The Challenge of Syntax

- The classical machine translation pyramid
Advantages of Syntax-Based Translation

- Reordering for syntactic reasons
  - e.g., move German object to end of sentence

- Conditioning on syntactically related words
  - translation of verb may depend on subject or object

- Use of syntactic language models
Syntactic Language Model

- Good syntax tree $\rightarrow$ good English
- Allows for long distance constraints

- Left translation preferred by syntactic LM
String to Tree Translation

- Use of English syntax trees [Yamada and Knight, 2001]
  - exploit rich resources on the English side
  - obtained with statistical parser [Collins, 1997]
  - flattened tree to allow more reorderings
  - works well with syntactic language model
Kare ha ongaku wo kiku no ga daisuki desu
## Reordering Table

| Original Order | Reordering       | p(reorder|original) |
|----------------|------------------|-------------|
| PRP VB1 VB2    | PRP VB1 VB2      | 0.074       |
| PRP VB1 VB2    | PRP VB1 VB2      | 0.074       |
| PRP VB1 VB2    | PRP VB2 VB1      | 0.723       |
| PRP VB1 VB2    | VB1 PRP VB2      | 0.061       |
| PRP VB1 VB2    | VB1 VB2 PRP      | 0.037       |
| PRP VB1 VB2    | VB2 PRP VB1      | 0.083       |
| PRP VB1 VB2    | VB2 VB1 PRP      | 0.021       |
| VB TO          | VB TO            | 0.107       |
| VB TO          | TO VB            | 0.893       |
| TO NN          | TO NN            | 0.251       |
| TO NN          | NN TO            | 0.749       |
Decoding as Parsing

- Pick Japanese words
- Translate into tree stumps
Decoding as Parsing

- Pick Japanese words
- Translate into tree stumps

kare ha ongaku wo kiku no ga daisuki desu
Decoding as Parsing

- Apply grammar rules (with reordering)
Decoding as Parsing

- PRP: he
- NN: music
- TO: to
- VB: listening

Japanese: kare ha ongaku wo kiku no ga daisuki desu
Decoding as Parsing

kare ha ongaku wo kiku no ga daisuki desu

- he
- music
- to
- listening

PRP NN TO VB
Decoding as Parsing

He loves listening to music.
Decoding as Parsing

- Finished when all foreign words covered
Inversion Transduction Grammars

- Generation of both English and foreign trees [Wu, 1997]
- Rules (binary and unary)
  - $A \rightarrow A_1 A_2 \| A_1 A_2$
  - $A \rightarrow A_1 A_2 \| A_2 A_1$
  - $A \rightarrow e \| f$
  - $A \rightarrow e \| *$
  - $A \rightarrow * \| f$

$\Rightarrow$ Common binary tree required
  - limits the complexity of reorderings
Syntax Trees

Mary did not slap the green witch

- English binary tree
Syntax Trees (2)

- Spanish binary tree

Maria no daba una bofetada a la bruja verde
Combine tree with reordering of Spanish
Inversion Transduction Grammars

- Decoding by parsing (as before)
- Variations
  - may use real syntax on either side or both
  - may use multi-word units at leaf nodes
Chiang: Hierarchical Phrase Model

• Chiang [ACL 2005, CL 2007]
  – context free bi-grammar
  – one non-terminal symbol
  – right hand side of rule may include non-terminals and terminals

• Now one of the dominant approaches to SMT

• Basis of the Cambridge Engineering’s highly competitive SMT systems
Types of Rules

- Word translation
  - $X \rightarrow \text{maison} \parallel \text{house}$

- Phrasal translation
  - $X \rightarrow \text{daba una bofetada} \parallel \text{slap}$

- Mixed non-terminal / terminal
  - $X \rightarrow X \text{ bleue} \parallel \text{blue X}$
  - $X \rightarrow \text{ne X pas} \parallel \text{not X}$
  - $X \rightarrow X1 X2 \parallel \text{X2 of X1}$

- Technical rules
  - $S \rightarrow S X \parallel S X$
  - $S \rightarrow X \parallel X$
Learning Hierarchical Rules

X → X verde || green X
Maria no daba una botefada a la bruja verde.

X → a la X ∥ the X
Details

- Too many rules
  - filtering of rules necessary

- Efficient parse decoding possible
  - hypothesis stack for each span of foreign words
  - only one non-terminal $\rightarrow$ hypotheses comparable
  - length limit for spans that do not start at beginning
Improved Translations

- we must also this criticism should be taken seriously .
  \( \rightarrow \) we must also take this criticism seriously .

- i am with him that it is necessary , the institutional balance by means of a political revaluation of both the commission and the council to maintain .
  \( \rightarrow \) i agree with him in this , that it is necessary to maintain the institutional balance by means of a political revaluation of both the commission and the council .

- thirdly , we believe that the principle of differentiation of negotiations note .
  \( \rightarrow \) thirdly , we maintain the principle of differentiation of negotiations .

- perhaps it would be a constructive dialog between the government and opposition parties , social representative a positive impetus in the right direction .
  \( \rightarrow \) perhaps a constructive dialog between government and opposition parties and social representative could give a positive impetus in the right direction .