SMT/NMT: OSM and OOV

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Lecture Today

• I will present two pieces of further work by the group today:
  – Operation Sequence Model (OSM)
    • Competitor to PBSMT
    • Widely combined with PBSMT (as a set of feature functions)
  – Using Bilingual Word Embeddings for Domain Adaptation of NMT
    • This involves modeling Out-Of-Vocabulary (OOV) words
    • OOV words are words we want to translate that do not occur in the parallel training data
A Short Introduction to the Operation Sequence Model

Alexander Fraser
(slides mostly from Nadir Durrani)
Improving the modeling of syntax in SMT

- Novel model: **Operation Sequence Model**
- New model overcoming problems with phrase-based model
- Joint work with Durrani and Schmid
  - Durrani's 2013 PhD thesis won GSCL prize for best CL/NLP thesis in Germany from 2011-2013
  - Numerous papers at *ACL* conferences
Motivation: Long Distance Reordering in German-to-English SMT

- Er hat ein Buch gelesen → He read a book

- Er hat gestern Nachmittag mit seiner kleinen Tochter, die aufmerksam zugehört hat, und seinem Sohn, der lieber am Computer ein Videogame gespielt hätte, ein spannendes Buch gelesen

- We want a model that
  - captures "hat … gelesen = read"
  - captures the generalization that an arbitrary amount of stuff can occur between hat and gelesen (in the so-called "mittelfeld")
  - is a simple left-to-right model
Example

Sie würden gegen Sie stimmen

They would vote against you

• Rules:
  – Simultaneous generation of bilingual sentence pair through a sequence of operations
  – Generation is done in order of the target (English) sentence
  – Idea behind operations: either Translate or Reorder
Example

Sie würden gegen Sie stimmen

They would vote against you

Operations

$o_1$: Generate (Sie – They)
Example

Sie würden gegen Sie stimmen

They would vote against you

Operations

o₁ Generate (Sie, They)

o₂ Generate (würden, would)
Example

Sie würden gegen Sie stimmen

They would vote against you

Operations

- $o_1$ Generate (Sie, They)
- $o_2$ Generate (würden, would)
- $o_3$ Insert Gap
Example

Sie würden gegen Sie stimmen

They would vote against you

Operations

- $o_1$ Generate (Sie, They)
- $o_2$ Generate (würden, would)
- $o_3$ Insert Gap
- $o_4$ Generate (stimmen, vote)
Example

Sie würden gegen Sie stimmen
They would vote against you

Operations

- $o_1$ Generate (Sie, They)
- $o_2$ Generate (würden, would)
- $o_3$ Insert Gap
- $o_4$ Generate (stimmen, vote)
- $o_5$ Jump Back (1)
Example

Sie würden gegen Sie stimmen

They would vote against you

Operations

- $o_1$ Generate (Sie, They)
- $o_2$ Generate (würden, would)
- $o_3$ Insert Gap
- $o_4$ Generate (stimmen, vote)
- $o_5$ Jump Back (1)
- $o_6$ Generate (gegen, against)
Example

Sie würden gegen Sie stimmen

They would vote against you

Operations

- $o_1$ Generate (Sie, He)
- $o_2$ Generate (würde, would)
- $o_3$ Insert Gap
- $o_4$ Generate (stimmen, vote)
- $o_5$ Jump Back (1)
- $o_6$ Generate (gegen, against)
- $o_7$ Generate (Sie, you)
Model

- Joint probability model over operation sequences

\[
p_{osm}(F, E, A) = p(o_1^J) = \prod_{j=1}^{J} p(o_j | o_{j-n+1}, \ldots, o_{j-1})
\]

Context window: 9-gram model
Example of a learned pattern

• Operations
  – Generate (würden, would)
  – Insert Gap
  – Generate (stimmen, vote)

• Can generalize to
  – Die Menschen würden dafür stimmen
  – Die Menschen würden gegen meine Außenpolitik stimmen
  – Die Menschen würden für die Legalisierung der Abtreibung in Kanada stimmen

• Equivalent to hierarchical phrase “würden X stimmen – would vote X”

• Gaps can be created recursively
  – Multiple gaps can occur simultaneously
Results and outlook

• Operation sequence model overcomes problems with the phrase-based model
  • Models minimal translation units well that are highly dependent on one another but not contiguous, unlike phrase-based
  • Reordering is integrated with lexical generation
• Operation sequence model is available as a feature function in the latest version of Moses (open-source statistical machine translation toolkit)
• The model is widely acknowledged to lead to actual improvements in systems in large scale evaluation campaigns such as WMT and IWSLT
  • Standardly used in all competitive PBSMT systems
• What I didn't talk about: our related work on synchronous grammars, particularly Synchronous Context-Free Grammars (SCFG), Synchronous Tree Substitution Grammars (STSG)
• Thank you!