A Smorgasbord of Features for Statistical Machine Translation

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Enormous progress in MT due to statistical methods

- Enormous progress in recent years
  - TIDES MT Evaluation: $\Delta$BLEU=4-7% per year
  - Good research systems outperform commercial-off-the-shelf systems
    - On BLEU/NIST scoring
    - Subjectively
But still many mistakes in SMT output…

- Missing content words:
  - MT: Condemns US interference in its internal affairs.
  - Human: **Ukraine** condemns US interference in its internal affairs
- Verb phrase:
  - MT: Indonesia *that oppose the presence* of foreign troops.
  - Human: Indonesia reiterated its opposition to foreign military presence.
- Wrong dependencies
  - MT: …, particularly those who cheat the audience the players.
  - Human: …, particularly those **players who cheat the audience**.
- Missing articles:
  - MT: …, he is fully able to activate team.
  - Human: … he is fully able to activate **the** team.
What NLP tools are used by best SMT system?

STD NLP TOOLS:
• Named Entity tagger
• POS tagger
• Shallow parser
• Deep parser
• WordNet
• FrameNet
• …

• USED:
  – N-grams
  – Bilingual phrases
  – (+rule-based translation of numbers&dates)

• Can we produce better results with POS tagger/parser/…?
“Syntax for SMT”-Workshop

- 6-week NSF Workshop at JHU
- Goal: Improve Chinese-English SMT quality by using ‘syntactic knowledge’
- Baseline system: best system from TIDES MT evaluations
  - Alignment template MT system (ISI)
Baseline system

- Alignment template MT system
  - Training corpus: 150M words per language
  - Training: Store ALL aligned phrase pairs
  - Translation: Compose ‘optimal’ translation using learned phrase pairs

Treffen wir uns nächsten Mittwoch um halb sieben.

Let’s meet next Wednesday at six thirty.
Baseline System

• Log-Linear Model

\[ \Pr(e|f) = p^{M}(e|f) \propto \exp\left[ \sum_{m=1}^{M} \lambda_{m}h_{m}(e,f) \right] \]

  – Here: small number of informative features
  – Baseline: 11 features

• Maximum BLEU training
  – [Och03; ACL]
  – Advantage: directly optimizes quality
Approach: Incremental Refinement

1. Error analysis
2. Develop feature function ‘fixing’ error
3. Retrain using add’l feature function
4. Evaluate on test corpus
   - If useful: add to system
5. Goto 1

Advantage: Building on top of strong baseline
Approach: Rescoring of N-Best List

- Problem: How to integrate syntactic features?
  - Parser/POS-tagger are complicated tools in itself
  - Integration into MT system very hard
- Solution: Rescoring of (precomputed) n-best lists
  - No need to integrate features in DP search
  - Arbitrary dependencies:
    - Full Chinese + English Sentence, POS sequence, parse tree
    - No left-to right-constraint
  - Simple software architecture
How large are potential improvements?

• During workshop:
  – Development corpus: 993 sentences (‘01 set)
  – Test corpus: 878 sentences (‘02 set)
  – 1000-best list
• First best score: BLEU=31.6%
• Oracle Translations
  – best possible set of translations in n-best list
How large are potential improvements?

Note: 4-reference oracle too optimistic (see paper)
Syntactic Framework

• Tools
  – Chinese segmenter: LDC, Nianwen Xue
  – POS tagger: Ratnaparkhi, Nianwen Xue
  – English parser: Collins (+Charniak)
  – Chinese parser: Bikel (Upenn)
  –Chunker: fnTBL (Ngai, Florian)

• Data processed (pos-tagged/chunked/parsed)
  – Train: 1M sents (English), 70K sents (Chinese)
  – Dev/Test (n-bests): 7000 sents with 1000 bests
Feature Function Overview

• Developed 450 feature functions
  – Tree-Based
  – Tree Fragment-Based
  – Shallow: POS tags, chunker output
  – Word-Level: words and alignment

• Details: final report, project presentation slides
  http://www.clsp.jhu.edu/ws03/groups/translate/
Tree-Based Features

- Tree Probability
- Tree-to-String: Project English parse tree onto Chinese string (Yamada&Knight 2001)
- Tree-to-Tree: Align trees output by both parsers node-by-node (Gildea 2003)

**Result**: insignificant improvement less than 0.2%

**Problems**: efficiency, noisy alignments and noisy trees => tree decomposition
Tree Decomposition

$h_{\text{MarkovTreeToString}} = \log(P_{\text{TreeToString}}(\text{Frag0})) + \log(P_{\text{TreeToString}}(\text{Frag1})) + ...$
Features From Tree Fragments

China's 14 open border cities marked economic achievements

中国 十四个 边境 开放 城市 经济 建设 成就 显著
Features From Tree Fragments

• Fragment language model: unigram, bigram
• Fragment Tree-to-String Model

Result: improvement $\leq 0.4\%$
Shallow Syntactic Features

Projected POS Language Model:
• Project Chinese POS to English (using alignment)
• Attach to POS symbol change in word position
• Trigram language model on resulting symbols

Example:
CD+0_M+1  NN+3  NN-1  NN+2_NN+3
Fourteen   open   border   cities
Best features: give statistically significant improvement

IBM Model 1 score: lexical translation probabilities w/o word order
  \[ P(\text{chinese-words} | \text{english-words}) \]
  \[ \text{Sum of all alignments (no Viterbi): Triggering effect} \]
  \[ \text{Seems to fix tendency of baseline to delete content words} \]

Lexicalized phrase reordering model
  \[ \text{Next slide} \]
Features on Phrase Alignment

achievements

economic

marked

cities

border

open

14

's

China

1-P(left-monotone)

1-P(right-continuous)

P(left-monotone)

P(right-continuous)
Syntax for SMT - Results

• End-to-End improvement by greedy feature combination: 1.3%
  – 31.6% to 32.9%: statistically significant
  – (+ minimum Bayes risk decoding: 1.6%)

• Improvements due to:
  – Word/Phrase Level FF (>1%; statistically significant)
  – Shallow / Tree-Fragment Based (<=0.4%)
  – Tree-Based (<=0.2%)

• Conclusion: unfortunately no significant improvement using explicit syntactic analysis
Syntax - Potential Reasons for Small Improvements?

• Parsers not trained on general news text
  – ParserProb(MT output)>ParserProb(Oracle)
  – ParserProb(Oracle)>ParserProb(HumanReference)

• Parse trees often not corresponding between SL and TL
  – Many structural divergences between SL and TL

• Parsing ‘bad MT output’ problematic
  – Parser ‘hallucinate’ structures, constituents
  – In sentences without verb: noun gets analyzed as verb
Parsing/Tagging Noisy Data
Syntax - Potential Reasons for Small Improvements?

• Limited scalability of used framework?
  – Small Discriminative Training Corpus (993 sentences)
  – Maximum BLEU training prone to overfitting
  – Therefore: No training run on all 450 features

• Baseline system is too good?
  – Baseline MT trained on 170M words
  – Parser/Tagger trained on 1M words

• Is BLEU the right objective function for subtle improvements in syntactic quality?
Conclusions

• Discriminative reranking of N-Best lists in MT is a promising approach
  – 1.6% overall improvement on 1000-best list in 6 weeks on top of best Chinese-English MT system

• Still unclear if parsers are useful for (S)MT
  – What kind of analysis tools would be helpful?
  – B. Mercer: “With friends like statistics, who needs linguistics?” -- true for MT?
Round-robin (11o-oracle) vs. optimal oracle (avBLEUr3n4)
Processing Noisy Data

• Tagger tries to “fix up” ungrammatical sentences
  – China_NNP 14_CD open_JJ border_NN cities_NNS achievements_VBZ remarkable_JJ
• Same effects in parser
• **Resulting problem**: parses will look syntactically well-formed even for ill-formed sentences
Example Chinese-English

• North Korean Delegation, North Korea Has No Intention to Make Nuclear Weapons
• Seoul (Afp) - South Korean officials said that the North and South Korea ministerial-level talks between the North Korean delegation, said today that North Korea has no intention to make nuclear weapons.
• South Korean delegation spokesman Li FUNG said that North Korea, "North Korea that it was not making nuclear weapons," he said.