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
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.

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.

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

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

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

(3) a. **coming**:VBG [Arg1 months] ,
   b. coming/JJ months ,

(4) a. [Arg1 net income in its first half] **rose** 59 %
   b. [Arg1 net income] in its first half **rose** 8.9 %

(5) a. That could [Arg2 net] substantially **reduce** the value of the television assets .
   b. the proposed acquisition could [ArgM-MNR substantially] **reduce** competition ...
Some verbs are ambiguous in whether they take arguments and what type of arguments they take.

a. [Arg1 Analysts] had mixed responses
b. [Arg1 Analysts] had expected

Much argument identification ambiguity rooted in difficulties resolving syntactic ambiguity.

a. seeking [Arg1 a buyer] [PP for several months]
b. seeking [Arg1 a buyer] [only its shares]

Some argument relations depend upon the sense of the verb, which depends upon other arguments of verb.

a. [Arg0 he] will return Kidder to prominence
b. [Arg1 he] will return to his old bench.

FrameNet

FrameNet is an online lexical resource for English (with FrameNets also in other languages)

- 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

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.

Predicates

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

Syntax-semantics examples

Frame semantics is between syntax and “deep” semantics e.g., generalizes over verbal alternations:

- [Peter]agent hi[cause,impact] [the ball]impactee
- [The ball]impactee was hi[cause,impact]

and over nominalizations:

- [Evelyn]speaker spoke[statement] [about her past]topic
- [Evelyn’s]speaker statement[statement] [about her past]topic

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:

  (9) "[Schlecht]Message ", antworter [NP
  " Badly ", answers the die Branche]Speaker [PP im Chor].
  industry section in unison.

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 relation 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.