CmpE 590 Research Project

SYSTRAN

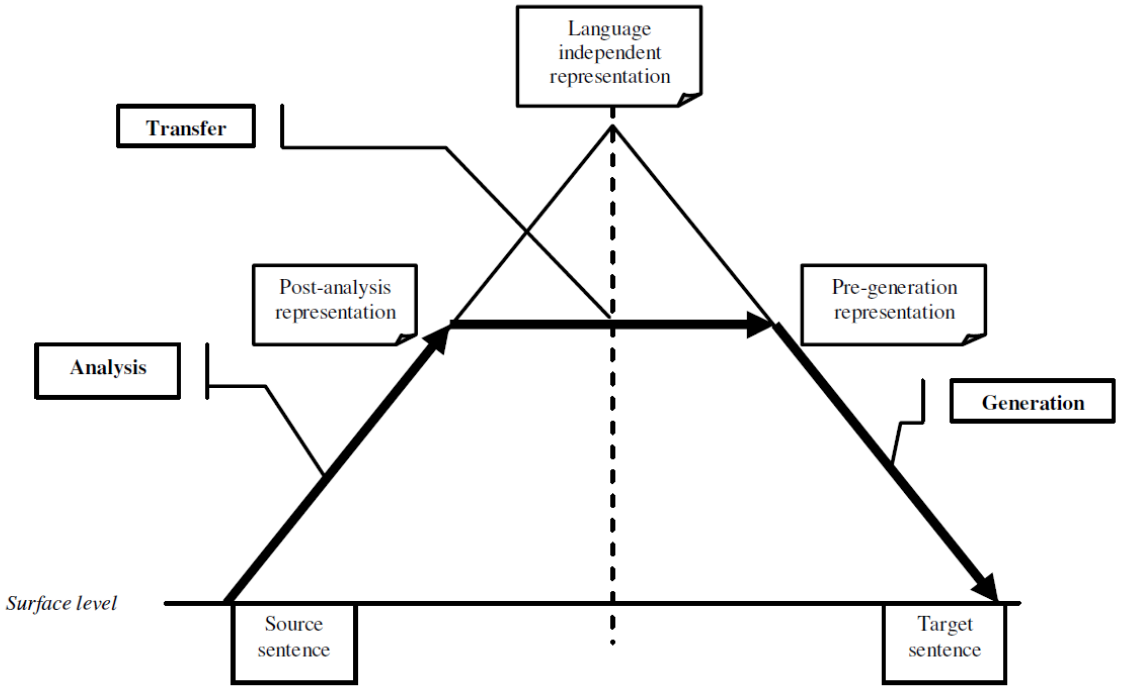
Systran History

- Founded in 1968
- Important breakthroughs
  - First hybrid MT system
  - First neural network MT system

Hybrid MT System

- Rule-based MT: the linguistic rules and general or domain specific resources
- The statistical analysis derived from monolingual corpus

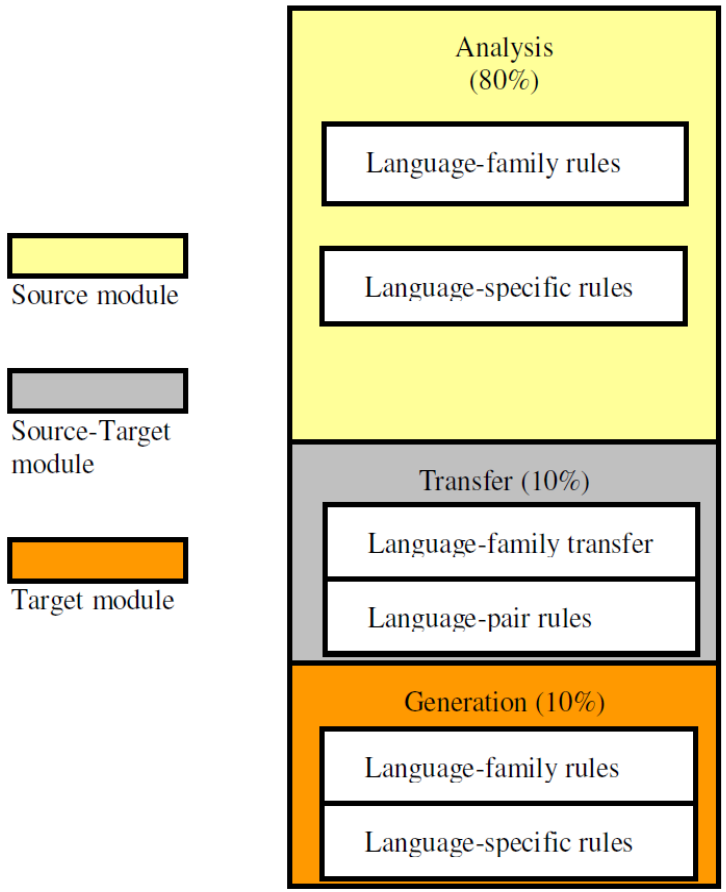
Rule-based System Architecture



Rule-Based System Architecture

- Analysis Module
  - Converting source sentence into an intermediate structure with its syntactical information
- Transfer Module
  - transferring into another intermediate structure with syntactical information about target sentence
  - specific to each language pair
  - not re-usable
- Analysis and Generation modules are re-usable, 90% of the code

Analysis + Transfer + Generation
Paradigm



Analysis Module

- language-family rules
- language specific rules
- the analysis of the ambiguity related to infinitive/finite verbs
  - unimportant when translating from German to English (“laufen”- “run”)
  - but required to describe a disambiguation rule to get the infinitive form (“laufen”-“correr” rather than “corren”) in Romance languages.

Transfer Module

- divided into different sub-modules based on language family
- language-pair rules
- transfer cost can be reduced thanks to the similarities between source and target languages

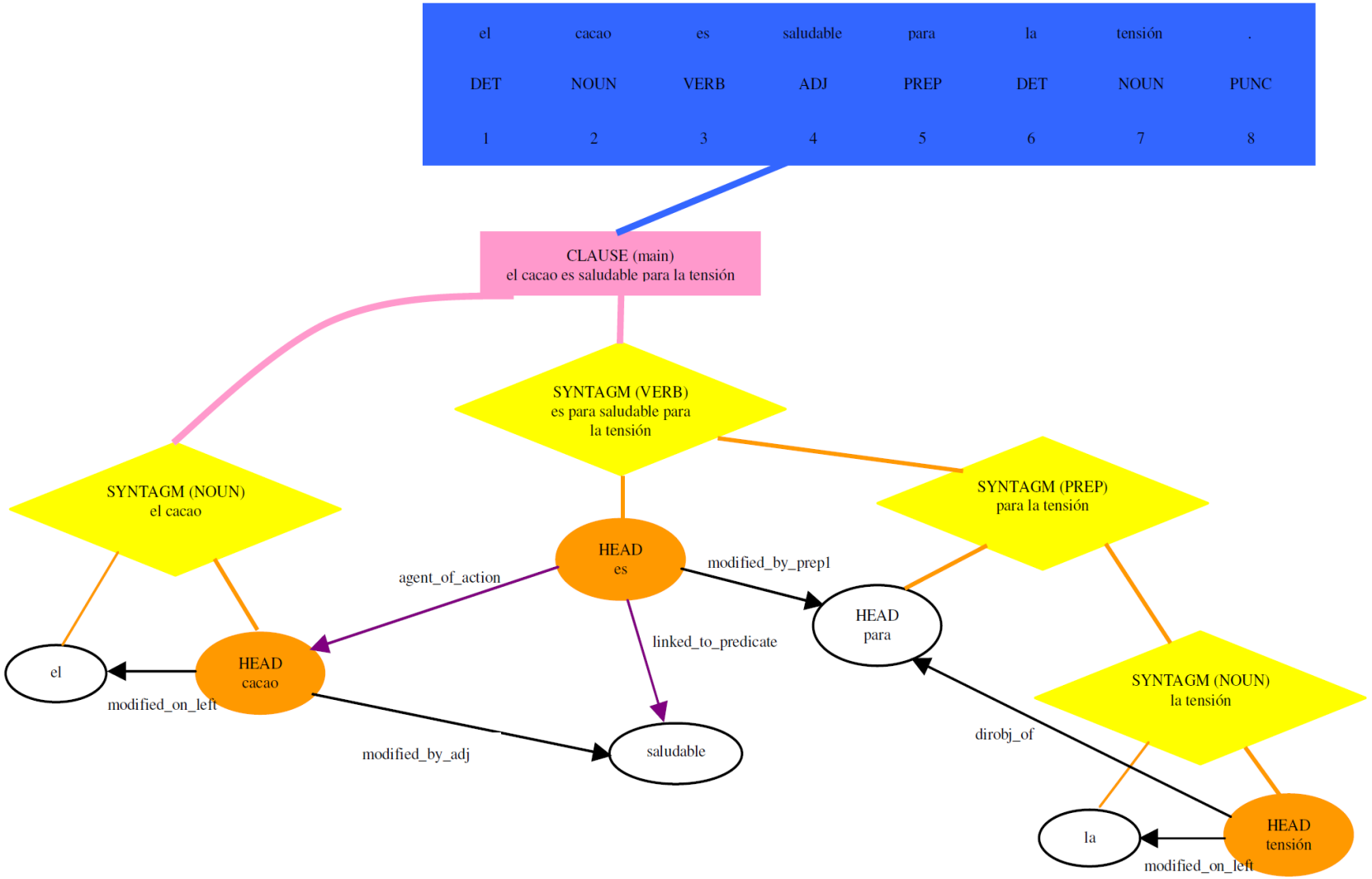
e.g. translating from Spanish/ Italian/ Portuguese to Spanish/ Italian/ Portuguese does not need much effort

the different languages like Spanish/ Italian/ Portuguese and German require more detailed transfer rules in order to reach correct word reordering.

XML-Based interface

- from the transfer module to the generation module the intermediate target structure is represented in XML-Based interface
- store all linguistic, typographical and structural information and markups that show which word are spellchecked and used dictionaries.

XML-based İnterface



Generation Module

- developed in C++ and the object-oriented programming paradigm is implemented in terms of linguistic families.
- The abstract classes represent syntactic constituents like word, syntagm, clause and sentence.
- The methods are language independent operations :
  - updating the structures (checking inflection agreement between a noun and its adjectives, or a verb and its auxiliaries),
  - the synthesis of missing elements (subject personal pronouns are dropped in Spanish, but in German they should be synthesized)
  - reordering,
  - updating the target tree based on punctuation, typography.

Generation Module

- the more special classes inheriting from the base classes represents the features of language family.
- The new methods covering particular linguistic knowledge to language family such as Western, Romance, Germanic are added or the existing methods are overridden.
- For example, the Spanish / Italian / Portuguese classes additionally includes the methods about verbal auxiliaries and enclitic pronouns.

Statistical Post-Editing

- perform on the translation output produced by the rule-based system in
- The statistical information derived from monolingual corpora
  - adding new terms, entities and terminology to the current dictionaries,
  - resolving the ambiguities,
  - use of language model to select alternative translations, determiner choice, and reordering.

Statistical Post-Editing

- translate unknown words in the Systran RBS
- capture slight terminology changes but still preserving POS and meaning to improve fluency (e.g. politicians → politiciens vs the more commonly used “hommes politiques”),
- capture multiword expressions and locutions
- update
  - determiner (on political commitments → sur des engagements politiques vs. sur les engagements politiques)
  - preposition (across the Atlantic → à travers l’atlantique vs. de l’autre côté de l’atlantique),
  - pronoun, tense (should not be hidden → ne devraient… vs. ne doivent…), number and gender, and re-arrange word-ordering

Statistical Post-Editing

Source :En>Fr,De>En,Es>en	SYSTRAN	SYSTRAN +SPE
Monetary policy can be used to stimulate an economy just as much as fiscal policy, if not more, in election years, which politicians will always want to do.	La politique monétaire peut être employée pour stimuler une économie juste comme beaucoup que la politique fiscale, sinon plus, en années d'élection, que les politiciens voudront toujours faire.	La politique monétaire peut être utilisée pour stimuler l'économie, tout comme la politique fiscale, pour ne pas dire plus, dans les années d'élection, que les hommes politiques voudront toujours faire.
Fortschritte der 12 Bewerberländer auf dem Weg zum Beitritt	Progress of the 12 applicant countries on the way to the entry	Progress of the 12 candidate countries along the road to accession
En una perspectiva a más largo plazo, habrá una moneda única en todo el continente.	In a perspective to more long term, there will be a unique currency in all the continent.	In a more long-term perspective, there will be a single currency for the whole continent.

Lexicographic Resources

- has been growing for over years
- The system consists of
  - the main dictionary
  - the transfer dictionary
  - the phrase-based dictionary

Main Dictionary

- Provide thousands of bilingual entries with all necessary information about source words and target words for each language pair.
- Obtained from the monosource / multilingual dictionaries carefully prepared by lexicographers.
- For instance, French-to-English bilingual main dictionary is derived from the multitarget French source dictionary.
- Collect only grammatical words: prepositions, pronouns, particles, conjunctions, and very fundamental verbs: copulas, auxiliaries, linking verbs and verbs used commonly in periphrastic idioms and homographic words

Transfer Dictionary

- Built based on Intuitive Coding Technology
- Intuitive Coding Technology allows user to easily enter information to bilingual dictionaries.
- However, the inflection paradigms and homographs are guessed by the internal lexicographic rules and heuristics about morpho-syntax.
- Includefull words: nouns, verbs, adjectives and idiomatic sequences.

Phrase-based Dictionary

- Written by the statistical information about phrase-pairs extracted from parallel corpora.
- By the way, the existing rule-based, general-purpose MT system can be adapted into a given domain.
- Learning phrasal entries for rule-based system:
  - capture domain context to disambiguate the translation.
  - word-to-word translation is not of use in phrase translation
  - Strong collocations may resolve the syntactic ambiguity in the source sentence

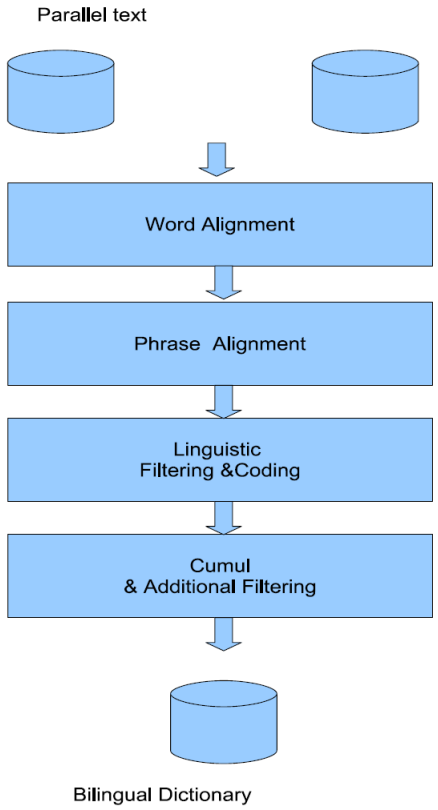
Phrase-based Dictionary

- limited to pharese having the same syntactic structure

  e.g. noun phrases should be translated as noun phrases

- In the extraction process,
  - Words and phrases in each corpus are aligned
  - For each candidate phrase pair, some statistical features like frequency in the corpus, lexical weights in both directions, the lemma counts are calculated
  - Only the most frequent or best aligned (according to lexical weight) translation per source phrase is elected
  - Each extracted phrase-pair which delivers translation score calculated based on BLUE metrics below the threshold is pruned out
  - only remaining ones are added to current dictionaries in order to prevent to damage the rule-based system

Phrase-based Dictionary



Neural Machine Translation

- deep learning approach to deliver high performance in several large-scale translation
- Possible to directly model the relationship between an input text in a source language and its translation in a target language in neural MT systems
- But very expensive in terms of computation and training duration.

Neural Machine Translation

- Systran NMT has been developed based on the open source project seq2seq-attn maintained by Harvard NLP group.
- The first generation works for generic translations, and covers 12 languages for 32 language pairs.

seq2seq-attn

- seq2seq-attn project provides various features
  - training with bidirectional encoders
  - pre-trained word embeddings
  - handling unknown words in decoding by substituting them with themselves or looking up their translation from an external resource
  - switching between CPU and GPU for both training and decoding.

Neural Machine Translation

- Integration of several features into the existing framework
- In tokenization, standard token separators (spaces, tabs, etc.) and language dependent linguistic rules are utilized
- Support for an arbitrary number of discrete word features as additional inputs to encoder and decoder
  - The features are represented in continuous and normalized vectors
  - Concatenated the vectors to word embeddings.
  - Supporting additional features on the target part is implemented by generating feature at time t+1 for the word generated at time t.

Neural Machine Translation

- The internal Named Entity modules previously developed for RMBT and SMT systems.
- Re-implement guided alignment strategy which guides attention mechanism in a NMT like IBM model 4 Viterbi alignments to handle placeholder substitutions and unknown words.
- Politeness feature is added to each source sentence in training

  very meaningful when translating from a language like English to a language including politeness expressions like Korean

Neural Machine Translation

- In the customization process,
  - Incrementally adapted into a specific domain by running additional training epochs over newly available in-domain data.
  - Even in limited in-domain data, the system demonstrates improved results.
- In post-editing,
  - monolingual and multi-source Neural Post Editing systems trained on the same data
  - Even multi-source NPE deliver similar performance to NMT after parameters are converged they are better than SPE.

Neural Machine Translation

- Training resources for each language pair:
  - a baseline corpus(1 million sentence) for day-scale experiments
  - a medium corpus (2-5 million sentences) for week-scale experiments
  - a very large corpora (more than 10 million sentences)