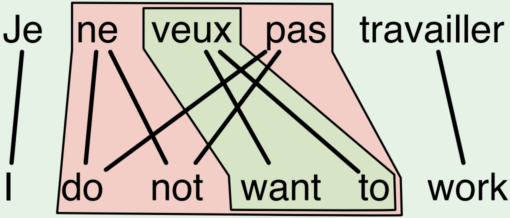


- ⟨ Je, I ⟩, ⟨ veux, want to ⟩, ⟨ travailler, work ⟩, ⟨ ne veux pas, do not want to ⟩, ⟨ ne veux pas travailler, do not want to work ⟩, ⟨ Je ne veux pas, I do not want to ⟩, ⟨ Je ne veux pas travailler, I do not want to work ⟩

Models of translation

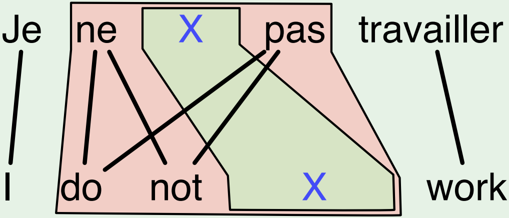
SCFG Rule extraction:



- X -> ⟨ ne veux pas, do not want to ⟩

Models of translation

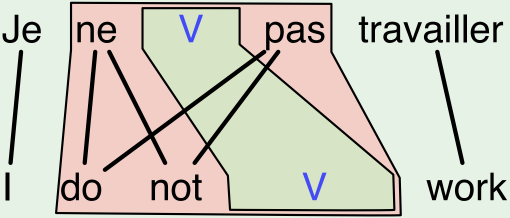
SCFG Rule extraction:



- X -> ⟨ ne veux pas, do not want to ⟩,
- X -> ⟨ ne $X_{\boxed{1}}$ pas, do not $X_{\boxed{1}}$ ⟩

Models of translation

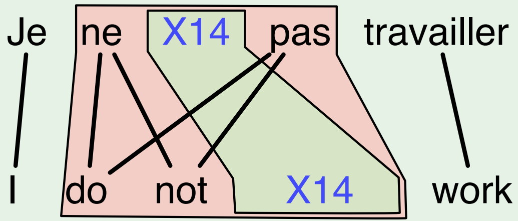
SCFG Rule extraction:



- VP/NN -> $\langle$ ne veux pas, do not want to $\rangle$,
- VP/NN -> $\langle$ ne $V_{\boxed{1}}$ pas, do not $V_{\boxed{1}}$ $\rangle$

Models of translation

SCFG Rule extraction:



- X10 -> ⟨ ne veux pas, do not want to ⟩,
- X10 -> ⟨ ne $X14_{\boxed{1}}$ pas, do not $X14_{\boxed{1}}$ ⟩

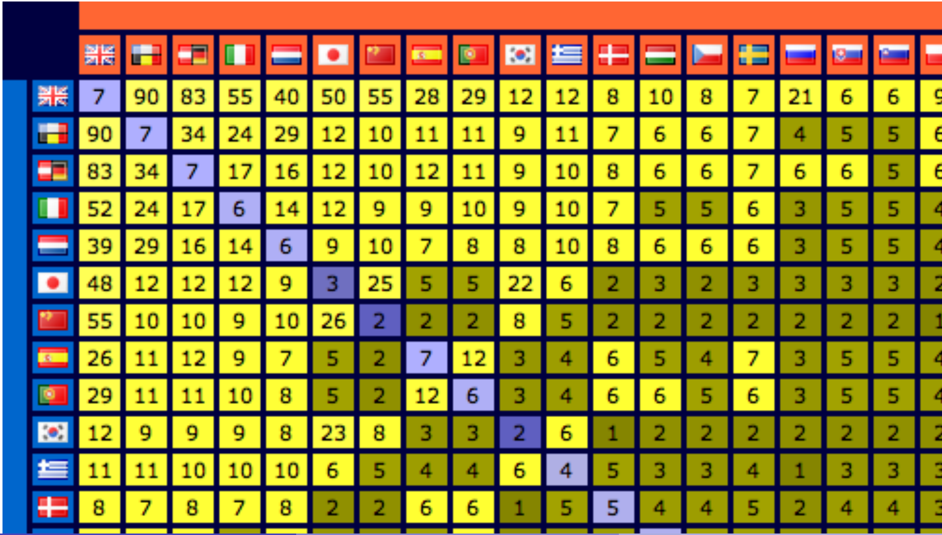
Impact

Language	Words	Domain
English	4.5M	Financial news
Chinese	0.5M	Broadcasting news
Arabic	300K (1M planned)	News
Korean	54K	Military

Table: Major treebanks: data size and domain

Impact

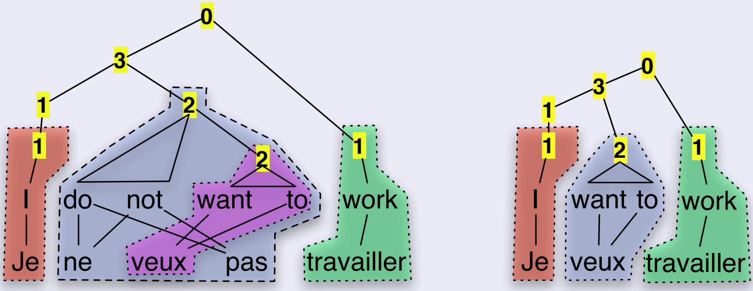
Parallel corpora far exceed treebanks (millions of words):



	🇬🇧	🇫🇷	🇩🇪	🇮🇹	🇳🇱	🇯🇵	🇨🇳	🇪🇸	🇵🇹	🇰🇷	🇬🇷	🇩🇰	🇭🇺	🇨🇿	🇸🇪	🇷🇺	🇸🇰	🇸🇮	
🇬🇧	7	90	83	55	40	50	55	28	29	12	12	8	10	8	7	21	6	6	9
🇫🇷	90	7	34	24	29	12	10	11	11	9	11	7	6	6	7	4	5	5	6
🇩🇪	83	34	7	17	16	12	10	12	11	9	10	8	6	6	7	6	6	5	6
🇮🇹	52	24	17	6	14	12	9	9	10	9	10	7	5	5	6	3	5	5	4
🇳🇱	39	29	16	14	6	9	10	7	8	8	10	8	6	6	6	3	5	5	4
🇯🇵	48	12	12	12	9	3	25	5	5	22	6	2	3	2	3	3	3	3	2
🇨🇳	55	10	10	9	10	26	2	2	2	8	5	2	2	2	2	2	2	2	1
🇪🇸	26	11	12	9	7	5	2	7	12	3	4	6	5	4	7	3	5	5	4
🇵🇹	29	11	11	10	8	5	2	12	6	3	4	6	6	5	6	3	5	5	4
🇰🇷	12	9	9	9	8	23	8	3	3	2	6	1	2	2	2	2	2	2	2
🇬🇷	11	11	10	10	10	6	5	4	4	6	4	5	3	3	4	1	3	3	3
🇩🇰	8	7	8	7	8	2	2	6	6	1	5	5	4	4	5	2	4	4	3

Models of translation

Hierarchical



- AIM: Implement a large scale open-source synchronous constituent learning system.
- AIM: Investigate and understand the relationship between the choice of synchronous grammar and SMT performance,
- AIM: and fix our decoders accordingly.

Evaluation goals

We will predominately evaluate using BLEU, but also use automatic structured metrics and perform small scale human evaluation:

- Evaluate phrasal, syntactic, unsupervised syntactic,
- Aim 1: Do no harm (not true of existing syntactic approach)
- Aim 2: Exceed the performance of current non-syntactic systems.
- Aim 3: Meet or exceed performance of existing syntactic systems.

Workshop Streams

- Implement scalable SCFG grammar extraction algorithms.
- Improve SCFG decoders to effieciently handle the grammars produce.
- Investigate discriminative training regimes the leverage features extracted from these grammars.

Language pairs (small)

- BTEC Chinese-English:
  - 44k sentence pairs, short sentences
  - Widely reported ‘prototyping’ corpus
  - Hiero baseline score: 52.4 (16 references)
  - Prospects: BTEC always gives you good results
- NIST Urdu-English:
  - 50k sentence pairs
  - Hiero baseline score: MT05 - 23.7 (4 references)
  - Major challenges: major long-range reordering, SOV word order
  - Prospects: small data, previous gains with supervised syntax

Language pairs (large)

- NIST Chinese-English:
  - 1.7M sentence pairs, Standard NIST test sets
  - Hiero baseline score: MT05 - 33.9 (4 references)
  - Major challenges: large data, mid-range reordering, lexical ambiguity
  - Prospects: supervised syntax gains reported
- NIST Arabic-English:
  - 900k sentence pairs
  - Hiero baseline score: MT05 - 48.9 (4 references)
  - Major challenges: strong baseline, local reordering, VSO word order
  - Prospects: difficult
- Europarl Dutch-French:
  - 1.5M sentence pairs, standard Europarl test sets
  - Hiero baseline score: Europarl 2008 - 26.3 (1 reference)
  - Major challenges: V2 / V-final word order, many non-literal translations
  - Prospects: ???

Summary

- Scientific Merit:
  - A systematic comparison of existing syntactive approaches to SMT.
  - An empirical study of how constituency is useful in SMT.
  - An evaluation of existing theories of grammar induction in a practical application (end-to-end evaluation).
- Potential Impact:
  - Better MT systems, for more languages, across a range of domains.
  - More accessible high performance translation models for researchers.
- Feasibility:
  - A great team with a wide range of both theoretical and practical experience.
  - Solid preparation.
- Novelty:
  - First attempt at large scale unsupervised synchronous grammar induction.