Semantic Role labeling

A little while ago and Now

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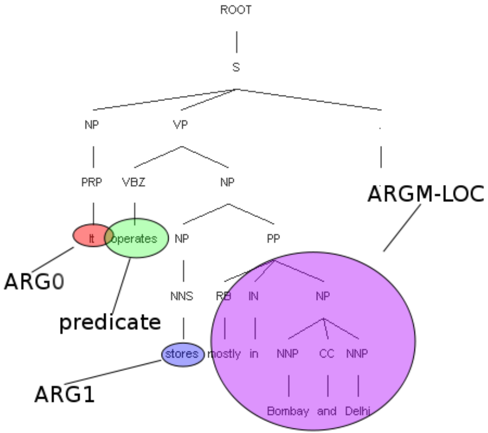
Outline

1. Introduction
2. Basics
3. State of the art
4. Conclusion and further work

What is SRL?

- Semantic Frames and relationships
- FrameNet, PropBank, etc.

Example of SRL.



Why SRL?

- Better Understanding
- Immediate Question Answering
- Sense disambiguation

Immediate and consistant question answering

1. [$_{ARG0}$ Praveen] broke [$_{ARG1}$ the window.]
2. [$_{ARG1}$ The window] broke.

A sample question: *What* broke?

Example of why SRL

1. Chavi left the room.
2. Chavi left his brother all his belongings in his will.

In the first case:

ARG0: Entity Leaving
ARG1: Place Left

In the second case:

ARG0: Giver
ARG1: Thing given
ARG2: Beneficiary

How SRL's are done?

- Manually
  - FrameNet (Some verbs) (1998)
  - PropBank (More verbs) (2005)
  - NomBank (Nouns) (2007)

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- Automatically

Timeline

- **2002** : *Automatic Labeling of Semantic Roles* by David Gildea, Daniel Jurafsky.
- **2003** : *Semantic Role Labeling by Tagging Syntactic Chunks* by Kadri Hacioglu, Sameer Pradhan, Wayne Ward, James H. Martin, Daniel Jurafsky
- **2004** : *Pruning heuristics for Two Stage SRL systems* by Xue and Palmer
- **2004** : *Semantic role labeling via integer linear programming inference* by V Punyakanok, D Roth, W Yih, D Zimak
- **2005** : *Semantic Role Labeling: A sequence tagging problem* by Marquez, Pere Comas, and Catala

Outline

How it all began?

The famous two layer architechture:

1. Recognize the boundaries of Arguments
2. Label the arguments

- Used *Lattice organization* of probabilities with more specific probabilities on the top and the probabilities propagating down for estimation.
- Introduced the primary set of features that were later used for machine learning.

Automatic Labeling of Semantic Roles by Gildea and Jurafskey.

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The holy grail I

Assumption A robust parsing of the sentence. Used the Collin's parser (1997).

The main features that they introduced were:

- **Phrase Type** : For example in a communication phrase:
  - **SPEAKER** is generally NP
  - **TOPIC** is generally PP
  - **MEDIUM** is generally PP
- **Governing Category** : *Only for NPs* Whether the phrase is governed by a S or by a VP.

The holy grail II

- **Parse Tree Path** : Path from the target word invoking that frame to the constituent invoking that frame.

Frequency	Path	Usual Description
14.2%	$VB \uparrow VP \downarrow PP$	PP argument/adjunct
11.8%	$VB \uparrow VP \uparrow S \downarrow NP$	Subject (ARG0/ARG1)
10.1%	$VB \uparrow VP \uparrow NP$	Object (ARG0/ARG1)
...		

- **Position** : Before the predicate or after it. To overcome errors due to incorrect parses.
- **Voice** : Active / Passive
- **Head Word** : Head words from the phrases taken as according to *Collin (1999)*

The holy grail III

- **Subcategorization** : *Only for Verbs* The structure of the node just above the verb in the parse of the sentence.
  1. *He opened the door.* : **opened** has sub-category of $VP \longrightarrow VB - NP$
  2. *The door opened.* : **opened** has sub-category of $VP \longrightarrow VB$
- **Frame Element Group** : *Only for Verbs* : The possible frames that might be present with a verb, and their probabilities.

Performance

- They used simple counting, splitting over features for identification, and linear interpolation of probabilities using difference features.
- Performance was marred by erroneous FrameNet annotations.
- 82% accuracy in identifying pre-segmented data.
- While simultaneously identifying segments and labeling them: 65% precision and 61% recall.

Outline

Towards Robust Semantic Role Labeling I

The pioneers in using SVMs in SRL task. The paper talks about the performance of *ASSERT* on various corpus of data.

1. PropBank Wall Street Journal corpus.
2. PropBank Brown Corpus data.

The task is the same, but using SVMs.

- *Why SVMs?* **Multidimensional Data** : A huge classification problem.
- *Which SVMs?* **One $^{v}/_{s}$ All, Binary Classifiers** : Used a Sigmoid function to map distance to probability.
- *Only SVMs?* **Problem of Independence** : This means that all nodes in the parse tree have a class (which can be NULL), independent of what are the classes of its neighbors.

Towards Robust Semantic Role Labeling II

- **Viterbi Search** : So another model is made, similar to the Markov models
  - **States** : *n-best* hypothesis ARGs from the SVMs.
  - **State probabilities** : Tri-grams of possible classes sequences (trained along with the SVMs)
  - **Observation Probabilities** : Function of probabilities obtained from the SMVs
  - **Search** : Is constrained such that no two overlapping nodes are given a NON-NULL label.

Robustness I

- The performance:

Parse	Task	Prec(%)	Rec (%)	Accuracy (%)
TreeBank	Id.	97.5	96.1	-
	Class.	-	-	93.0
	Both	91.8	90.5	-
Auto[1]	Id.	87.8	84.1	-
	Class.	-	-	92.0
	Both	81.7	78.4	-

- Performance on Brown Corpus was more difficult because the problem is fundamentally harder to solve for heterogeneous data.
- Parsing is **not** a problem any more.

Robustness II

- More general features needed for classification, while Identification is robust.
- More diverse training and testing data.

[1] Charniak parser was used for parsing

Importance of Parsing and Inference in SRL I

Pioneers in attempting to use Linear Programming and Inference in Semantic Role Labeling task. The paper talks about the effect of using features from complete Parsers $^{v}/_{s}$ shallow parsers for SRL.

1. Used the Charniak parser's top five parses.
2. Used the Collin's parser full parse tree.
3. Used inference and pruning stage.
4. *Identification without Parsing* Two classifiers.

Importance of Parsing and Inference in SRL II

Design of the Inference engine:

- Constrains were designed:
  1. Arguments cannot overlap
  2. If there exists a *R-arg*[2] then a parent *arg* must be present.
  3. Given the predicate, some frames are illegal: *stalk* only takes A0 or A1.

  ...

Importance of Parsing and Inference in SRL III

- A linear program was made for the constrains:

$$u^* = argmax_{u \in \{0,1\}^d} p.u$$

Constrains: $C_1.u \geq b_1$ and $C_2.u = b_2$ With p as a cost vector. Then the classes

$$\hat{c}^{1:M} = argmax_{c^{1:M} \in C} \sum_{i=1}^{M} score(S^i = c^i)$$

are the same as:

$$\hat{c}^{1:M} = argmax_{u_{ic} \in 0,1; \forall i \in [1,M]; c \in C} \sum_{i=1}^{M} \sum_{c \in C} p_{ic} u_{ic}$$

Importance of Parsing and Inference in SRL IV

Where p_{ic} is the probability of constituent S^i being of class c^i and
Subject to

$$\sum_{c \in C} u_{ic} = 1 \forall i \in [1, M]$$

, that is each segment gets only one class.

- **Note:** Solving a Integer Linear Program is in general NP-hard, but in practice its competitively fast.

[2]Reference Argument

Necessity of Full parsing

- Full Parsing greatly enhances the identification of Constituent boundaries.
- Joint inference with multiple probabilities considered from more than one source improves performance.

	Full	**Parsing**	**Shallow**	**Parsing**
Parse	Prec.	Rec	Prec.	Rec
Gold	86.22	87.40	75.34	74.28
Auto	77.09	75.51	75.48	67.13

Outline

When the hurly-burly's done . . .

- **Future of Parsing**
  - Importance ascertained
  - State-of-the-art Accuracy ascertained
- **Semantic Role Labeling**
  - Need for another breakthrough?
  - More experimentation :
    - Combining SVMs with the Inferences as constrains in Viterbi Search.
    - Performing SVMs on parses from various parsers.

References

- *Importance of Parsing and Inference in SRL (2006)* by Punyakanok, Roth and Yih
- *Towards Robust Semantic Role Labeling (2006)* by Pradhan, Ward and Martin
- *Automatic Labeling of Semantic Roles (2002)* by Gildea and Jurafsky

Thank you

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