Semantic Role Labeling
Deep Processing Techniques for NLP
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Semantic Role Labeling

- Aka Thematic role labeling, shallow semantic parsing
- Form of predicate-argument extraction

Task:
- For each predicate in a sentence:
  - Identify which constituents are arguments of the predicate
  - Determine correct role for each argument

- Both PropBank, FrameNet used as targets

- Potentially useful for many NLU tasks:
  - Demonstrated usefulness in Q&A, IE
SRL in QA

• Intuition:
  • Surface forms obscure Q&A patterns
  • Q: What year did the U.S. buy Alaska?
  • S_A: ...before Russia sold Alaska to the United States in 1867

• Learn surface text patterns?
  • Long distance relations, require huge # of patterns to find

• Learn syntactic patterns?
  • Different lexical choice, different dependency structure
Semantic Roles & QA

- Approach:
  - Perform semantic role labeling
    - FrameNet
  - Perform structural and semantic role matching
  - Use role matching to select answer
Q: Who discovered prions?
S: 1997: Stanley B. Prusiner, United States, discovery of prions, ...

\textbf{SemStruc}^q

- p: discover
- Original SR assignments:
  - EAP
  - prions

\textbf{SemStruc}^{ac}(ac: Stanley B. Prusiner)

- p: discovery
- Original SR assignments:
  - ac
  - prions

\textbf{Optimized SR assignments:}

- EAP
- prions
Summary

- FrameNet and QA:
  - FrameNet still limited (coverage/annotations)
  - Bigger problem is lack of alignment b/t Q & A frames

- Even if limited,
  - Substantially improves where applicable
  - Useful in conjunction with other QA strategies
  - Soft role assignment, matching key to effectiveness
SRL Subtasks

• Argument identification:
  • The [San Francisco Examiner] issued [a special edition] [yesterday].
  • Which spans are arguments?
    • In general (96%), arguments are (gold) parse constituents
    • 90% arguments are aligned w/auto parse constituents

• Role labeling:
  • The $\text{[Arg}_0\text{San Francisco Examiner]}$ issued $\text{[Arg}_1\text{a special edition]}$ $\text{[Arg}_M\text{-TMP}\text{yesterday]}$. 
Semantic Role Complexities

- Discontinuous arguments:
  - $[\text{Arg}_1 \text{The pearls}], [\text{Arg}_0 \text{she}]$ said, $[\text{C-Arg}_1 \text{ are fake}]$.

- Arguments can include referents/pronouns:
  - $[\text{Arg}_0 \text{The pearls}], [\text{R-Arg}_0 \text{that}]$ are $[\text{Arg}_1 \text{ fake}]$
SRL over Parse Tree

Figure 20.16 Parse tree for a PropBank sentence, showing the PropBank argument labels. The dotted line shows the path feature NP↓S↓VP↓VBD for ARG0, the NP-SBJ constituent the San Francisco Examiner.
Basic SRL Approach

- Generally exploit supervised machine learning
- Parse sentence (dependency/constituent)
  - For each predicate in parse:
    - For each node in parse:
      - Create a feature vector representation
      - Classify node as semantic role (or none)
- Much design in terms of features for classification
Classification Features

- Gildea & Jurafsky, 2002 (foundational work)
  - Employed in most SRL systems

- Features:
  - specific to candidate constituent argument
  - for predicate generally

- Governing *predicate*:
  - Nearest governing predicate to the current node
    - Verbs usually (also adj, noun in FrameNet)
    - E.g. ‘issued’
  - Crucial: roles determined by predicate
SRL Features

- Constituent internal information:
  - Phrase type:
    - Parse node dominating this constituent
    - E.g. NP
    - Different roles tend to surface as different phrase types
  - Head word:
    - E.g. Examiner
    - Words associated w/specific roles – e.g. pronouns as agents
  - POS of head word:
    - E.g. NNP
SRL Features

- Structural features:
  - Path: Sequence of parse nodes from `const` to `pred`
    - E.g. `NP|S|VP|VBD`
    - Arrows indicate direction of traversal
    - Can capture grammatical relations
  - Linear position:
    - Binary: Is constituent `before` or `after` predicate
      - E.g. before
  - Voice:
    - Active or passive of clause where constituent appears
      - E.g. active (strongly influences other order, paths, etc)
  - Verb subcategorization
Other SRL Constraints

- Many other features employed in SRL
  - E.g. NER on constituents, neighboring words, path info

- Global Labeling constraints:
  - Non-overlapping arguments:
    - FrameNet, PropBank both require

- No duplicate roles:
  - Labeling of constituents is not independent
    - Assignment to one constituent changes probabilities for others
Classification Approaches

- Many SRL systems use standard classifiers
  - E.g. MaxEnt, SVM
  - However, hard to effectively exploit global constraints

- Alternative approaches
  - Classification + reranking
  - Joint modeling
  - Integer Linear Programming (ILP)
    - Allows implementation of global constraints over system
State-of-the-Art

- Best system from CoNLL shared task (PropBank)
- ILP-based system (Punyakanok)
FrameNet “Parsing”

- (Das et al., 2014)
- Identify targets that evoke frames
  - ~ 79.2% F-measure
- Classify targets into frames
  - 61% for exact match
- Identify arguments
  - ~ 50%
SRL Challenges

- Open issues:
  - SRL degrades significantly across domains
    - E.g. WSJ → Brown: Drops > 12% F-measure
  - SRL depends heavily on effectiveness of other NLP
    - E.g. POS tagging, parsing, etc
    - Errors can accumulate
  - Coverage/generalization remains challenging
    - Resource coverage still gappy (FrameNet, PropBank)

- Publicly available implementations:
  - Shalmaneser, SEMAFOR
Summary

- Computational Semantics:
  - Deep compositional models yielding full logical form
  - Semantic role labeling capturing who did what to whom
  - Lexical semantics, representing word senses, relations
Computational Models of Discourse
Roadmap

- Discourse
  - Motivation

- Dimensions of Discourse

- Coherence & Cohesion

- Coreference
What is a Discourse?

- Discourse is:
  - Extended span of text
  - Spoken or Written
  - One or more participants
  - Language in Use
  - Goals of participants
    - Processes to produce and interpret
Why Discourse?

- Understanding depends on context
  - Referring expressions: it, that, the screen
  - Word sense: plant
  - Intention: Do you have the time?

- Applications: Discourse in NLP
  - Question-Answering
  - Information Retrieval
  - Summarization
  - Spoken Dialogue
  - Automatic Essay Grading
Reference Resolution

U: Where is A Bug’s Life playing in Summit?
S: A Bug’s Life is playing at the Summit theater.
U: When is it playing there?
S: It’s playing at 2pm, 5pm, and 8pm.
U: I’d like 1 adult and 2 children for the first show. How much would that cost?

- Knowledge sources:
  - Domain knowledge
  - Discourse knowledge
  - World knowledge

From Carpenter and Chu-Carroll, Tutorial on Spoken Dialogue Systems, ACL ‘99
First Union Corp. is continuing to wrestle with severe problems. According to industry insiders at PW, their president, John R. Georgius, is planning to announce his retirement tomorrow.

Summary:

First Union President John R. Georgius is planning to announce his retirement tomorrow.

Inter-sentence coherence relations:

- Second sentence: main concept (nucleus)
- First sentence: subsidiary, background
Different Parameters of Discourse

- Number of participants
  - Multiple participants -> Dialogue

- Modality
  - Spoken vs Written

- Goals
  - Transactional (message passing) vs Interactional (relations, attitudes)
  - Cooperative task-oriented rational interaction
Coherence Relations

- John hid Bill’s car keys. He was drunk.
- ?? John hid Bill’s car keys. He likes spinach.

- Why odd?
  - No obvious relation between sentences
    - Readers often try to construct relations

- How are first two related?
  - Explanation/cause

- Utterances should have meaningful connection
  - Establish through coherence relations