Semantic role labeling

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Semantic role labeling

Semantic role labeling (SRL):

- Indicate the semantic relations among a predicate and its participants
  - Relations are typically drawn from a list of possible semantic roles

  (1) [The girl on the swing]$_{Agent}$ [whispered]$_{Pred}$ to [the boy beside her]$_{Recipient}$

- Provides a first-level semantic representation of a text

SRL used for tasks such as:

- information extraction (Surdeanu et al. 2003)
- machine translation (Komachi et al. 2006)
- question answering (Narayanan and Harabagiu 2004)

Slides based upon Márquez et al (2008), Semantic Role Labeling: An Introduction to the Special Issue, Computational Linguistics
Semantic resources

SRL requires corpora annotated with predicate-argument structure for training and testing data

- Gildea and Jurafsky (2002); Xue and Palmer (2004); Toutanova et al. (2005); Pradhan et al. (2005), ...

This has led to the development of statistical approaches to SRL
What are semantic roles?

Differing viewpoints, in terms of how specific they are:

- Situation-specific roles, e.g., Suspect, Authorities, Offense
- General roles, e.g., Agent, Theme, Location, Goal
- Core role: Proto-Agent & Proto-Theme

An important question for SRL:

- What is the mapping between the predicate-argument structure determining the roles & their syntactic realization?
Regularity in semantic roles

Verb classes (Levin):
- Patterns of syntactic alternation exhibit regularity which reflects an underlying semantic similarity among verbs
- Lexical items are syntactically homogeneous & share coarse semantic properties
- No real notion of a semantic role

Frame semantics (Fillmore)
- Relates linguistic semantics to encyclopedic knowledge
- Delineates very situation-specific frames and semantic roles
  - Not chosen from a pre-specified list
Characterization of participants

Frame semantics:

▶ Core frame elements: e.g., Suspect, Authorities, Offense
▶ Peripheral, or extra-thematic, elements: e.g., Manner, Time Place
  ▶ SRL systems tend to do better on core elements

SRL tends to focus on verbs, but nouns, adjectives, & prepositions also can have frames
▶ e.g., proud that we finished the paper: Theme subordinate clause of proud
Semantic annotation

Corpora with semantic annotation are increasingly relevant in natural language processing

▶ See: Baker et al. (1998); Palmer et al. (2005); Burchardt et al. (2006); Taulé et al. (2005)

Need feedback on annotation schemes:

▶ difficult to select an underlying theory (see, e.g., Burchardt et al. 2006)
▶ difficult to determine certain relations, e.g., modifiers (ArgM) in PropBank (Palmer et al. 2005)
▶ Not a clear consensus on what elements to tag and how to tag them (Palmer et al. 2000)

Semantically-annotated corpora also have potential as sources of linguistic data for theoretical research
Senses & Relations

Broadly speaking, there are 2 main ways to do semantic annotation:

- **Lexical semantics: word senses**
  - The major issue here is how to deal with polysemy
  - How many senses does each word have, and what are they?

- **Compositional semantics: argument relations**
  - The connection to syntax is apparent
  - Requires an inventory of argument roles & relies on the particular verb sense

These concepts are interrelated in some ways, but we are more interested in the latter
Sense Tagging the Penn Treebank
Palmer et al. (2000)

Initially tagged a 5000-word corpus (later expanded for Propbank)

- Selected WSJ articles which contained “interesting verbs” & covered a range of topics
- Sense-tagged only the verbs & headwords of arguments/adjuncts
- Used WordNet senses
  - Additionally tagged proper nouns as person, company, date, or name
Predicate-argument structure

Building from the sense annotation, they also annotated predicate-argument structure

- Added subscripts to PTB trees to indicate what semantic role a constituent plays in a sentence
  - e.g., SBJ on an NP indicates a subject role
  - e.g., TMP on a PP indicates temporal information about an event

To obtain predicate-argument annotation, verbs needed to be linked to their arguments

- Required being able to automatically determine semantic heads of phrases
- Morphological information & phrasal lexical entries were also added
Predicate-argument relations (formally)

Semantic annotation is non-uniform:

(2) $[\text{Arg}_1 \text{ lending practices}] \text{ vary/vary.01} [\text{Arg}_2−\text{EXT widely}] [\text{Arg}_M−\text{MNR by location}]$

1. the verb sense
2. the span of each argument
3. argument label names
Some consistency issues
Dickinson and Lee (2008)

It is hard to maintain predicate-argument consistency, especially when built on top of other layers of annotation:

(3) a. **coming**/VBG \[Arg_1 \text{ months}\] ,
   
b. **coming**/JJ \text{ months} ,

(4) a. \[Arg_1 \text{ net income in its first half}] \text{ rose} 59 \%
   
b. \[Arg_1 \text{ net income}] \text{ in its first half} \text{ rose} 8.9 \%

(5) a. That could \[Arg_{2-MNR} \text{ substantially}] \text{ reduce} the value of the television assets .
   
b. the proposed acquisition could \[Arg_{M-MNR} \text{ substantially}] \text{ reduce} competition ...
Insights

- Some verbs are ambiguous in whether they take arguments and what type of arguments they take
  
  (6) a. \([Arg_1 \text{Analysts}] \text{had} \) mixed responses
  
  b. \([Arg_1 \text{Analysts}] \text{had expected} \) Consolidated to post a slim profit ...

- Much argument identification ambiguity rooted in difficulties resolving syntactic ambiguity
  
  (7) a. \(\text{seeking} [Arg_1 \text{a buyer}] [PP \text{for several months}] \)
  
  b. \(\text{seeking} [Arg_1 \text{a buyer for only its shares}] \)

- Some argument relations depend upon the sense of the verb, which depends upon other arguments of verb
  
  (8) a. \([Arg_0 \text{he}] \text{will return} \) Kidder to prominence
  
  b. \([Arg_1 \text{he}] \text{will return} \) to his old bench
FrameNet is an online lexical resource for English (with FrameNets also in other languages)

- [http://framenet.icsi.berkeley.edu/](http://framenet.icsi.berkeley.edu/)

FrameNet features

- 10,000 lexical units, with more than 825 semantic frames
- 135,000 annotated sentences

We’ll talk more about frame semantics momentarily ...
Frame Semantics

Frame semantics describes meaning as:

- characterized by the background knowledge necessary to understand each expression
- A frame is evoked by a word or expression
  - Coarse-grained frame descriptions generalize over different lexical items (unlike Propbank)
- Each frame has its own set of semantic roles, called frame elements
  - Participants & propositions of an abstract situation
  - Frame elements are local to individual frames, instead of using universal roles
Frame example: **STATEMENT**

Frame description

*This frame contains verbs and nouns that communicate the act of a speaker to address a message to some addressee using language. A number of the words can be used performatively, such as declare and insist.*
Frame example: **STATEMENT**

Frame elements

- **SPEAKER**: Evelyn said she wanted to leave.
- **MESSAGE**: Evelyn announced that she wanted to leave.
- **ADDRESSEE**: Evelyn spoke to me about her past.
- **TOPIC**: Evelyn’s statement about her past.
- **MEDIUM**: Evelyn preached to me over the phone.
Frame example: STATEMENT

Predicates

- acknowledge.v
- acknowledgement.n
- add.v
- address.v
- admission.n
- admit.v
- affirm.v
- affirmation.n
- allegation.n
- ...

Semantic role labeling
L645
SRL
Linguistics
Semantic resources
Propbank
FrameNet
Effect
Approaches
References
Frame semantics is between syntax and "deep" semantics e.g., generalizes over verbal alternations:

- [Peter]agent hitcauseimpact [the ball]impactee.
- [The ball]impactee was hitcauseimpact.

and over nominalizations:

- [Evelyn]speaker spokestatement [about her past]topic.
- [Evelyn’s]speaker statementsstatement [about her past]topic.
The SALSA project
Burchardt et al. (2006)

Large corpora and large domain-independent lexica can help the study of:

▶ lexical semantics
▶ syntax-semantics linking properties
▶ noncompositional phenomena, e.g., idiomatic & metaphoric expressions
▶ cross-lingual analysis & application of lexical semantic information
  ▶ particularly apt for frame semantics, as it has a common, largely language-independent word sense & role inventory

Project page: http://www.coli.uni-saarland.de/projects/salsa/
See http://www.coli.uni-saarland.de/projects/salsa/corpus/ for the release
Annotation for German

Build on top of the TIGER corpus of German

▶ Single flat tree for each frame
▶ Root node labeled with frame name; edges with frame element names
  ▶ Frame elements refer to syntactic constituents

Communication_response:


Annotation proceeds one predicate at a time & all instances of a predicate are annotated
Compositionality

- Support Verb Constructions
- Idioms: annotate complete multiword unit as frame-evoking element
- Metaphors, e.g., *unter die Lupe nehmen*: *to put* (lit. *take*) *under a magnifying glass*:
  - Source frame models syntactic realization patterns (e.g., *Taking*)
  - Target frame models the understood meaning (e.g., *Scrutiny*)
- Vagueness: annotators can assign more than 1 label (for frames or frame elements)
Effect of role inventory on SRL

There is a bit of an open question as to what effect the role inventory has on SRL.

- Gildea and Jurafsky (2002) mapped FrameNet frames into abstract thematic roles
- System used these roles without degradation

PropBank:
- Is it too domain-specific?
- Are the roles easier to label than FrameNet’s?
Approaches to Automatic SRL

SRL has two tasks:

- Identify the boundaries of the arguments of the verb predicate (argument identification)
- Label arguments with semantic roles (argument classification)

Most common architecture:

1. Filtering/pruning the set of arguments
2. Local scoring of argument candidates
3. Global scoring of argument candidates
Filtering

Filter/prune the set of argument candidates

- Can be continuous or discontinuous
  - This means *any* subsequence of words can be considered a candidate
- Typically use simple heuristics to reduce the space of candidates:
  - Xue and Palmer (2004): collect sister constituents of a predicate as possible arguments
  - Move up the tree, collecting sisters, all the way to the top
Local scoring

Locally score argument candidates via a function that outputs probabilities/confidence scores for each possible label

▶ Also include “no-argument” (NONE) label

▶ Candidates are treated independently of each other

Notes:

▶ Feature selection tends to be more crucial than choice of classification algorithm

▶ Argument identification & classification can be treated jointly or separately

▶ Separately = pipeline of argument/no-argument + specific label

▶ Useful features may be different for the 2 tasks
Global scoring

Joint (or global) scoring combines the predications of local scores to good a good structure

▶ Dependencies among several arguments of the same predicate can be exploited
  ▶ arguments do no overlap
  ▶ core arguments do not repeat
  ▶ etc.

▶ Could rerank or use probabilistic models to obtain structured output
Variations on common architecture

- Do only local scoring
- Skip directly to joint scoring
- Fourth step of fixing common errors
- Fourth step of enforcing coherence in solution
System combination

Combine:

► the output of several independent SRL basic systems
► several outputs from the same SRL system
  ▶ Change input annotations or other internal parameters

Could combine the best among competing full solutions or combine fragments of alternative solutions
Feature engineering

Given a verb and a candidate argument, three types of features are used:

1. Features that characterize the candidate argument & its context
   - e.g., phrase type, headword, governing category of the constituent

2. Features that characterize the verb predicate & its context
   - e.g., lemma, voice, & subcategorization pattern of the verb

3. Features that characterize the realtion between the candidate & the predicate
   - e.g., L/R position of the constituent w.r.t. the verb, category path between them

There are lots of extensions to this (e.g., syntactic frame, syntactic path variants, semantic relation/selectional preferences)

... We’ll talk more next time: read the Pradhan et al paper
Evaluation

CoNLL-2005 shared task showed:

- $F_1$ scores around 80% 
- Argument identification accounts for most of the errors
  - recall about 81% of correct unlabeled arguments
  - about 95% of these are assigned the correct semantic role
References


http://verbs.colorado.edu/~mpalmer/papers/lrec00.ps.gz.


