Tree Edit Models for Recognizing Textual Entailments, Paraphrases, and Answers to Questions

Michael Heilman and Noah A. Smith

Carnegie Mellon

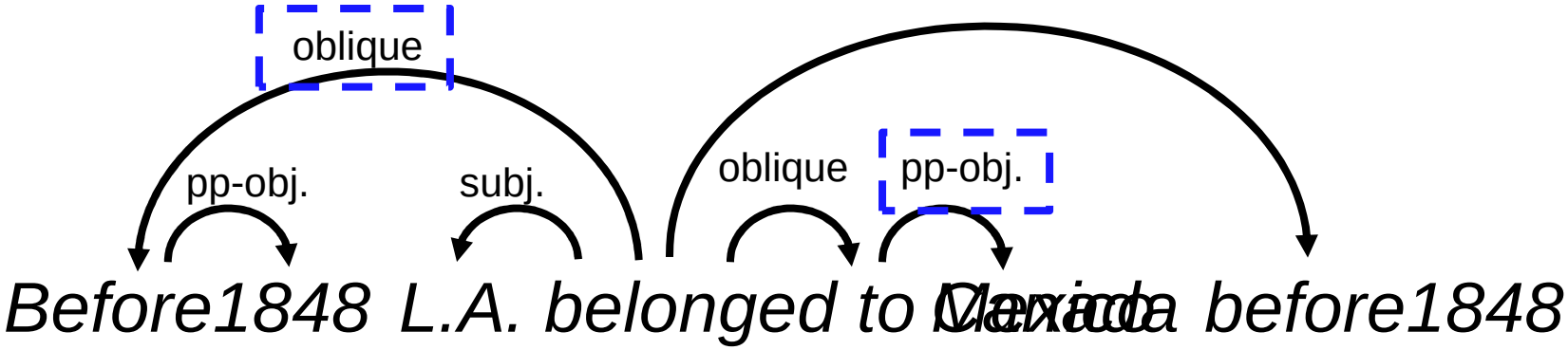
pier @ Carnegie Mellon
PROGRAM FOR INTERDISCIPLINARY EDUCATION RESEARCH

Summary

- Simple transformational approach for modeling sentence pair relations.
- Experiments for multiple problems:
  - Recognizing textual entailment
  - Paraphrase identification
  - Answer selection for question answering
- Competitive but not standout performance.

Intuition

Tree edits are syntactic transformations that can modify semantic properties in various ways.



We represent sentence pairs as sequences of edits that convert one tree into the other.

Outline

- Introduction
- **Connections to Prior Work**
- Finding & Classifying Edit Sequences
- Experiments

Prior Work on Sentence Pairs

- Numerous approaches for sentence pair relations, some task-specific.
- Considerable work involving tree and phrase alignments.

Das & Smith, 09; MacCartney et al., 08; Zanzotto, 09; Chang et al., NAACL-10; inter alia

- Less work on transformational or tree edit approaches.

Harmeling, 07; Bar Haim et al., 07

Prior Work on Tree Edit Distance

1. Local edits without reordering.
   - insert, relabel, delete
2. No learning of associations between labels and features of edit sequences.

Chawathe et al., 97; Punyakanok et al., 04; Wan et al., 06; Bernard et al., 08; inter alia

Our Method

1. Includes edits for reordering children and moving subtrees.
2. Learns associations between edit sequences and features of labeled data.
3. Does not require:
   - WordNet
   - Distributional Similarity
   - NER
   - Heavy task-specific tuning
   - Coreference resolution
   - Etc.

Possible future work

Outline

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- Connections to Prior Work
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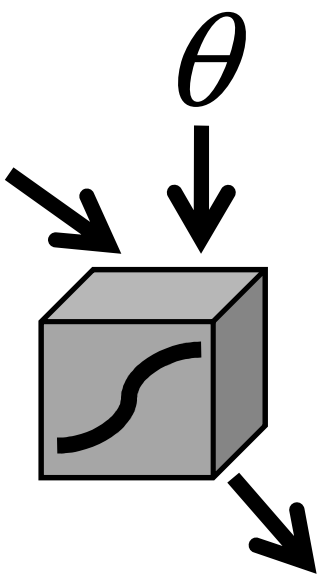
- Experiments

With a wry smile, Mr. Bush replied, “You're looking pretty young these days.”

Bush shot back: “You're looking pretty young these days.”

DELETE (*a*)
DELETE (*wry*)
DELETE (*smile*)
DELETE (*with*)
RELABEL (*replied*, *shot*)
DELETE (*Mr.*)
INSERT (*back*, *shot*)
RELABEL (*comma*, *:*)

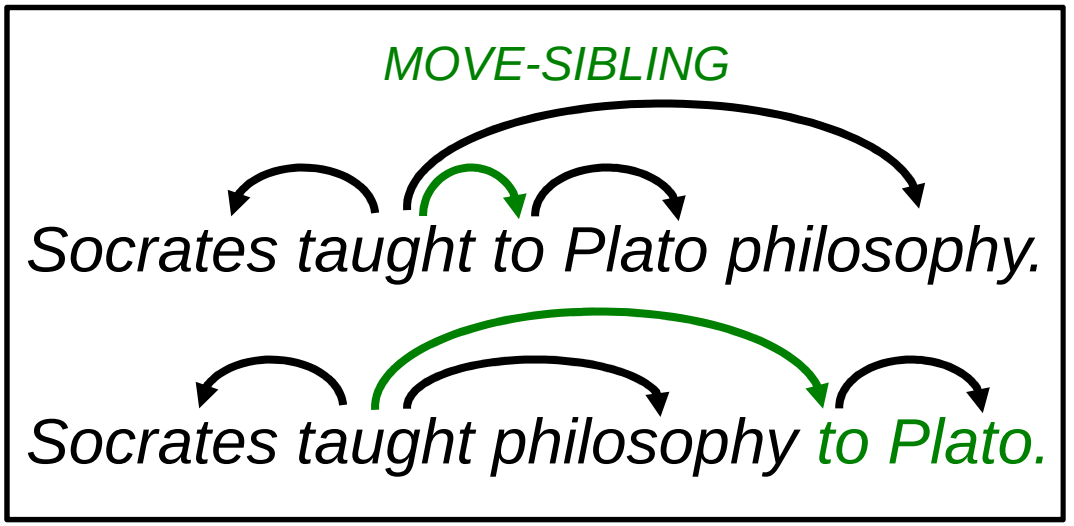
Feature	***Value***
# edits	8
# unedited nodes	11
# DELETE	5
# INSERT	1
# delete subject	0
…	

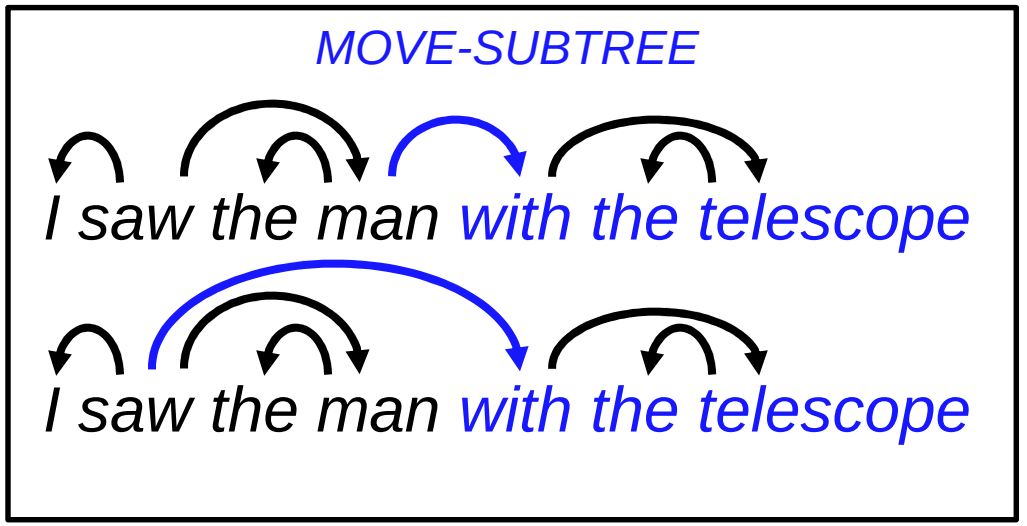


PARAPHRASE

Types of Tree Edits

- Inserting, Deleting, Relabeling Nodes
  - INSERT-CHILD
  - INSERT-PARENT
  - DELETE-LEAF
  - DELETE-AND-MERGE
  - RELABEL-NODE
  - RELABEL-EDGE
- Reordering Children
  - MOVE-SIBLING
- Moving Subtrees
  - MOVE-SUBTREE
  - NEW-ROOT





Complexity

- Tree edit distance with insert, relabel, delete edits:

  $O(n^3 \log n)$

  Klein, 98

- With reordering and moving subtrees:

  Polynominal runtime algorithms

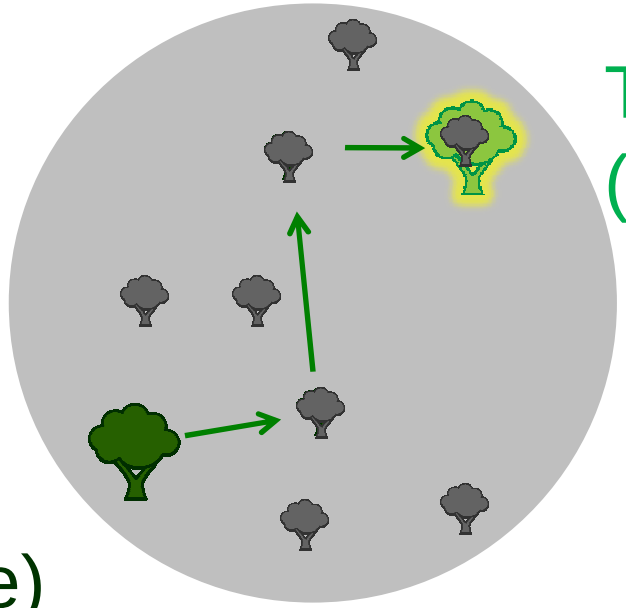
  not available

Greedy Best-First Search

- We choose the next tree according to the heuristic function only.

Pearl, 84

  - We ignore path cost.



Target Tree
(e.g., hypothesis)

Initial Tree
(e.g., premise)

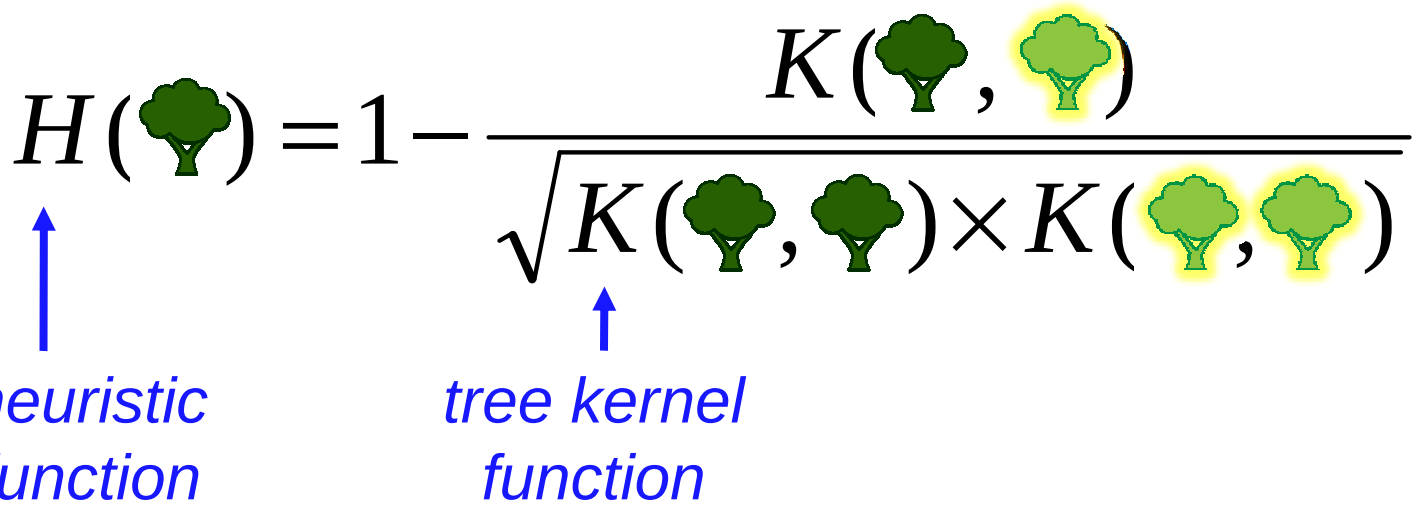
Tree Kernel Search Heuristic

- Heuristic compares current tree to target tree ().
- *Tree kernel*: similarity measure between trees based on similarities of all their subtrees.
  - Efficient dynamic programming solution.

D. Haussler, 99;
Collins & Duffy, 01;
Zanzotto & Moschitti, 06;
Zelenko et al., 06

Tree Kernel Search Heuristic

- In general, larger trees will have larger kernel values.
- So we “normalize” to [0, 1]:

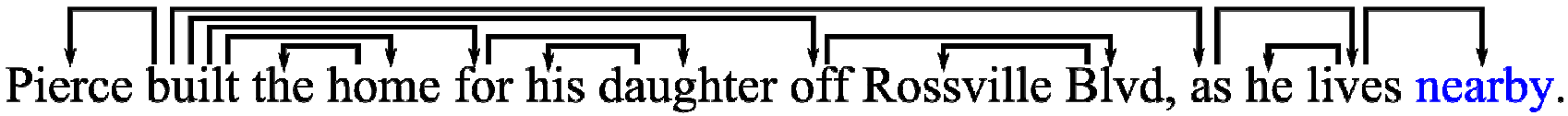


Finding Edit Sequences

- Operations are very expressive.
  - Search rarely fails (< 0.5%).

- Resulting sequences:
  - Succinct and plausible upon inspection
  - Internally consistent representation
  - Lead to good performance

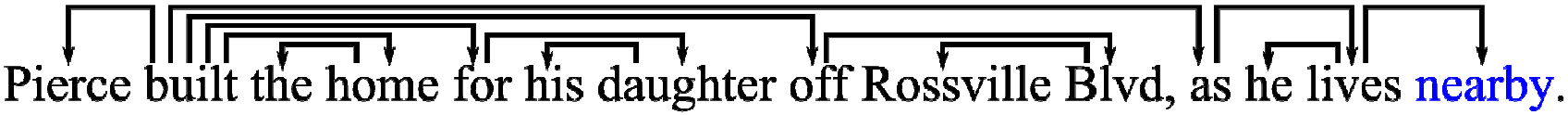
Example Edit Sequence



Premise

Hypothesis

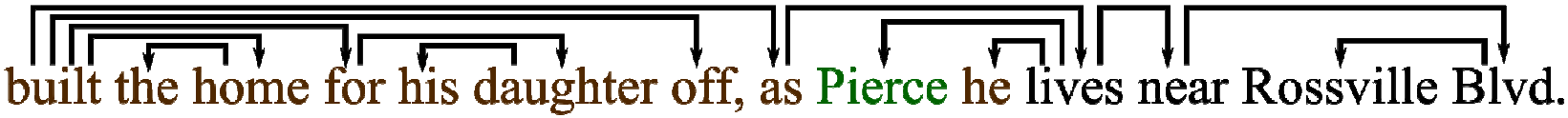
Example Edit Sequence



RELABEL-NODE(nearby)

MOVE-SUBTREE(Blvd.)

MOVE-SUBTREE(Pierce)



Multiple RELABEL-EDGE, DELETE-LEAF, DELETE-AND-MERGE edits

Classifying by Edit Sequences

- Logistic Regression with 33 features.
  - total number of edits
  - number of X edits
  - number of edits removing a subject
  - number of unedited nodes
  - etc.

- We learn separate parameters for each task from labeled sentence pairs.

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- **Experiments**

Recognizing Textual Entailment

Challenge: Decide whether a hypothesis follows from a premise.

- Testing: RTE-3 test data.
- Training: RTE-3 dev. data and data from previous RTE tasks.

Giampiccolo et al., 07

RTE-3 Results

de Marneffe et al. 06

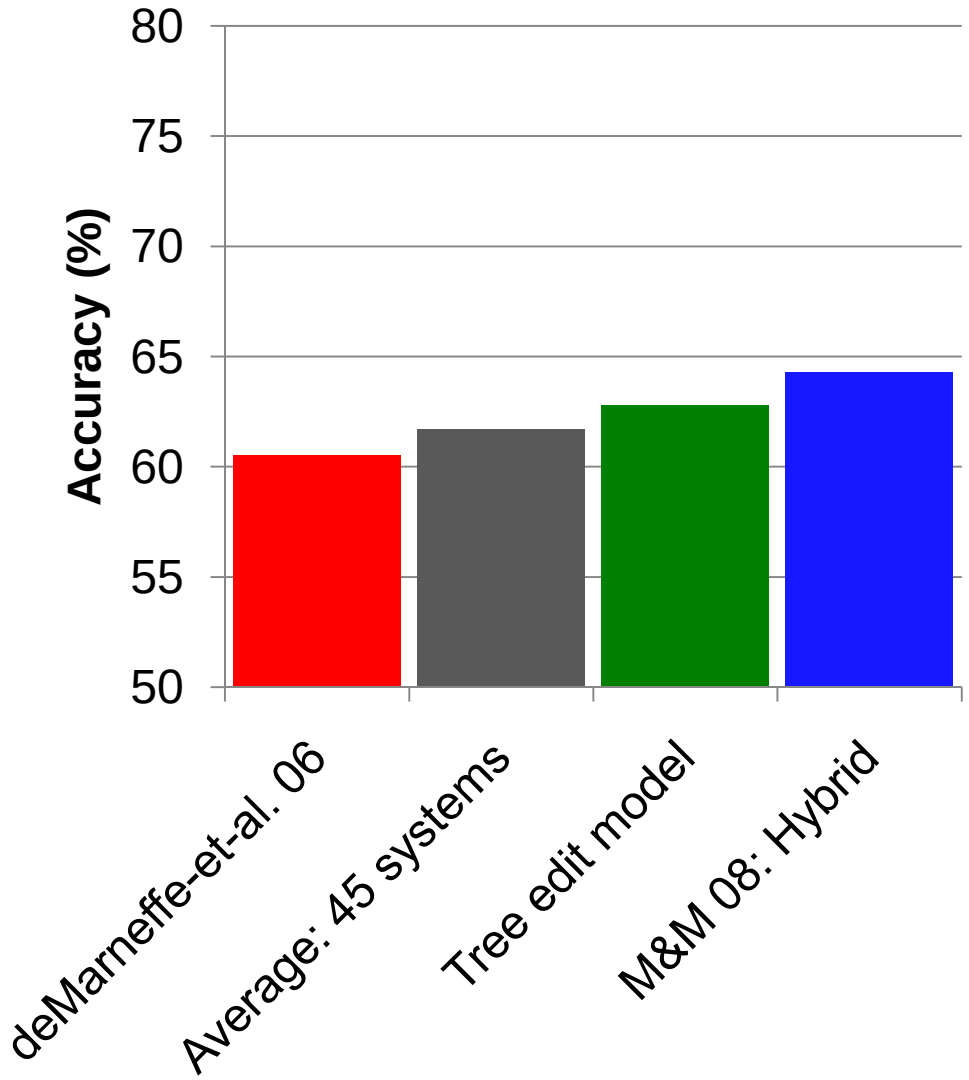
Syntactic alignment + classification

Tree edit model

MacCartney & Manning 08: Hybrid

de Marneffe et al. 06

+ Natural Logic technique



Paraphrase Identification

Challenge: Decide whether 2 sentences are paraphrases of each other.

- Paraphrase ≈ bidirectional entailment.
- Microsoft Research Paraphrase Corpus
  - Standard training and testing splits

Dolan et al., 04

Paraphrase Identification Results

Tree edit model

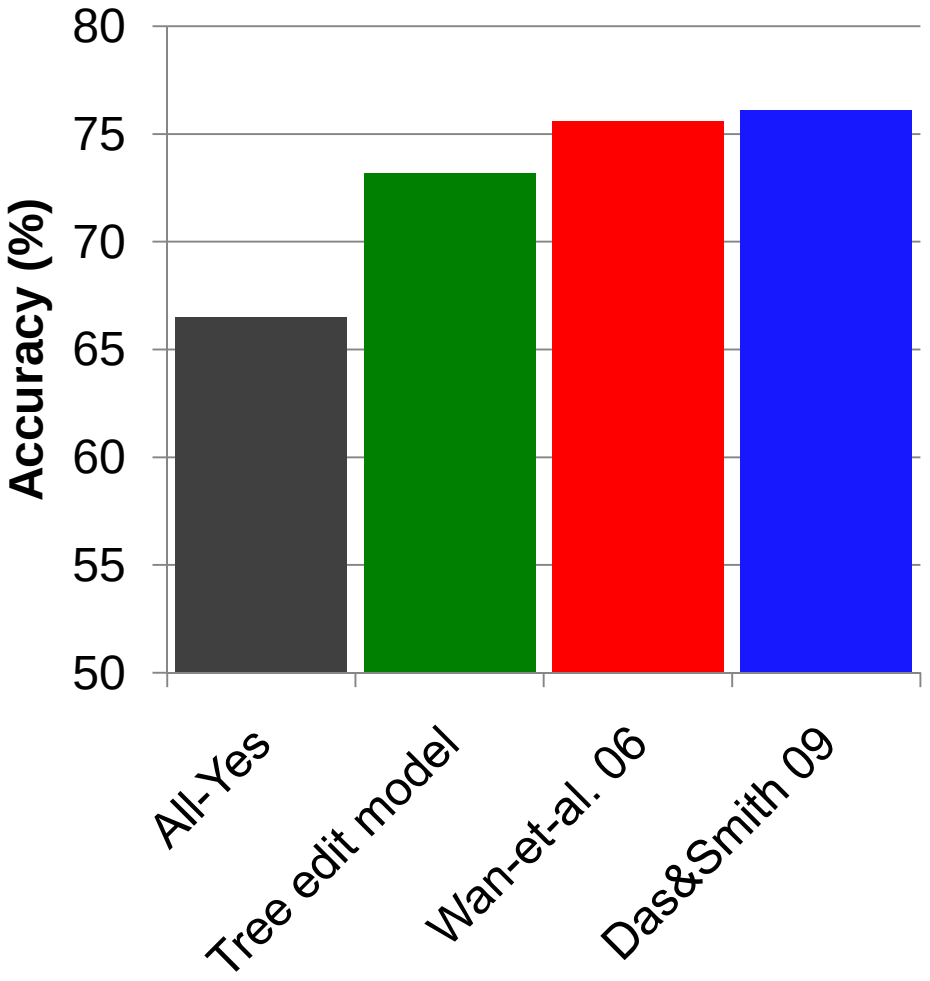
Wan et al. 06

SVM with syntactic dependency overlap, BLEU scores, tree edit distance, etc.

Das & Smith 09

Quasi-synchronous Grammar to model syntactic alignments

+ n-gram overlap



Answer Selection for QA

Challenge: rank sentences by correctness as answers to a given question.

- We find edit sequences from answers to questions.
- We rank by the estimated probabilities of correctness.

Answer Selection Data

- Q&A pairs from TREC-8 through TREC-13.
- Training, Dev., Testing data sets: about 100 questions and 500-1500 answers each

Answer Selection Results

Punyakanok et al. 04

Tree edit distance

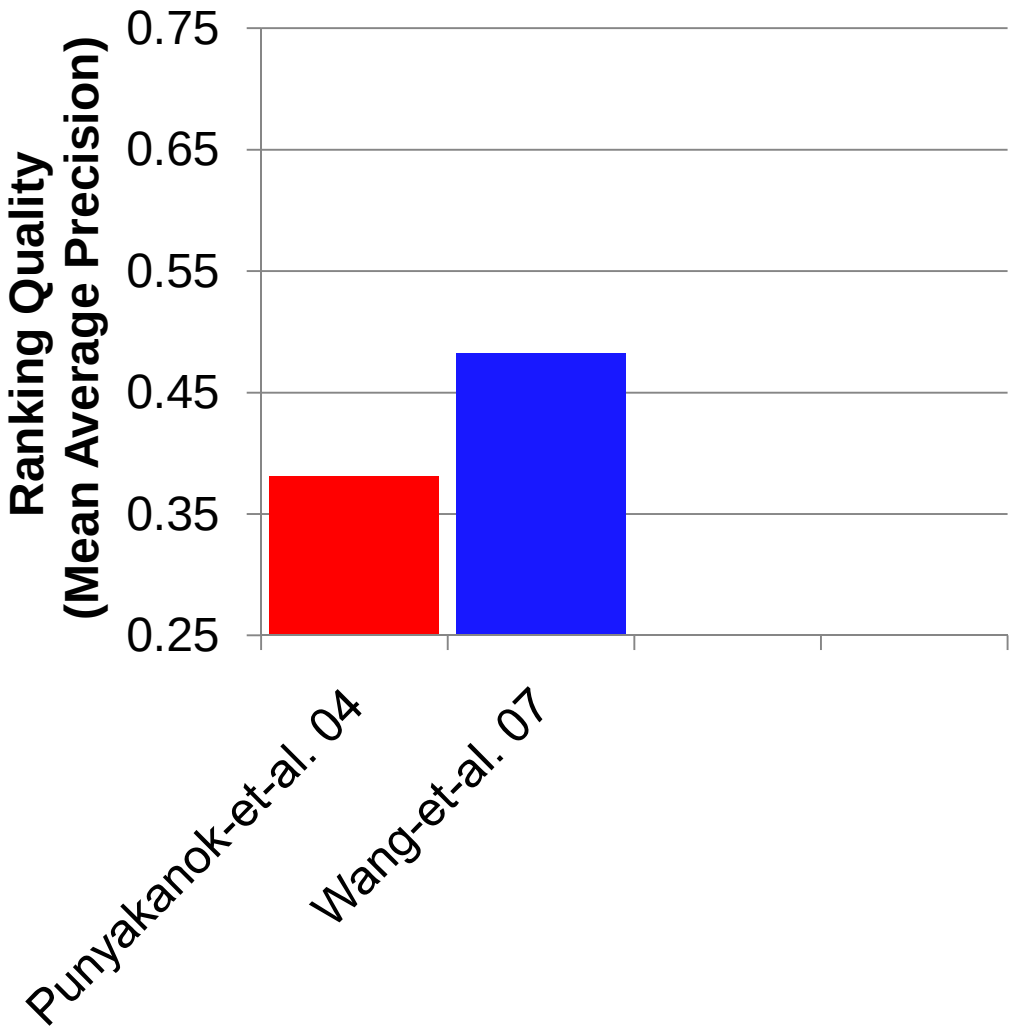
Wang et al. 07

Quasi-synchronous Grammar to model syntactic alignments

Wang et al. 07 + WN

plus lexical semantics from WordNet

Tree edit model



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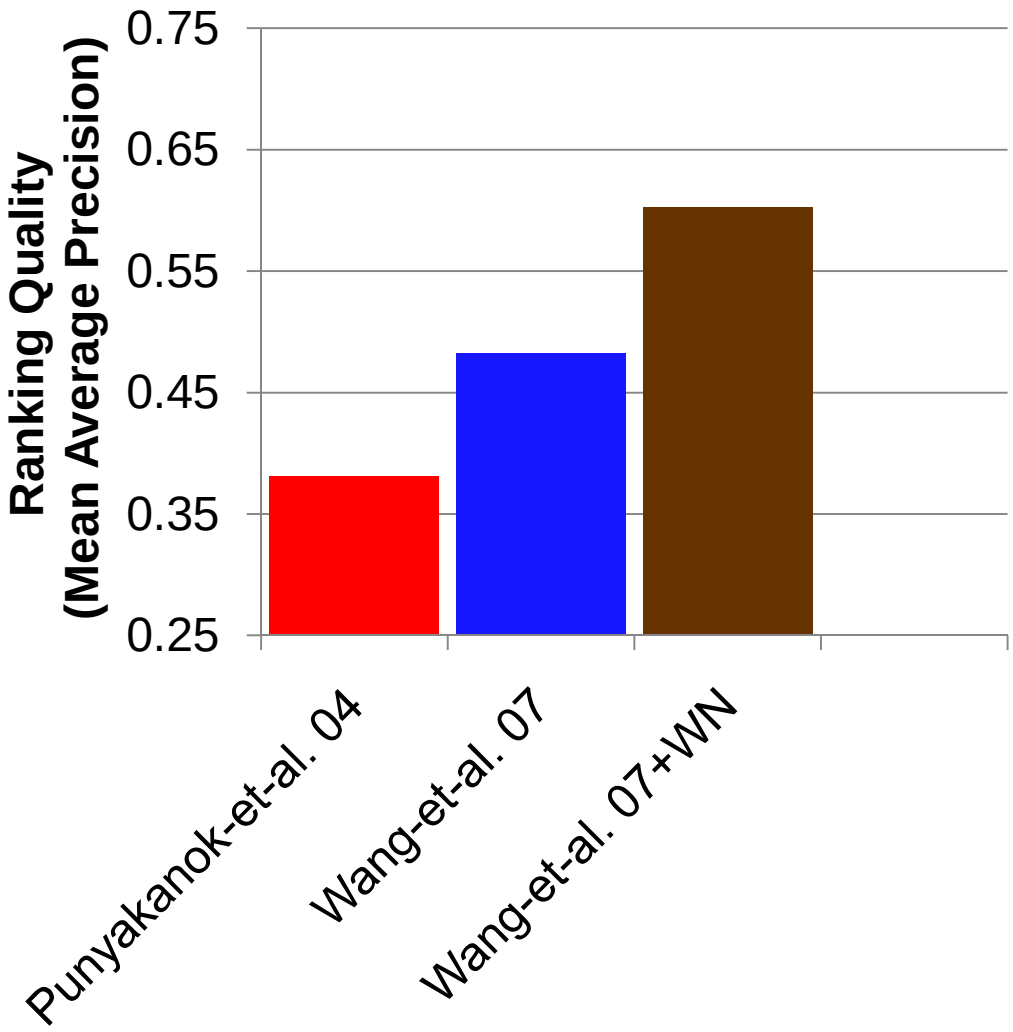

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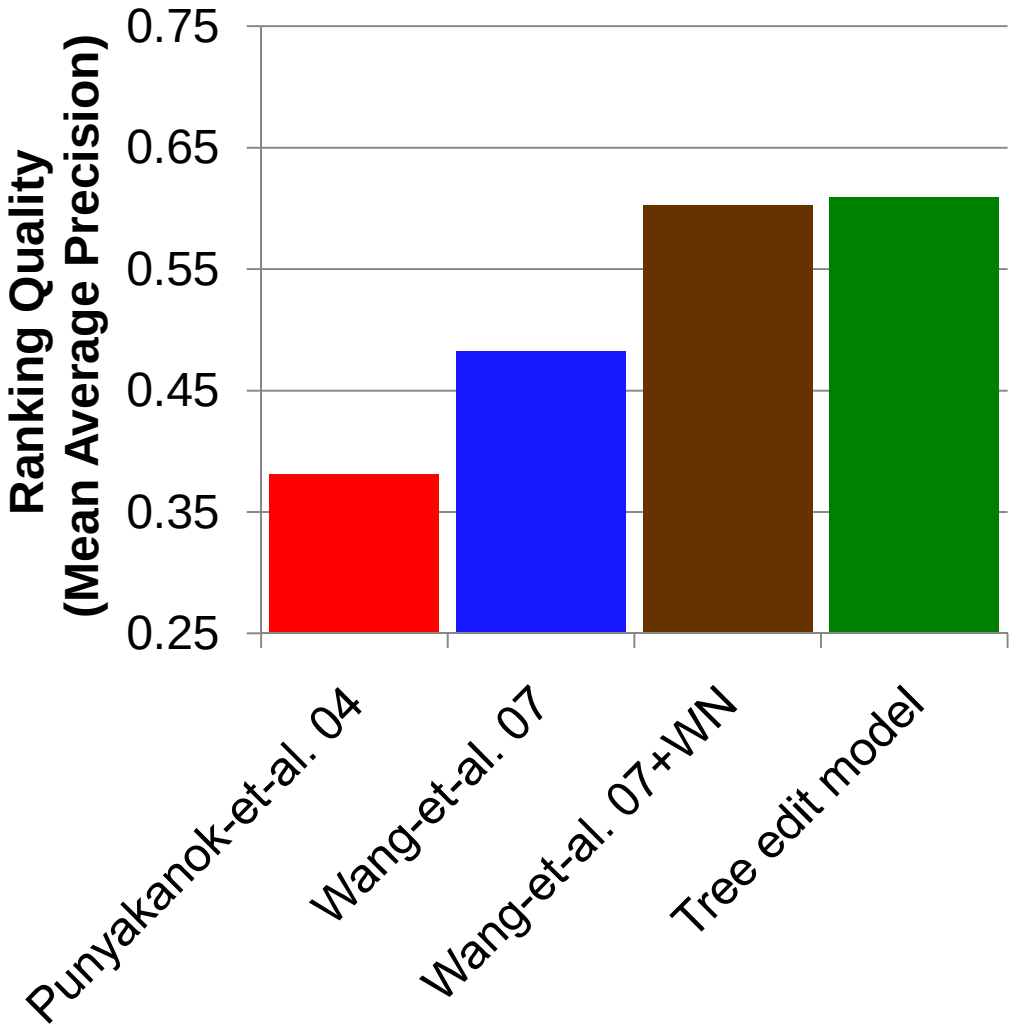

Conclusions

Syntax-based tree edit algorithm for classifying sentence pairs according to semantic relationships.

- *Expressive*: includes tree edits for reordering and moving subtrees.
- *Data Driven*: learns parameters from labeled examples.
- *Useful for various tasks*