Can the Internet help Improve Machine Translation?

Ariadna Font Llitjós

June 4, 2006
Problem and Motivation

MT output: Assassinated a diplomat Russian and kidnapped other four in Bagdad
MT output: Assassinated a diplomat Russian and kidnapped other four in Bagdad

- Could hire experts to correct machine translations
Problem and Motivation

MT output: Assassinated a diplomat Russian and kidnapped other four in Bagdad

• Could hire experts to correct machine translations

• Expensive + time consuming
Problem and Motivation

MT output: Assassinated a diplomat Russian and kidnapped other four in Bagdad

• Not feasible for large amounts of data (google, yahoo, etc.)

• Does not generalize to new sentences
My Solution

SL: Asesinado un diplomático ruso y secuestrados otros cuatro en Bagdad

TL: Assassinated a diplomat Russian and kidnapped other four in Bagdad

• Get non-expert bilingual speakers to provide correction feedback online
  – Make correcting translations easy and fun
  – 5-10 minutes a day → Large amounts of correction data
My Solution

SL: Asesinado un diplomático ruso y secuestrados otros cuatro en Bagdad

TL: Assassinated a diplomat Russian and kidnapped other four in Bagdad

• Get non-expert bilingual speakers to provide correction feedback online
  – Make correcting translations easy and fun
  – 5-10 minutes a day → Large amounts of correction data

• Feed corrections back into the MT system, so that they can be generalized
  → System will translate new sentences better
MT Approaches

- Interlingua
  - Syntactic Parsing
  - Semantic Analysis
  - Sentence Planning
  - Text Generation

Transfer Rules

Source (e.g. English) ➔ Target (e.g. Spanish)

Direct: SMT, EBMT
Related Work

- Corston-Oliver & Gammon, 2003
- Imamura et al. 2003
- Menezes & Richardson, 2001
- Su et al. 1995
- Brill, 1993
- Gavaldà, 2000
- Callison-Burch, 2004
- Allen & Hogan, 2000

My Thesis
- Non-expert user feedback
- Provides human reference translations
- Generalizes over unseen data
System Architecture

INPUT TEXT

Rule Learning and other Resources

Run-Time MT System

Rule Refinement

OUTPUT TEXT
Main Technical Challenge

Simple user edits to MT output

Mapping between

Blame assignment
Rule Modifications
Lexical Expansions

Improved Translation Rules
TCTool (Demo)

Actions:
• Add a word
• Delete a word
• Modify a word
• Change word order

Interactive elicitation of error information
Eng2Spa User Study
[LREC 2004]

<table>
<thead>
<tr>
<th></th>
<th>precision</th>
<th>recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>error detection</td>
<td>90%</td>
<td>89%</td>
</tr>
<tr>
<td>error classification</td>
<td>72%</td>
<td>71%</td>
</tr>
</tbody>
</table>

- MT error classification $\rightarrow$ 9 linguistically-motivated classes [Flanagan, 1994], [White et al. 1994]:
  - word order, sense, agreement error (number, person, gender, tense), form, incorrect word and no translation
Types of Refinement Operations

1. **Refine a translation rule:**
   
   \[ R0 \rightarrow R1 \text{ (change } R0 \text{ to make it more specific or more general)} \]

   **R0:**
   
   \[ \text{DET} \rightarrow \text{NP} \rightarrow \text{ADJ} \rightarrow \text{N} \]
   
   a nice house

   **R1:**
   
   \[ \text{DET} \rightarrow \text{NP} \rightarrow \text{ADJ} \rightarrow \text{N} \rightarrow \text{ADJ} \rightarrow \text{N} \]
   
   a nice house una casa bonita

   **N gender = ADJ gender**
Types of Refinement Operations (2)

2. Bifurcate a translation rule:

R0 → R0 (same, general rule)

→ R1 (add a new more specific rule)

R0:

\[
\begin{align*}
\text{DET} & \quad \text{ADJ} & \quad \text{N} \\
\text{a} & \quad \text{nice} & \quad \text{house} \\
\end{align*}
\]

→

\[
\begin{align*}
\text{DET} & \quad \text{N} & \quad \text{ADJ} \\
\text{una} & \quad \text{casa} & \quad \text{bonita} \\
\end{align*}
\]

R1:

\[
\begin{align*}
\text{DET} & \quad \text{ADJ} & \quad \text{N} \\
\text{a} & \quad \text{great} & \quad \text{artist} \\
\end{align*}
\]

→

\[
\begin{align*}
\text{DET} & \quad \text{ADJ} & \quad \text{N} \\
\text{un} & \quad \text{gran} & \quad \text{artista} \\
\end{align*}
\]

ADJ type: pre-nominal
Formalizing Error Information

$W_i = \text{error}$

$W_i' = \text{correction}$

$W_c = \text{clue word}$

$\overrightarrow{TL_m} = (W_1, \ldots, W_i, \ldots, W_n)$

$\overrightarrow{TL'_m} = (W_1, \ldots, W_i', \ldots, W_c, \ldots, W_n')$

$W_i = \text{bonito}$

$W_c = \text{casa}$

$W_i' = \text{bonita}$

$\text{N gender} = \text{ADJ gender}$
Triggering Feature Detection

Comparison at the feature level to detect triggering feature(s)

→ Delta function: \( \delta(W_i, W_i') \)

Examples:

- \( \delta(\text{bonito}, \text{bonita}) = \{\text{gender}\} \)
- \( \delta(\text{comiamos}, \text{comia}) = \{\text{person, number}\} \)
- \( \delta(\text{mujer}, \text{guitarra}) = \{\emptyset\} \)

If \( \delta \) set is empty, need to postulate a new binary feature (\( \text{feat}_i = \{+, -\} \))
Refinement Steps

- Error Correction Elicitation
- Finding Triggering Features
- Blame Assignment
- Rule Refinement
Refinement Steps

- Error Correction Elicitation
- Finding Triggering Features
- Blame Assignment
- Rule Refinement
SL: Gaudí was a great artist

TL: Gaudí era un artista grande

CTL: Gaudí era un gran artista
Refinement Steps

1. Edit:
   \[ W_i = \text{grande} \quad W_i' = \text{gran} \]

2. Change Word Order:
   \[ \text{artista gran} \rightarrow \text{gran artista} \]
Refinement Steps

Error Correction Elicitation

Finding Triggering Features

Blame Assignment

Rule Refinement

1. Edit:
   $W_i = \text{grande} \quad W_i' = \text{gran}$

2. Change Word Order:
   artista gran $\rightarrow$ gran artista
2. Finding Triggering Features

**Delta function**

<table>
<thead>
<tr>
<th>ADJ</th>
<th>ADJ</th>
<th>difference at the feature level?</th>
</tr>
</thead>
<tbody>
<tr>
<td>[great] → [grande]</td>
<td>[great] → [gran]</td>
<td>(\delta(\text{grande}, \text{gran}) = \emptyset)</td>
</tr>
<tr>
<td>agr num = sg</td>
<td>agr num = sg</td>
<td>agr gen = masc</td>
</tr>
</tbody>
</table>
2. Finding Triggering Features

Delta function difference at the feature level?

<table>
<thead>
<tr>
<th>ADJ</th>
<th>ADJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>[great] → [grande]</td>
<td>[great] → [gran]</td>
</tr>
<tr>
<td>agr num = sg</td>
<td>agr num = sg</td>
</tr>
<tr>
<td>agr gen = masc</td>
<td>agr gen = masc</td>
</tr>
</tbody>
</table>

\[ \delta(\text{grande, gran}) = \emptyset \]

→ need to postulate a new binary feature: feat1
2. Finding Triggering Features

Delta function difference at the feature level?

<table>
<thead>
<tr>
<th>ADJ</th>
<th>ADJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>[great]</td>
<td>[great]</td>
</tr>
<tr>
<td>agr num = sg</td>
<td>agr num = sg</td>
</tr>
<tr>
<td>agr gen = masc</td>
<td>agr gen = masc</td>
</tr>
</tbody>
</table>

\[ \delta(\text{grande, gran}) = \emptyset \]

→ need to postulate a new binary feature: feat1

\[ [\text{feat1} = +] = [\text{type} = \text{pre-nominal}] \]

\[ [\text{feat1} = -] = [\text{type} = \text{post-nominal}] \]
2. Finding Triggering Features

**Delta function** difference at the feature level?

ADJ
[great] → [grande]
agr num = sg
agr gen = masc

ADJ
[great] → [gran]
agr num = sg
agr gen = masc

\[ \delta(\text{grande, gran}) = \emptyset \]

new binary feature: feat1

**REFINE**

ADJ
[great] → [grande]
agr num = sg
agr gen = masc
feat1 = −

ADJ
[great] → [gran]
agr num = sg
agr gen = masc
feat1 = +
Refinement Steps

Error Correction Elicitation

Finding Triggering Features

Blame Assignment

Rule Refinement

1. Edit:
   \[ W_i = \text{grande} \quad W_i' = \text{gran} \]

2. Change Word Order:
   \[ \text{artista gran} \rightarrow \text{gran artista} \]

   - grande \ [\text{feat1} = -] 
   - gran \ [\text{feat1} = +]
Refinement Steps

Error Correction Elicitation

1. Edit: $W_i = \text{grande} \quad W_i' = \text{gran}$

2. Change Word Order: artista gran → gran artista

Finding Triggering Features

Blame Assignment

Rule Refinement
3. Blame Assignment

(from transfer and generation tree)

tree: <( S,1 (NP,2 (N,5:1 "GAUDI") )
   (VP,3 (VB,2 (AUX,17:2 "ERA") )
   (NP,8 (DET,0:3 "UN"
       (N,4:5 "ARTISTA"
       (ADJ,5:4 "GRANDE")))) )>
Refinement Steps

Error Correction Elicitation

Finding Triggering Features

1. Edit:
   \[ W_i = \text{grande} \quad W_i' = \text{gran} \]

2. Change Word Order:
   \text{artista gran} \rightarrow \text{gran artista}

Blame Assignment

NP,8
N ADJ \rightarrow \text{ADJ N}

Rule Refinement
Refinement Steps

Error Correction Elicitation

Finding Triggering Features

Blame Assignment

Rule Refinement

1. Edit:
   \[ W_i = \text{grande} \quad W_i' = \text{gran} \]

2. Change Word Order:
   artista gran → gran artista

   \[
   \begin{align*}
   \text{grande} & \quad [\text{feat1} = -] \\
   \text{gran} & \quad [\text{feat1} = +] \\
   \end{align*}
   \]

   NP,8
   N ADJ → ADJ N
4. Rule Refinement

NP,8:

NP
DET
a
ADJ
great
N
artist

NP
DET
un
N
artista
ADJ
gran

BIFURCATE

NP,8’:

NP
DET
a
ADJ
great
N
artist

NP
DET
un
ADJ
gran
artista

REFINE

ADJ feat1 = +
4. Rule Refinement

NP,8:

\[
\text{DET} \quad \text{ADJ} \quad \text{N} \\
\text{a} \quad \text{great} \quad \text{artist}
\]

NP

\[
\text{DET} \quad \text{N} \quad \text{ADJ} \\
\text{un} \quad \text{artista} \quad \text{gran}
\]
Refinement Steps

Error Correction Elicitation

Finding Triggering Features

Blame Assignment

Rule Refinement

1. Edit:
   \[ W_i = \text{grande} \rightarrow W_i' = \text{gran} \]

2. Change Word Order:
   \[ \text{artista gran} \rightarrow \text{gran artista} \]

- grande [feat1 = −]
- gran [feat1 = +]

NP,8
(N ADJ → ADJ N)

NP,8
ADJ N → N ADJ

NP,8'
ADJ N → ADJ N
[ADJ feat 1 = +]
Correct Translation Output

NP,8 $\rightarrow$ ADJ(great-grande)  
[feat1 = -]

NP,8' $\rightarrow$ ADJ(great-gran)  
[ADJ feat1 =c +]  [feat1 = +]

Gaudi era un artista grande
Gaudi era un gran artista
*Gaudi era un grande artista
Generalization Power:
abstract feature (feat_i)

Irina is a great friend → Irina es una gran amiga
(instead of *Irina es una amiga grande)

Juan is a great person → Juan es una gran persona
(instead of *Juan es una persona grande)
Generalization Power++

When triggering feature already exists in the grammar/lexicon (POS, gender, number, etc.):

*I see the red car* → *veo un auto roja* → veo un auto rojo

<table>
<thead>
<tr>
<th>gender = masc</th>
<th>gender = fem</th>
<th>gender = masc</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>veo un auto roja</em></td>
<td>veo un auto rojo</td>
<td></td>
</tr>
</tbody>
</table>

Refinements generalize to all lexical entries that have that feature (**gender**):

*The yellow houses are his* → *las casas amarillas son suyas*
(before: *las casas amarillos son suyas*)

<table>
<thead>
<tr>
<th>gender = fem</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>las casas amarillos son suyas</em></td>
</tr>
</tbody>
</table>

*We need to go to a dark cave* → *tenemos que ir a una cueva oscura*
(before: *cueva oscuro*)

<table>
<thead>
<tr>
<th>gender = fem</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>cueva oscuro</em></td>
</tr>
</tbody>
</table>
Impact on Transfer-Based MT
Impact on Transfer-Based MT

Rule Learning and other Resources
- Handcrafted rules
- Learning Module
- Transfer Rules
- Morphological analyzer
- Lexical Resources

Run-Time System
- INPUT TEXT
- Transfer System
- Translation Candidate Lattice

Rule Refinement
- Online
Impact on Transfer-Based MT

Rule Learning and other Resources
- Handcrafted rules
- Learning Module
- Transfer Rules
- Morphological analyzer
- Lexical Resources

Run-Time System
- INPUT TEXT
- Transfer System
- Translation Candidate Lattice

Rule Refinement
- Online
- Rule Refinement
Impact on Transfer-Based MT
Impact on Transfer-Based MT
TCTool can help improve

• Rule-based MT (grammar, lexicon, LM)

• EBMT (examples, lexicon, alignments)

• Statistical MT (lexicon, and alignments)
Work in Progress

• We have identified 10 different types of refinement operations, integrating last 2 into the system.

• Handling *incorrect* Correction Instances
  – Have multiple users correct the same set of sentences
    → filter out noise (threshold: 90% users agree)

• User study with multiple users
  → evaluate improvement after refinements.
Contributions so far

New Framework to improve MT quality: an expandable set of rule refinement operations

An efficient online GUI to display translations and alignments and solicit pinpoint fixes from *non-expert* bilingual users.
Future work

• Explore other ways to make the interaction with users more fun

• Games with a purpose
  [Von Ahn and Blum, 2004 & 2006]
Future work

- Explore other ways to make the interaction with users more fun
- Games with a purpose [Von Ahn and Blum, 2004 & 2006]
- Language Learning
Gracias!