

# **A Machine Translation System from English to American Sign Language**

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(Presented by Amber Wilcox-O'Hearn)

# Overview

- ASL Linguistic Issues
  - Written Representation
  - Phonology
  - Morphology
  - Syntax
- Machine Translation
  - Architecture
  - Tree Adjoining Grammars
  - Synchronous TAGs
- TEAM
  - EMOTE system for graphical sign synthesis
  - Areas for Improvement
  - Contributions

# ASL Linguistic Issues

- ASL linguistics is in its infancy
- Only recently was it recognized as a real language (Stokoe 1960).
  - Symbols, arbitrary or iconic, combined systematically, productively create meaning.
- Models for basic mechanisms are still in development and sometimes controversial.
- ‘Phonology’: study of the smallest contrastive units of language.


# Written Representation

- The main difficulty is the simultaneous nature of signs.
  - Handshape, Location, Orientation, Movement, Local movement, Non-manual
- No standard written notation is accepted by the Deaf.
  - Difficult to obtain transcribed corpora
  - Statistical Approaches non-existent
  - Generation systems typically customize their own representation
  - Chosen abstraction directly constrains expressiveness of output

# Written Representation (continued)

- Stokoe Notation
  - Orientation and location lumped together
  - Parameter values not specific enough
  - Omits non-manual signals
  - Changes in parameters in the course of a sign treated as secondary
  - Awkward representation of signs with more than one segment
  - Example: what is  $[\text{C}^{x>x}]$ ?

# Written Representation (continued)

- HamNoSys
  - Stokoe derivative
  - Improved detail
  - E.g. 'TIRING' 
- Movement-Hold Model - (see next slide)
  - Adequately descriptive
  - Not compact enough for reading or writing
- Sutton SignWriting
  - Intuitive graphical representation
  - Easy to read and write
  - May or may not catch on

# ASL Phonology

## Movement-Hold Model (Liddell and Johnson 1989)

- Sequence of segments: holds and movements
  - Hold segments - Articulatory Bundle:
    - Handshape
    - Location
    - Orientation
    - Local movement
    - Non-manual
  - Movement Segments
    - Transition of some aspect of articulation

Examples: KNOW/THINK, DRY/SUMMER, NUDE/RUDE,  
RAIN/SNOW, LATE/NOT-YET, CLEVER, HEARING

# ASL Morphology

- Primarily incorporative, not concatenative
- Modify some aspect of the sign
- Inflection
  - aspect, manner, degree - e.g. 'STUDY'
  - subject-object agreement - e.g. 'GIVE'
- Derivation
  - noun-verb pairs - e.g. 'SIT/CHAIR'
  - compounds - e.g. 'BELIEVE = THINK+MARRY'
  - fingerspelled - e.g. 'DOG'
  - numerical incorporation - e.g. 'MINUTE'
  - classifier predicates
  - perspective verbs

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# ASL Syntax

- Not well understood because of the role of non-manual signals
- SVO is the basic word order, despite earlier claims. (Neidle et al., 2000)
- Topicalization common.
- Non-manual negation, question, condition
- Lexical tense markers
- Morphological aspect markers
- Morphological and Non-manual agreement markers

# Architecture

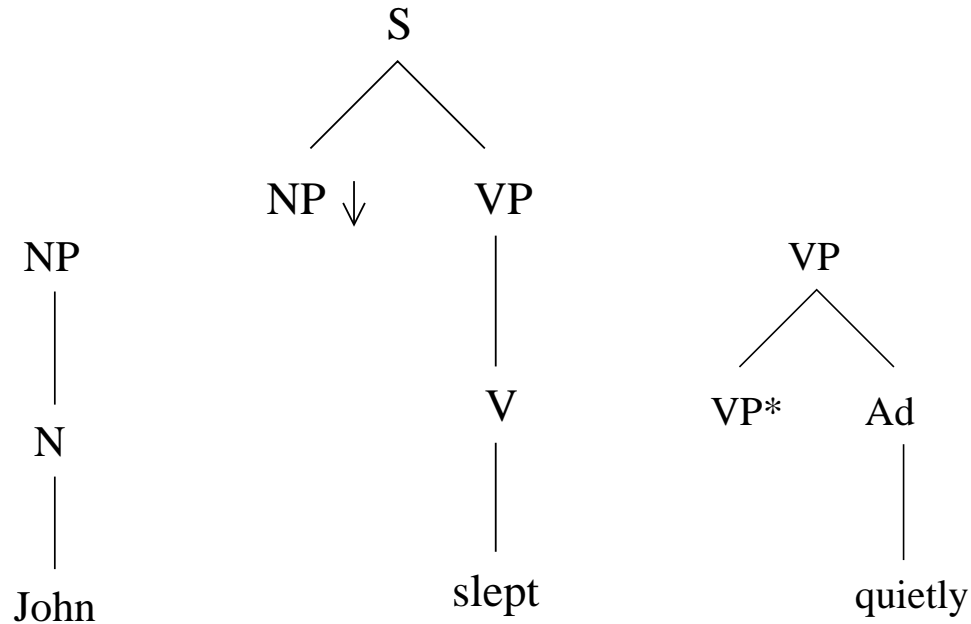
## **Dorr, Jordan, and Benoit 1998. A Survey of Current Paradigms in Machine Translation**

- MT architectural designs can be seen as falling on a spectrum of level of analysis:

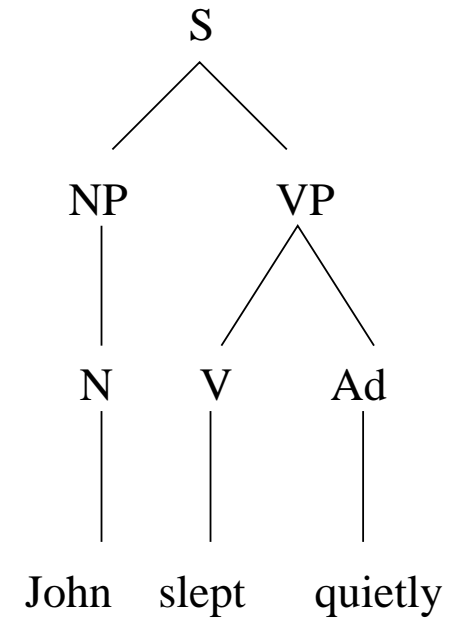
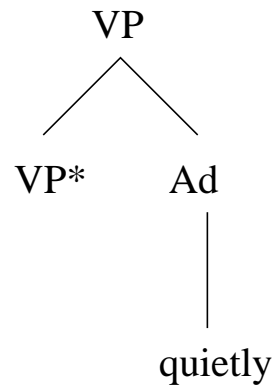
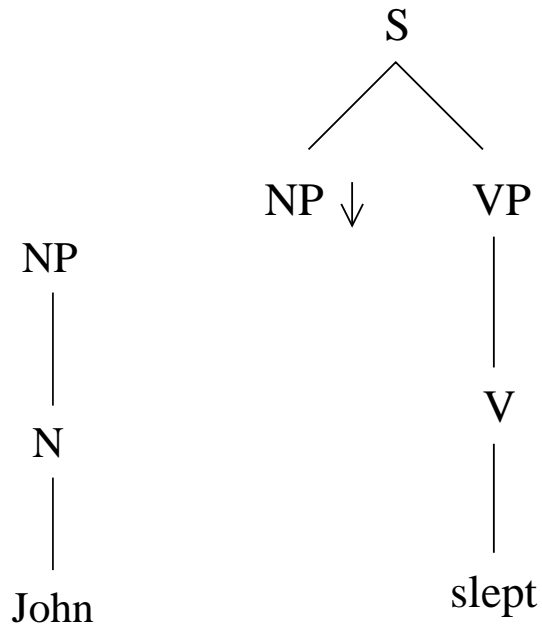
Direct → Syntactic/Semantic Transfer → Interlingual

- Direct systems translate word-for-word.
- Syntactic and Semantic Transfer systems perform respective analyses before translating.
- Interlingual systems produce a typically language-independent semantic representation before translating.

# Tree Adjoining Grammars (TAGs)



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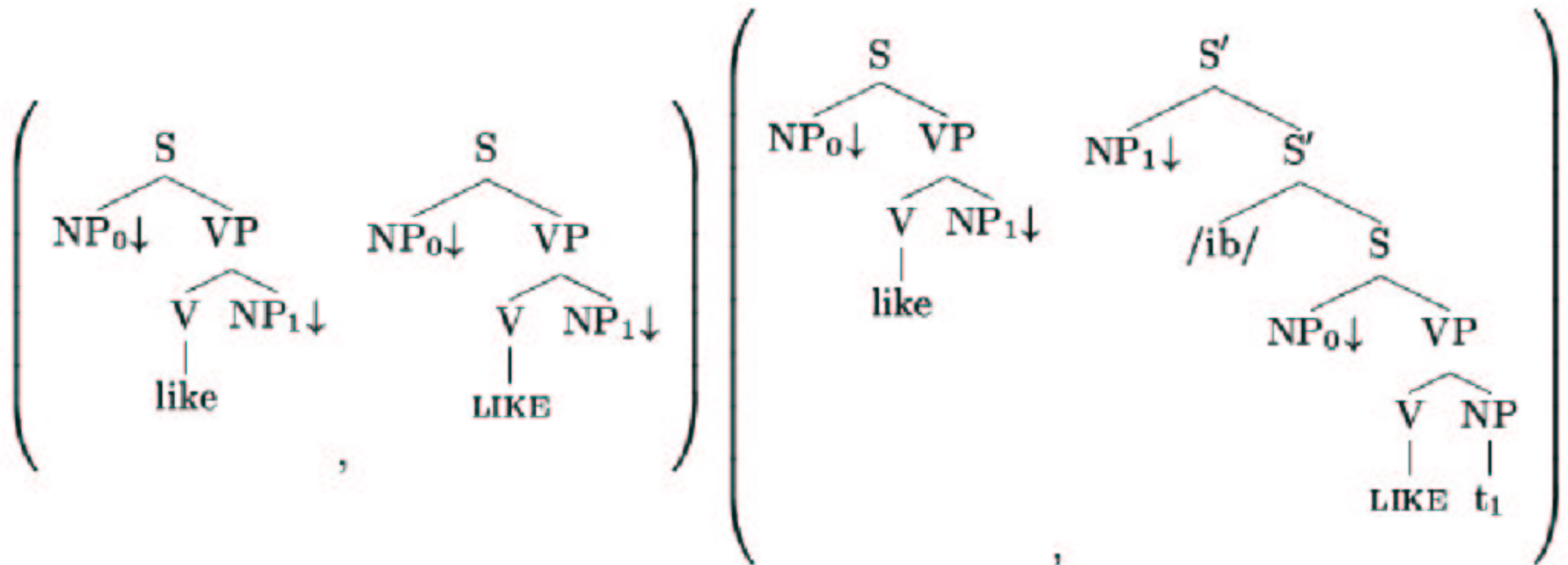


# Synchronous TAGs

Shieber and Schabes, 1990

- Given a derivation tree from parsing a sentence in the source language, the target derivation tree is built by a node to node correspondence.
- Originally, correspondences were between only elementary trees.
- In order to cope with other cases, correspondences are extended to partially derived trees.
  - Words in one language correspond to expressions in the other
  - Different syntactic constructions
- Even better would be to extend to feature structures.

# Synchronous TAGs



**Fig. 3.** Untopicalized tree and topicalized tree for pronouns

# TEAM

(Translation from English to ASL by Machine)

- Phonology loosely based on Movement-Hold (Goal-Via)
- Syntactic/Semantic Transfer using STAGs
- EMOTE model for sign synthesis

# Graphical Sign Synthesis

- EMOTE model (Chi, Costa, Zhao, Badler 2000)
  - Laban Movement Analysis
  - ‘Effort’ and ‘Shape’ phrasing across movement
  - Whole body engagement
- Results in more natural-looking movement, because of body coordination.
- Success in expressing some morphological derivations and inflections: noun-verb pairs, adverbials and verbal aspect.
- Potential for incorporating more non-manual aspects of signing, such as head tilt.

# Areas for Improvement

- Discourse factors strongly influence generation choices - not modelled here
- Monolithic sign representation prevents phonological blending between signs
- Phrase structure formalism inappropriately used (negation and other non-manual signals, directional verbs)

# Contributions

- First implementation of an MT system from English to animated ASL
- Extensible to other signed languages
- EMOTE model for expressing adverbials and possibly incorporating non-manual signals