

Machine Translation

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Machine Translation: An Old Example

Well-known apocryphal example (E → R):
“The spirit is willing but the flesh is weak”
“The vodka is good but the meat is rotten”

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Multilingual Applications

- **Information Retrieval:** Cross-language; Is disambiguation necessary?
- **Foreign Language Tutoring:** Computerized Second Language Acquisition
- **Machine Translation/Gisting:** Parameterization, “getting the gist” vs. full translation

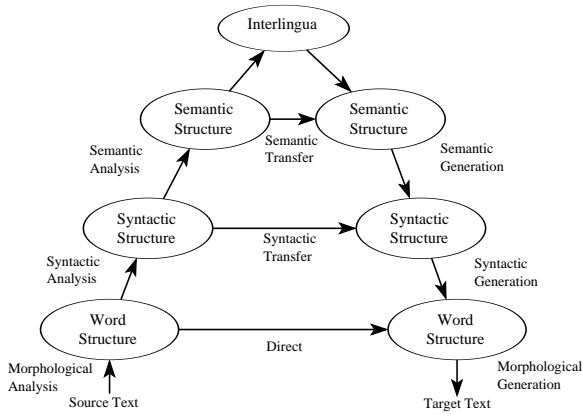
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MT History

- 1950's: Intensive research activity in MT.
1960's: Direct word-for-word replacement.
Yo le di puñaladas a Juan → I gave knife-wounds to John
1966 (ALPAC): NRC Report on MT
- Result: Many concluded that MT and other NL applications had failed and were no longer worthy of serious scientific consideration.
1966 – 1975: 'Recovery' period
1975 – 1985: Resurgence (Europe & Japan)
1985 – present: Resurgence (U.S.)
- What happened Between ALPAC and now?
 - Need for MT and other NLP applications confirmed.
 - Change in expectations.
 - Computers have become faster, more powerful.
 - Maturation of field of computational linguistics.
Yo le di puñaladas a Juan → I stabbed John

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Three Approaches: Direct, Transfer, Interlingual



Three Approaches (continued)

- **Direct Systems:** **GAT:** [Georgetown, 1964]; **TAUM-METEO:** [Colmerauer et al., 1971].
- **Transfer systems:** **GETA/ARIANE:** [Boitet, 1978], [Chauché, 1975], [Vauquois, 1977], [Vauquois & Boitet, 1985], and [Boitet, 1987]; **LMT:** [McCord, 1989]; **METAL:** [Thurmain, 1990]; **LFG-MT:** [Kaplan et al., 1989], [Zajac, 1990]; **MiMO:** [Arnold et al., 1988], [Arnold & Sadler, 1990], [van Noord et al., 1989], [van Noord et al., 1990], and [Sadler et al., 1990]; **LTAG:** [Abellé et al., 1990], [Shieber & Schabes, 1990], [Joshi, 1985].
- **Interlingual systems:** **KBMT:** [Carbonell & Tomita, 1987], [Nirenburg et al., 1992]; **PIVOT:** [Muraki, 1987]; **TRANSLATOR:** [Nirenburg et al., 1987]; **MOPTRANS:** [Schank, 1974], [Lytinen & Schank, 1982]; **ATLAS:** [Uchida, 1989]; **CETA:** [Vauquois, 1975]; **UNITRAN:** [Dorr, 1990, 1993].

Three Approaches (continued)

• **Direct approach:**

E: *I checked his answers against those of the teacher* →
 S: *Yo comparé sus respuestas de los estudiantes a las de la profesora*
 Direct Mapping:
 check X against Y → comparar X a Y

• **Transfer approach:**

G: *Ich habe ihn gesehen* → E: *I have seen him*
 Transfer Rule:
 [clause agt aux obj pred] → [clause agt aux pred obj]

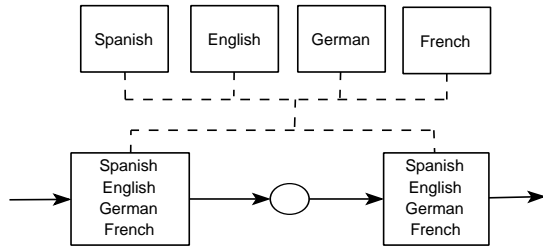
• **Interlingual approach:**

E: *I like Mary* → S: *María me gusta a mí*
 Interlingual Representation:
 [state BE_{ident} I [Position AT_{ident} I MARY] [Manner LIKINGLY]]

Comparison of Three Approaches

	ADVANTAGES	DISADVANTAGES
DIRECT	- simple - inexpensive - fast	- unreliable - not powerful: no theoretical foundation - single monolithic program: analysis, synthesis, linguistic knowledge all merged into one large program - proliferation of highly specific rules - proper choice of lexical equivalent requires too much context (whole sentence) - requires major restructuring after lexical substitution
TRANSFER	- don't need to find language-neutral representation - no translation rules hidden in lexicon - faster than interlingual	- n ² sets of transfer rules - proliferation of language-specific rules in lexicon and in syntax - difficult to extend (not parameterized) - analyzer and generator are not uniform across languages - cross-linguistic generalizations lost
INTERLINGUAL	- extensible (parameterizable) - lexical rules easily stated on uniform representation of sentence - can state structural transformations more simply on normalized structure - economy of selectional restrictions (no proliferation of rules, e.g., active vs. passive) - portable - more expressive power - more explanatorily adequate	- difficult to deal with terms on primitive level - must decompose and reassemble concepts - useful information lost (paraphrase) - no universal for tense/aspect/mood

Interlingual Design



- two stages
- intermediate interlingual representation
- language independent
- extensible
- bidirectional

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Translation Challenges

- Linguistic Challenges
- Operational Considerations

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Parameterization of the Interlingua: Syntax

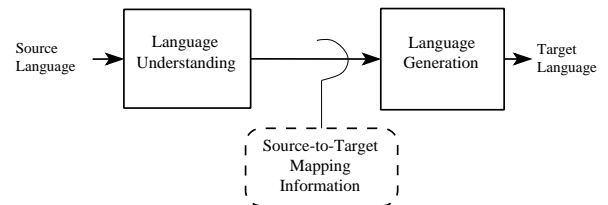
German	Spanish	English
VP ⇒ NP V	VP ⇒ V NP	VP ⇒ V NP
S ⇒ NP VP Aux	S ⇒ NP Aux VP	S ⇒ NP Aux VP
PP ⇒ P NP	PP ⇒ P NP	PP ⇒ P NP
	S ⇒ Aux VP	
	S ⇒ Aux VP NP	

Replace with parameter settings.

Parameter	German	Spanish	English
Null Subject	NO	YES	NO
Constituent Order	V:HF S:HF P:HI	V:HI S:HI P:HI	V:HI S:HI P:HI

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Linguistic Considerations



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Linguistic Challenge 1: Ambiguity

- **Syntactic Ambiguity:**

I saw the man on the hill with the telescope

- **Lexical Ambiguity:**

E: book

S: libro, reservar

- **Semantic Ambiguity:**

- Homography:

E: ball

S: pelota, baile

- Polysemy:

E: kill

S: matar, acabar

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Linguistic Challenge 2: Issues in Sentence Generation

- **Lexical Selection:**

- S: esperar

E: wait, hope

- G: können

E: know, understand

- E: be

S: ser, estar

- E: fish

S: pez, pescado

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Semantic Ambiguity

- **Contextual Ambiguity:**

- E: The computer outputs the data; it is fast

S: La computadora imprime los datos; es rápida

'The computer outputs the data; (it) is rapid'

- E: The computer outputs the data; it is stored in ascii

S: La computadora imprime los datos; están almacenados en ascii

'The computer outputs the data; (they) are stored in ascii'

- **Complex Contextual Ambiguity:**

E: John hit the dog with a stick

S: John golpeó el perro con el palo / que tenía el palo

'John hit the dog with the stick / that had the stick'

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Tense Generation

- **Tense Generation:**

C: Wǒ bèi Hángzhōu de fēngjǐng xīyīnzhù le

E: I was captivated by the scenery of Hangchow

E: I am captivated by the scenery of Hangchow

- **Tense Generation:**

- E: Mary went to Mexico. During her stay she learned Spanish.

S: Mary iba a Mexico. Durante su visita, aprendió español.

- E: Mary went to Mexico. When she returned she started to speak Spanish.

S: Mary fue a Mexico. Cuando regresó, comenzó a hablar español.

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Linguistic Challenge 3: Differences (Typology)

- **Thematic Divergence:**
E: I like Mary
S: Mary me gusta
'Mary (to) me pleases'
- **Head-Switching Divergence:**
E: I like to eat
G: Ich esse gern
'I eat likingly'
- **Structural Divergence:**
E: John entered the house
S: Juan entró en la casa
'John entered in the house'
- **Categorial Divergence:**
E: I am hungry
G: Ich habe Hunger
'I have hunger'
- **Conflational Divergence:**
E: I stabbed John
S: Yo le di puñaladas a Juan
'I gave knife-wounds to John'

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Evaluation of MT Systems

How do we evaluate MT? Depends on intended use.

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Operational Considerations

- Extensibility to new domains and languages
- System maintenance
- Integration with other software
- Evaluation metrics

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Evaluation Approaches

- Black-box
- Glass-box

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Black-Box Evaluation

- Evaluate translation quality of MT.
- Use human-based evaluation criteria: fluency, accuracy, etc.
- More recent automatic approach: Measure closeness to human MT by a numerical metric.

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Evaluation Metrics

1. Semantic Invariance: Is the “meaning” of the source text preserved in the target text?
2. Pragmatic Invariance: Is the implicit intent or illocutionary force (e.g., politeness, urgency, etc.) of the source text preserved in the target text?
3. Structural invariance: Is the syntactic structure of the source text preserved in the target text?
4. Lexical invariance: is there a one-to-one mapping of words or phrases from source to target texts?
5. Spatial invariance: are the external characteristics of the source text, such as length, location on page, etc. preserved in the target text?

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Glass-Box Evaluation

- Linguistic coverage
- Linguistic framework
- Performance of individual modules

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Summary

- History of MT
- MT Approaches
- Linguistic Challenges
 - NLU: ambiguity
 - NLG: lexical selection / syntactic realization
 - MT Divergences: mapping rules for cross-linguistic variation
- Operational Challenges
- Evaluation

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