



Statistical Machine Translation Using Thot

Daniel Ortiz Martínez

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Introduction

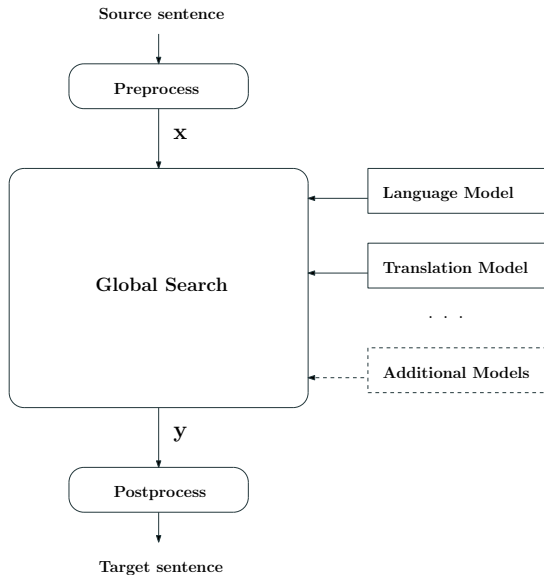
Statistical Machine Translation

- For a given source sentence \mathbf{x} , SMT finds the translation of highest probability in the target language, \mathbf{y}

$$\hat{\mathbf{y}} = \arg \max_{\mathbf{y}} \{Pr(\mathbf{y}|\mathbf{x})\} = \arg \max_{\mathbf{y}} \{Pr(\mathbf{y}) \cdot Pr(\mathbf{x}|\mathbf{y})\}$$

- SMT is based on statistical models
 - Measure the correctness of the translation
 - Trained on parallel corpora
- Given \mathbf{x} and the models, \mathbf{y} is obtained through a search process

Architecture of an SMT System



- Before translating, it is useful to *digest* the input text to make things easier to the translation system
- Common preprocessing tasks:
 - **Tokenization**: “Black ink cartridge.” → “Black ink cartridge .”
 - **Lowercasing**: “Black ink cartridge .” → “black ink cartridge .”
- Post-processing is necessary to obtain raw output text:
 - **Recasing**: “cartucho de tinta negro .” → “Cartucho de tinta negro .”
 - **Detokenization**: “Cartucho de tinta negro .” → “Cartucho de tinta negro.”

Modeling

- **Language model**

- Measures the fluency of the target sentence
- Assigns better score to well formed target text

- **Translation model**

- Measures the adequacy of the target sentence as a translation of the source sentence
- Assigns better score to accurate and complete translations

- n -gram models are a popular implementation of language models
- An n -gram is a vector of n consecutive words
- Assign scores to each word depending on the $n - 1$ preceding words
- They are estimated from target texts
- An n -gram model is basically a set of n -gram counts

- Phrase models are a common way to implement translation models
- Phrase-based translation follows a three step process:
 1. Divide the source sentence into segments
 2. Choose the target translations for each segment
 3. Reorder the target phrases to compose the final translation
- A phrase model is basically a dictionary of phrase pairs with scores

Phrase-based Translation Example

Step 1 (source segmentation):

x: material excelente para diversos usos

Step 2 (phrase translation):

material → material

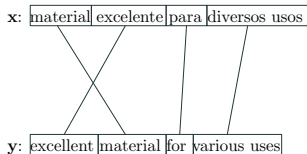
excelente → excellent

para → for

diversos usos → various uses

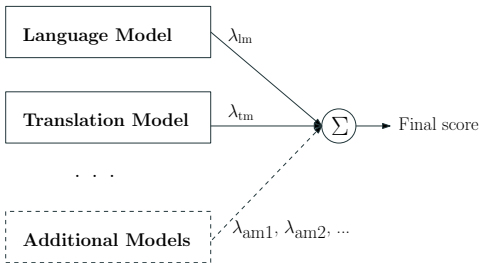
Step 3 (reordering):

y: excellent material for various uses



Model Combination

- Common SMT systems rely on a combination of different models
- Language and translation models are the basis of the combination
- Additional models can be included
- Each model has a weight, λ , defining its importance



Training

- SMT systems use training corpora to estimate model parameters
- Language models require monolingual data for the target language

Black ink cartridge for Canon
Pure grapefruit essential oil
Adidas FEF Spain shoe bag
...

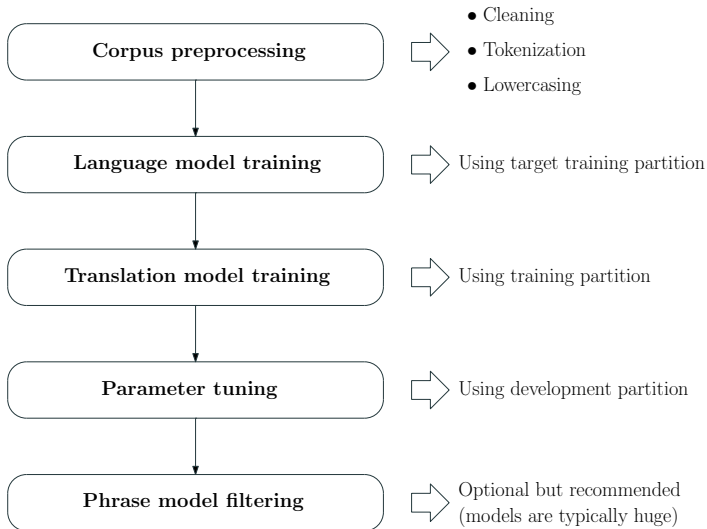
- Phrase models require bilingual data

Cargador para portátil ACER Aspire	Laptop charger for ACER Aspire
Nuevo reloj TAG-HEUER Fórmula-1	New TAG-HEUER Formula-1 watch
Funda de almohada decorativa 40cm	16" decorative pillowcase
...	...

- Translation quality is strongly affected by corpora availability
 - Corpus size is very important (the larger the better)
 - Corpus domain is also critical
- Models estimated from very large corpora are difficult to handle
 - Training is very time consuming
 - Huge amounts of memory are required to load them
 - Loading times can also be huge

- To carry out experiments, the training corpus is typically divided into three partitions:
 - **Training partition:** a large subset of the whole corpus which is used to train language and translation models
 - **Development partition:** a small portion (a few thousand sentences) useful to adjust the weights of the model combination
 - **Test partition:** a small subset (a few thousand sentences) of the corpus used to generate translations and evaluating the final quality

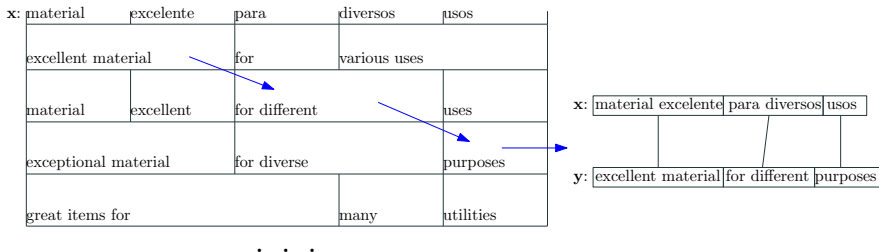
Training Pipeline



Search

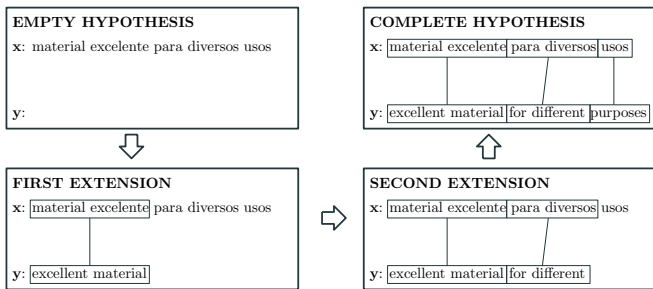
Search

- After training the models, they can be used to generate translations
- Given a source sentence, x , it can be translated in many ways:

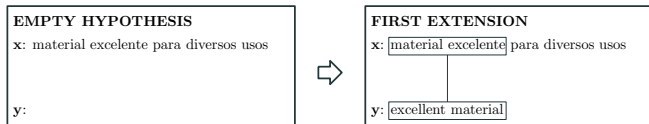


Search

- The search space is explored by generating translation hypotheses
- Translation hypotheses are built in an incremental manner
- Partial hypotheses can be extended by adding words to them



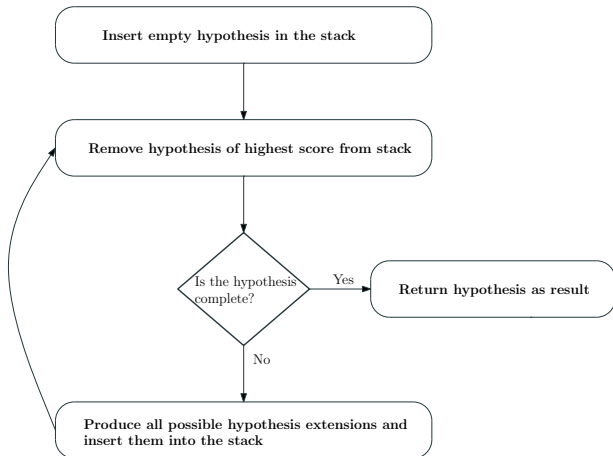
- SMT finds the translation of highest score according to the models
- The score of a partial hypothesis is revised after each extension



- Contributions to score for the previous example:
 - **Phrase model:** adds a score due to the translation of “material excelente” by “excellent material”
 - **Language model:** adds a score due to the addition of the words “excellent material”

Search Algorithm

- An iterative algorithm is used to reach the goal translation
- The algorithm uses a stack (priority queue) to organize the search



Evaluation

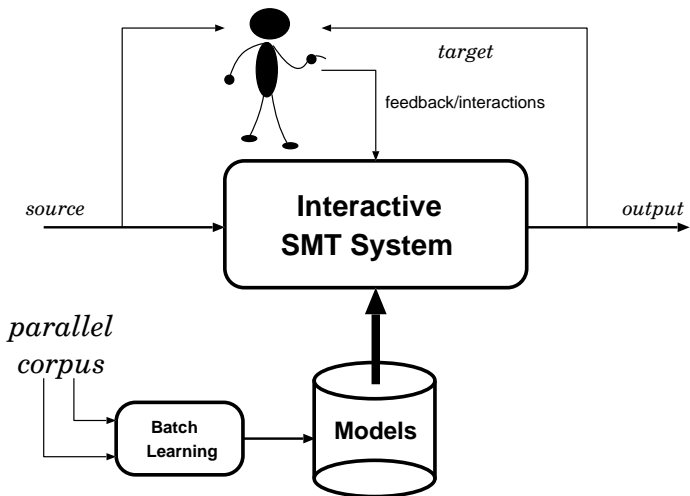
- Translation quality measures can be automatic or manual
- The test partition can be used to compute automatic measures using the target sentences as references
- Two common automatic measures:
 - **BLEU**: the BLEU (bilingual evaluation understudy) score is a quality measure based on n -gram precision for different values of n plus a brevity penalty
 - **WER**: the WER (word error rate) measure counts the number of substitutions, insertions and deletions required to convert the system translation into the reference sentence

Advanced Topics

Post-Editing and Interactive Machine Translation

- SMT allows us to translate a source text without human intervention
- Unfortunately, SMT results are not error-free
- SMT output can be supervised to obtain high-quality translations
- Two SMT applications allow users to collaborate with the system:
 - Post-editing (PE): sequential collaboration
 - Interactive Machine Translation (IMT): interactive collaboration

Interactive Machine Translation



Interactive Machine Translation Example

source(x): Para ver la lista de recursos

reference(\hat{y}): To view a listing of resources

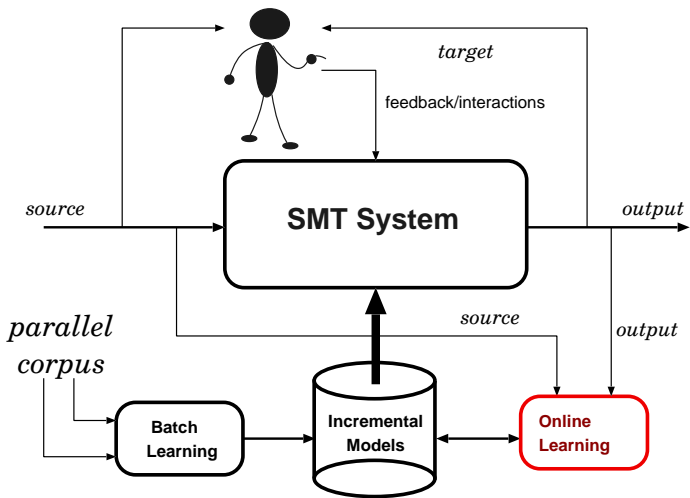
interaction-0	p s	To view the resources list
interaction-1	p k s	To view a list of resources
interaction-2	p k s	To view a list i ng resources
interaction-3	p k s	To view a listing o f resources
acceptance	p	To view a listing of resources

- Appropriate in those learning tasks in which learning must take place over time
- Examples are not available a priori but become available over time, usually one at a time
- Online learning is opposed to batch learning, where there is a finite set of examples that are available a priori

Main Features of Online Learning

- No re-processing of previous samples is required.
- The learner can, at any time, produce an answer to a query
- The quality of the answers improves over time

Online Learning for SMT



Statistical Machine Translation with Thot

- Thot is a toolkit for phrase-based SMT
- Hosted on github: <http://daormar.github.io/thot/>
- Many features
 - Training, tuning and searching functionality
 - Can be executed in parallel on multiprocessors or clusters
 - Incorporates interactive machine translation and online learning
- Currently under development

Installation

- Obtain the package using git:

```
git clone https://github.com/daormar/thot.git
```

- Change to the directory with the package's source code and type:

```
./reconf
```

```
./configure
```

```
make
```

```
make install
```

NOTE: use `--prefix` option of `configure` to install the package in a custom directory

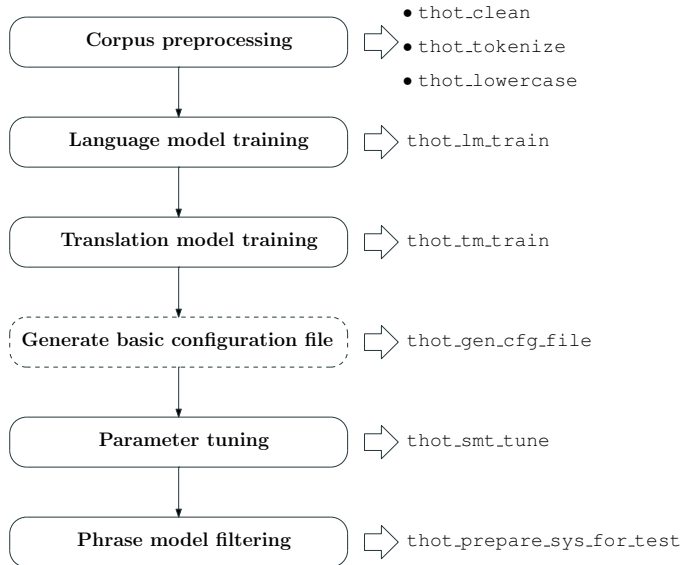
- Finally, after installation, the package can be checked by typing:

```
make installcheck
```

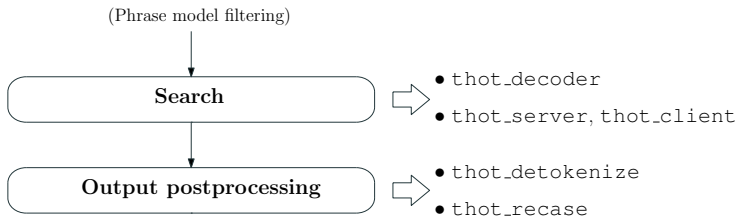
File Naming Conventions

- To simplify the usage of some tools, a naming convention has been adopted for the files containing a corpus partition
- One example can be found in the Spanish to English toy corpus included with `Thot`:
 - `{sp}|{en}.train`: training partition
 - `{sp}|{en}.dev`: development partition
 - `{sp}|{en}.test`: test partition
- Additional conventions have been defined to name files containing tokenized (`tok` suffix) and lowercased (`lc` suffix) texts

SMT Pipeline and Thot Commands (I)



SMT Pipeline and Thot Commands (II)



Thot Additional Commands

- `thot_auto_smt`: automates the whole SMT pipeline with one simple command
- `thot_calc_bleu`: computes the BLEU score
- `thot_calc_wer`: computes the WER measure
- ...

For additional information, check the [Thot documentation](#)

Questions?

`daniel.o@webinterpret.com`