Machine Translation Systems

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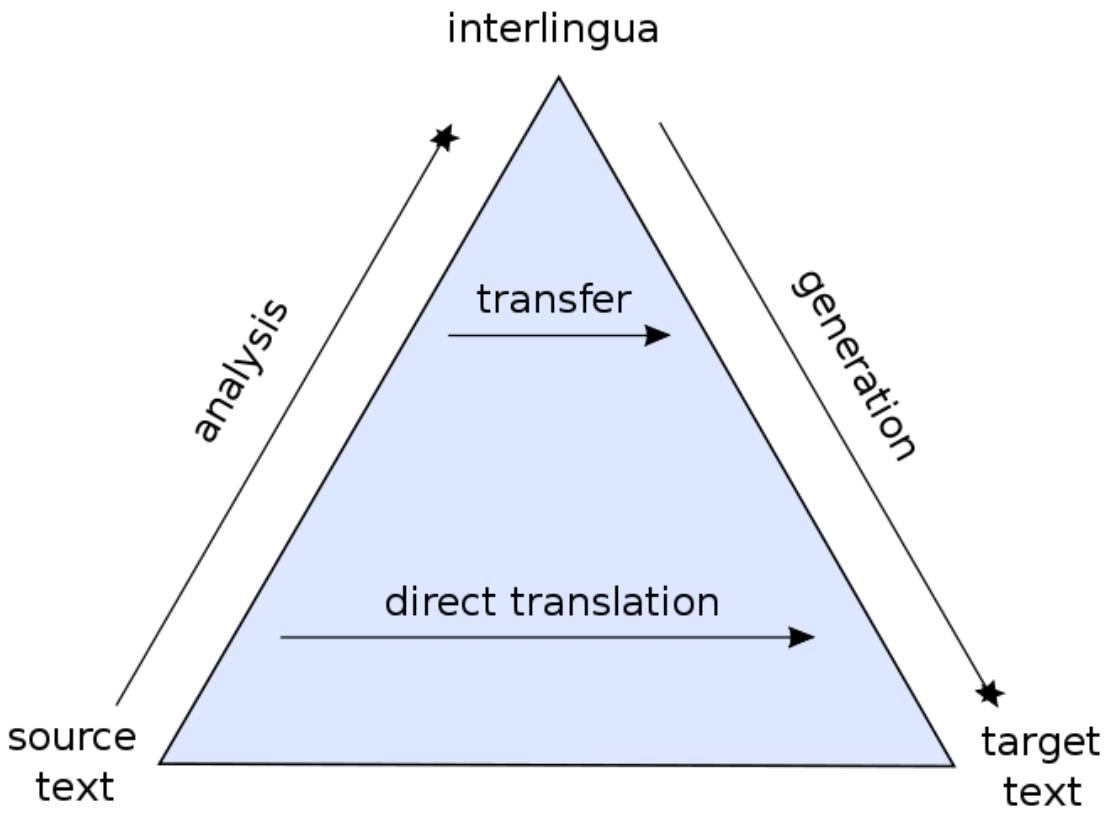
Outline

1) Introduction

- Translation involves 2 stages
  - First: decoding the meaning of the source language
  - Second: re-encoding the meaning into the target language



1) Introduction

- Behind this process set of complex operations
  - full knowledge of the source language which include
    - ★ morphology
    - ★ syntax
    - ★ semantics
  - the context features of the text
  - the same in-depth knowledge to re-encode the meaning in the target language

- Different MT systems have been proposed:
  - Rule-based Systems
  - Example-based Systems
  - Statistical Systems (popular)
  - Advanced Systems

2) Rule-based Systems

- They are meaning-oriented MT systems (1980s-1990s)
- Intermediate representations: morphology, syntax and semantics patterns
  $\rightarrow$ collected and revised manually by linguistics experts
- Rule-based systems are effective because much of the lingustics knowledge is static
- Two major limitations:
  - construction of linguistics rules (time, cost, ambiguity[idioms])
  - processing efficiency (solving conflicts)
- Commercial Systems: SYSTRAN, LOGOS and EUROTRA

3) Example-based Systems

- Started early 1990s and were major turing point for MT
- Sometimes called corpus-based, analogy-based, memory-based or experience-guided
- Three main tasks
  - phrase matching
  - phrase alignment
  - phrase recombination
- They are faster than rule-based but does not gurantee better translations
- Example-based MT and Statistical MT are nearly similar

4) Statistical Systems

- In 1988, Brown et al. from IBM present the mathematics of statistical MT and suggest to find the best translation $\mathbf{e}_{\text{best}}$ with the highest probability based on a parallel corpus

$$\mathbf{e}_{\text{best}} = \text{argmax}_{\mathbf{e}}\ p(\mathbf{e}|\mathbf{f})$$

- Bayes rule, note the denominator $p(\mathbf{f})$ is independent of e then it can be discarded

$$\text{argmax}_{\mathbf{e}}\ p(\mathbf{e}|\mathbf{f}) = \text{argmax}_{\mathbf{e}} \frac{p(\mathbf{f}|\mathbf{e})\ p(\mathbf{e})}{p(\mathbf{f})}$$

- $p(\mathbf{f}|\mathbf{e})$ (translation model) and $p(\mathbf{e})$ (language model) simulate human translators by first understanding the text and then expressing it

5) Advanced Systems

- Syntactic tree prediction with the perceptron algorithm
- Syntactic tree prediction with the boosting technique
- Kernel-based methods for MT
- They explore extensive context and syntax information using Machine Learning technologies but complicate the MT (memory and power)
- Open questions:
  - which Machine Learning methodologies are appropriate for MT?
  - how to make use of these methods?
- Yizhao Ni has worked in this area and I will to continue his research

6) MT Evaluation

- How good is a given machine translation system?
- Hard problem, since many different translations acceptable
  $\rightarrow$ semantic equivalence / similarity
- Adequacy and fluency
  - Does the output convey the same meaning as the input sentence?
  - Is the output good fluent English?
- Evaluation metrics
  - Subjective judgments by human evaluators
  - Automatic evaluation metrics
    - ★ Precision and Recall of Words
    - ★ WER (Word Error Rate)
    - ★ BLEU (Bilingual Evaluation Understady) - popular

6) MT Evaluation

- Chinese example from the 2001 NIST evaluation set

  这个 机场 的 安全 工作 由 以色列 方面 负责 .

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- Chinese example from the 2001 NIST evaluation set

  这个 机场 的 安全 工作 由 以色列 方面 负责 .

1- Israeli officials are responsible for airport security.
2- Israel is in charge of the security at this airport.
3- Israeli side was in charge of the security of this airport.
4- Israel is responsible for the airport's security.
5- Israel is responsible for safety work at this airport.
6- Israel presides over the security of the airport.
7- Israel took charge of the airport security.
8- The safety of this airport is taken charge of by Israel.
9- This airport's security is the responsibility of the Israeli security officials.
10- The security work for this airport is the responsibility of the Israel government.

7) Resources

Y. Ni. Beyond multi-class structured learning for machine translation. PhD thesis, University of Southampton, 2010

Statistical Machine Translation, Philipp Koehn, textbook, Cambridge University Press, January 2010

`http://www.statmt.org`

`http://www.mt-archive.info`

Thank you!