Translating Negation:
Induction, Search and Model Errors

Federico Fancellu & Bonnie Webber
School of Informatics
University of Edinburgh
f.fancellu@sms.ed.ac.uk, bonnie@inf.ed.ac.uk
Why bother? - Examples
During my emergency duty, I have not diagnosed a patient with appendicitis twice.

在同一个急诊的值班中，我两次没有发现病患得了盲肠炎。
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During my emergency duty, I have n’t diagnosed a patient with appendicitis twice.
Why bother? - Examples
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Even if he took things that do not belong to him, that does n’t mean he is a thief

如果他拿了不属于他的东西并不说明他就是个惯偷
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- BLEU scores also showed a problem in translating negation
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<table>
<thead>
<tr>
<th>Source → Target</th>
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<th>Neg</th>
</tr>
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<tbody>
<tr>
<td>Fancellu &amp; Webber (2014)</td>
<td>Zh → En</td>
<td>27.16</td>
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<td>Wetzel &amp; Bond (2012)</td>
<td>26.70</td>
<td>22.77 (-3.93)</td>
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- Similar trend for:
  - German → English
  - Czech → English
What’s exactly wrong with negation?
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Potential problem
What’s exactly wrong with negation?

Potential problem → Translating negation
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Hypothesis
What’s exactly wrong with negation?

Potential problem → Translating negation

- structural mismatch between source and target language (Collins et al., 2005)
What’s exactly wrong with negation?

Potential problem  
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- structural mismatch between source and target language (Collins et al., 2005)
- not enough negative training data (Wetzel & Bond, 2012)
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Translating negation

- structural mismatch between source and target language (Collins et al., 2005)
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- the translation rules does not contain negation (Baker et al., 2013)
What’s exactly wrong with negation?

- structural mismatch between source and target language (Collins et al., 2005)
- not enough negative training data (Wetzel & Bond, 2012)
- the translation rules do not contain negation (Baker et al., 2013)
- the scoring function does not contain any negation-related feature (Fancellu & Webber, 2014)
What’s exactly wrong with negation?

Potential problem

Hypothesis

Testing

Translating negation

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Potential problem → Translating negation

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Rationale
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Potential problem

Hypothesis

Testing

BLEU?
Rationale

Potential problem

Error analysis

Hypothesis

Problem(s)

Testing

BLEU?
Contributions
Contributions

• Present ongoing work on:
Contributions

• Present ongoing work on:
  – Finding the *causes* of negation-related error during decoding
Contributions

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  – Finding the *causes* of negation-related error during decoding
  – Highlighting the shortcomings of previous techniques
    • Constrained decoding
Contributions

• Present ongoing work on:
  – Finding the reasons of negation-related error during decoding
  – Highlighting the shortcomings of previous techniques
    • Constrained decoding
  – Develop an informative way to analyze the translation of negation at each step during decoding
    • Chart analysis
Sub-constituents of negation

在 同 一 个 急 诊 的 值 班 中 ， 我 两 次 没 有 发 现 病 患 得 了 盲 肠 炎 。

During my emergency duty, I have n’t diagnosed a patient with appendicitis twice.
Sub-constituents of negation

在同一个急诊的值班中，我两次没有发现病患得了盲肠炎。

During my emergency duty, I have n’t diagnosed a patient with appendicitis twice.

• **Cue**: the morpheme, word or multi-word unit inherently expressing negation.
  • *im*-possible, breathlessness, 不要脸，不少，…
  • *by no means*, *save*, …
Sub-constituents of negation

During my emergency duty, I have\textit{ n’t} diagnosed a patient with appendicitis twice.

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- **Event**: the lexical unit the cue directly refers to
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• **Event**: the lexical unit the cue directly refers to

• **Scope**: all the elements whose falsity would prove negation to be false.
  • The *event* is included in the *scope*
What kind of errors?
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- Manual analysis of the errors involved in translating negation (Fancellu & Webber, 2015 – Ex-Prom @ NAACL ‘15)
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- **Rule/phrase Table**: the best translation cannot be generated because its necessary phrases/rules are absent from the search space \(\rightarrow\) induction errors
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- **Rule/phrase Table**: the best translation cannot be generated because its necessary phrases/rules are absent from the search space → **induction errors**
- **Search space**: the most probable output is absent from the search space → **search errors**
What is the source of these errors?

- **Rule/phrase Table**: the best translation cannot be generated because its necessary phrases/rules are absent from the search space → **induction** errors
- **Search space**: the most probable output is absent from the search space → **search** errors
- **Model**: the model scores a sub-optimal translation higher than an optimal one → **model** errors
Constrained decoding
Constrained decoding

• Tries to reconstruct the reference
Constrained decoding

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• *Reference reachability* as a proxy to analyze errors during decoding
Constrained decoding

• Tries to reconstruct the reference

• Reference reachability as a proxy to analyze errors during decoding

• Implemented as a feature in Moses:
  – 1 if the hypothesis is a sub-string of the reference
  – - inf if the hypothesis is not a sub-string of the reference
Constrained Decoding
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• If the reference is reconstructed:
Constrained Decoding

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  – **Search vs. model errors** (Wisniewski and Yvon, 2013):
    
    • if \( p(e) < p(\hat{e}) \): **search** error
    • if \( p(e) > p(\hat{e}) \): **model** error

\*e: 1-best hypothesis
\*\( \hat{e} \): reconstructed reference
Constrained Decoding

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• If the reference can *not* be reconstructed:
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- If the reference can *not* be reconstructed:
  - Increase the *translation option limit* (Auli and Lopez, 2009)
    - if the reference can now be reconstructed \( \rightarrow \) **induction** error
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• If the reference can *not* be reconstructed:
  – Increase the *translation option limit* (Auli and Lopez, 2009)
    • if the reference can now be reconstructed $\rightarrow$ **induction** error
  – Increase the *cube pruning pop limit*
    • if the reference can now be reconstructed $\rightarrow$ **search** error
Locality issues
Locality issues

- Negation is usually a local phenomenon
Locality issues

• Negation is usually a local phenomenon

就 拿 住 在 村 东南 一个 小 弯 子 里 的 湾 家人 来 说 吧 ， 虽然 那 一家 子 的 家长 有点 不要脸 ， 我们 伟大 的 中 村 不是 照样 会 罩 着 这 一家 吗 ？
Locality issues

• Negation is usually a local phenomenon

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• If we fail to reconstruct a whole reference, it is unclear whether it is because of negation
Locality issues

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If we fail to reconstruct a whole reference, it is unclear whether it is because of negation

Solution: isolate the part containing negation and use them as input to CD
Locality issues

• Negation is usually a local phenomenon

那一家子的家长有点不要脸

the parents of the family are somewhat shameless

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• Solution: isolate the part containing negation and use them as input to CD
Results
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  - Just a few induction/search errors
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- Enlarging translation option limit and cube pruning pop limit leads to a small improvement
  - Just a few induction/search errors
- \( p(e) \) always < \( p(\hat{e}) \)
  - model errors
Discussion
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• *Ad-interim* conclusion: one should enhance the **model**
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- However:
Discussion

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• **However:**
  - We are basing our results on less than a half test sentences
    - ! CD is based only one or a few references vs. virtually infinite ways of translating a sentence
Discussion

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    • ? CD is based only one or a few references vs. virtually infinite ways of translating a sentence
  – If model errors, which score component is the most responsible?
  – CD treats decoding as a “black box”
  – It is hard to connect CD with deletion and reordering errors
Chart analysis

• Analysis of each step during decoding
• Access to hypothesis stacks and sub-scores
  – In-depth analysis of **model** errors
• We can understand the causes of **deletion** and **reordering** errors
• We can analyze the translation of **cue**, **event** and **scope** separately
• We can analyze patterns of translation amongst these elements
How does it work?
How does it work?

- Input → decoding chart trace
How does it work?

- Input $\rightarrow$ decoding chart trace
- A good translation of negation needs to meet four conditions:
  1. The cue has to be translated
  2. The event has to be translated
  3. The cue has to refer to the right event
  4. The scope elements should be placed in the correct negation scope
How does it work?

- Input → decoding chart trace
- A good translation of negation needs to meet four conditions:

  1. The **cue** has to be translated
  2. The **event** has to be translated
  3. The **cue** has to refer to the right **event**
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How does it work? – Cont’d

- Assuming we know the elements of negation on the source, the cell has to satisfy a given condition if it cover one or more of those elements

<table>
<thead>
<tr>
<th>放弃</th>
<th>政府</th>
</tr>
</thead>
<tbody>
<tr>
<td>没有</td>
<td>他们</td>
</tr>
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How does it work? – Cont’d

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```

他们

没有

放弃

政府 ○
```
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scope element attached to the right event
How does it work? – Cont’d

• Assuming we know the elements of negation on the source, the cell has to satisfy a given condition if it cover one or more of those elements
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<tr>
<td>没有</td>
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</tbody>
</table>

All elements should be translated and should correctly related to each other
Stack analysis – model errors

- Analysis whether a component is more responsible for **model** errors

1. gave up | p(e|f) p(f|e) p(LM) p_{lex.} … ✗
2. not | p(e|f) p(f|e) p(LM) p_{lex.} …
[...]
10: did not give up | p(e|f) p(f|e) p(LM) p_{lex.} … ✓

10 meets all conditions, 1 does not

1: p(e|f) p(f|e) p(LM) p_{lex}(e|f) p_{lex}(e|f)
↓ ↓ ↓ ↓ ↓
10: p(e|f) p(f|e) p(LM) p_{lex}(e|f) p_{lex}(e|f)
Stack analysis – search/induction errors

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**Stack analysis – search/induction errors**

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- cue has to be translated in all cells marked with ○
Stack analysis – search/induction errors

- cue has to be translated in all cells marked with ○
- If no cue is found in any of these cells:
  - Modify translation option limit and cube pruning pop limit to assess the presence of search and model errors
- Same applies to the other two elements
Stack analysis – others/ongoing

他们

没有

放弃

政府
Stack analysis – others/ongoing

- Rule trace to study negation element combinatory tendencies
Stack analysis – others/ongoing

- Rule trace to study negation element combinatory tendencies
- Is cue translated along side the event?
Stack analysis – others/ongoing

- Rule trace to study negation element combinatory tendencies
- Is cue translated along side the event?
- Is cue and event translated separately and combined together via glue rules?
Stack analysis – others/ongoing

- Rule trace to study negation element combinatory tendencies

- Is cue translated along side the event?

- Is cue and event translated separately and combined together via glue rules?

- What about event and scope?
Negation detection

- Source → annotations from manual error analysis
- Target?

1. gave up ||| [...]
2. not ||| [...]
10: did not give up ||| [...]
[...]
25: he did not give up ||| [...]

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Negation detection

• Source ⇒ annotations from manual error analysis
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1. gave up ||| [...]  
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*CRF (F1 > 90%)

Not
No
Neither
Impossible
By no means
[…]

cue
Negation detection

• Source $\rightarrow$ annotations from manual error analysis
• Target?

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*CRF (F1 > 90%)

Give up
Protest
go
[…]

*CCEDIT

event
cue
Negation detection

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2. not ||| […]
10: did not give up ||| […]
[…]
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![Diagram with cues, events, and scope annotations]

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Neither
Impossible
By no means
[…]

Give up
Protest
go
[…]
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Better approach: **paraphrase + automatic negation detection** (see Future Work)
System and initial results

• System:
  – Zh → En HIERO; 54 sentences containing negation (from the *manual* error analysis)

• Results:
  – Errors related to the translation of the cue
  – The cue is *never* absent from the chart of *any* sentence
    • no *search* or *induction error*
  – Analysis of the model sub-scores:
    • *Indirect probabilities* (translation and lexical) are responsible for > 60% of bad-ranking
    • *LM* only 25%
Conclusion

• Translating negation is problematic
• Previous error detection techniques do not offer an in-depth analysis
• A chart analysis offers a better insight in the decoding process

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<thead>
<tr>
<th></th>
<th>Model</th>
<th>Search</th>
<th>Induction</th>
</tr>
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<tbody>
<tr>
<td>Cue</td>
<td>Y</td>
<td>N</td>
<td>N</td>
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<tr>
<td>Event</td>
<td>…</td>
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<td>Scope</td>
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Future Work

- Negation detection in the target hypothesis
- No list! How to leverage a reference translation?

The soldier wasn’t afraid of death

Negation detection component

Paraphrase generation

- The soldier wasn’t afraid of death
- The soldier had no fear of death
- The soldier didn’t fear death
- The soldier, without any fear of death, […]
- The soldier was fearless of death
Thank you!