Semantic role labelling

Semantic Role Labeling

- XYZ corporation bought the stock.
- They sold the stock to XYZ corporation.
- The stock was bought by XYZ corporation.
- The purchase of the stock by XYZ corporation...
- The stock purchase by XYZ corporation...

Event - ?

Participants - ?

Roles - ?

Semantic Role Labeling

Semantic roles are representations that express the abstract role that arguments of a predicate can take in the event; these can be very specific, like the *BUYER*, abstract like the *AGENT*, or super-abstract (the *PROTO-AGENT*). These roles can both represent general semantic properties of the arguments and also express their likely relationship to the syntactic role of the argument in the sentence. *AGENTS* tend to be the subject of an active sentence, *THEMES* the direct object, and so on.

Semantic role labeling is the task of assigning roles to the constituents or phrases in sentences.

Selectional restrictions, the semantic sortal restrictions or preferences that each individual predicate can express about its potential arguments, such as the fact that the theme of the verb eat is generally something edible.

Semantic roles

Agent: a participant which the meaning of the verb specifies as doing or causing something, possibly intentionally. Examples: subjects of *kill*, *eat*, *hit*, *smash*, *kick*, *watch*.

Causer: inanimate or non-volitional entity which is directly involved in the causation of an event. *The rain ruined the crop*.

Patient: a participant which the verb characterizes as having something happen to it, and as being affected by what happens to it. Examples: objects of *kill*, *eat*, *hear*, *love*.

Experiencer: a participant who is characterized as aware of something. Examples: subject of *love*, object of *annoy*.

Semantic roles

Theme: a participant which is characterized as changing its position or condition, or as being in a state or position. Examples: objects of *give*, *hand*, subjects of *walk*, *die*.

Location: the thematic role associated with the NP expressing the location in a sentence with a verb of location. Examples: *They stayed at the village*.

Source: object from which motion proceeds. Examples: *Jennifer walked home from the office*.

Goal: object to which motion proceeds. Examples: *Jennifer walked home from the office.*

Semantic roles

Stimulus: whatever causes a psychological response (i.e. Positive or negative) in the experiencer. *The situation scares me*.

Content: the content of a psychological state or of a representation. It expresses an idea or a mental representation that is entertained or perceived. *The jury heard his testimony.*

Instrument: inanimate entity used by an agent or experiencer in order to do something to a patient or theme. *John opened the lock with a key*.

Recipient: animate entity which receives or acquires something. *John gave Mary a book.*

Semantic roles

- *She ran* [*from the post-office*]$_{\text{SOURCE}}$ [*via the railway station*]$_{\text{PATH}}$ [*to the bus-stop.*]$_{\text{GOAL}}$
- *Jenny walked* [*from school*]$_{\text{PATH}}$
- *Walter drove* [*home*]$_{\text{GOAL}}$
- *The coin rolled* [*across the floor*]$_{\text{PATH}}$

Semantic roles

(22.3) *John* *broke the window.*
AGENT THEME

(22.4) *John* *broke the window with a rock.*
AGENT THEME INSTRUMENT

(22.5) *The rock* *broke the window.*
INSTRUMENT THEME

(22.6) *The window broke.*
THEME

(22.7) *The window was broken by John.*
THEME AGENT

The set of thematic role arguments taken by a verb is thematic grid often called the **thematic grid**, **θ-grid**, or **case frame**.

Semantic roles

1. John gave Mary a bouquet of roses;
2. John baked Mary a chocolate cake;
3. The key opened the lock;
4. S. Holmes heard a piercing scream;
5. John enjoyed the novel;
6. We put the box on the shelf;
7. Mike drove to Jackie’s house;
8. The burglar entered through the window.

Frame Semantics

Frame semantics is a theory of linguistic meaning developed by Charles J. Fillmore. It relates linguistic semantics to encyclopaedic knowledge.

Basic idea: one cannot understand the meaning of a single word without access to all the essential knowledge that relates to that word.

A word activates a frame of semantic knowledge relating to the specific concept it refers to (or highlights).

Frame Semantics

A **semantic frame** is a collection of facts that specify characteristic features, attributes, and functions of a denotatum, and its characteristic interactions with things necessarily or typically associated with it.

A **semantic frame** is a coherent structure of related concepts that are related such that without knowledge of all of them, one doesn’t have complete knowledge of any one.

Words not only highlight individual concepts, but also specify a certain perspective from which the frame is viewed.

Frame Semantics

BUYER subject	buy	GOODS object	(SELLER) from	(PRICE) for
Alfred	bought	the book	from Olivia	for 10 dollars
Alfred	bought	them		for 1 dollar
Alfred	bought	a bicycle	from Sarah	

Semantic Roles: Problems

a. The cook opened the jar with the new gadget.
b. The new gadget opened the jar.

a. Shelly ate the sliced banana with a fork.
b. *The fork ate the sliced banana.

The Proposition Bank

https://propbank.github.io/

The Proposition Bank, generally referred to as PropBank, is a resource of sentences annotated with semantic roles.

The Proposition Bank

(22.11) **agree.01**

Arg0: Agreer
Arg1: Proposition
Arg2: Other entity agreeing

Ex1: [$_{\text{Arg0}}$ The group] *agreed* [$_{\text{Arg1}}$ it wouldn't make an offer].
Ex2: [$_{\text{ArgM-TMP}}$ Usually] [$_{\text{Arg0}}$ John] *agrees* [$_{\text{Arg2}}$ with Mary] [$_{\text{Arg1}}$ on everything].

(22.12) **fall.01**

Arg1: Logical subject, patient, thing falling
Arg2: Extent, amount fallen
Arg3: start point
Arg4: end point, end state of arg1
Ex1: [$_{\text{Arg1}}$ Sales] *fell* [$_{\text{Arg4}}$ to $25 million] [$_{\text{Arg3}}$ from $27 million].
Ex2: [$_{\text{Arg1}}$ The average junk bond] *fell* [$_{\text{Arg2}}$ by 4.2%].

The Proposition Bank: ArgMs, (ArgMTMP, ArgM-LOC, etc)

TMP	when?	yesterday evening, now
LOC	where?	at the museum, in San Francisco
DIR	where to/from?	down, to Bangkok
MNR	how?	clearly, with much enthusiasm
PRP/CAU	why?	because ... , in response to the ruling
REC		themselves, each other
ADV	miscellaneous	
PRD	secondary predication	...ate the meat raw

(22.17) [$_{\text{Arg1}}$ The price of bananas] increased [$_{\text{Arg2}}$ 5%].
(22.18) [$_{\text{Arg1}}$ The price of bananas] rose [$_{\text{Arg2}}$ 5%].
(22.19) There has been a [$_{\text{Arg2}}$ 5%] rise [$_{\text{Arg1}}$ in the price of bananas].

We'd like a system to recognize that *the price of bananas* is what went up, and that 5% is the amount it went up, no matter whether the 5% appears as the object of the verb *increased* or as a nominal modifier of the noun *rise*.

FrameNet

https://framenet.icsi.berkeley.edu/fndrupal/

A **frame** in FrameNet is a background knowledge structure that defines a set of frame-specific semantic roles, called **frame elements**, and includes a set of predicates that use these roles. Each word evokes a frame and profiles some aspect of the frame and its elements. The FrameNet dataset includes a set of frames and frame elements, the lexical units associated with each frame, and a set of labeled example sentences.

For example, the ***change_position_on_a_scale*** frame is defined as follows:

This frame consists of words that indicate the change of an Item's position on a scale (the Attribute) from a starting point (Initial value) to an end point (Final value).

FrameNet: Roles

Core Roles	
ATTRIBUTE	The ATTRIBUTE is a scalar property that the ITEM possesses.
DIFFERENCE	The distance by which an ITEM changes its position on the scale.
FINAL_STATE	A description that presents the ITEM's state after the change in the ATTRIBUTE's value as an independent predication.
FINAL_VALUE	The position on the scale where the ITEM ends up.
INITIAL_STATE	A description that presents the ITEM's state before the change in the ATTRIBUTE's value as an independent predication.
INITIAL_VALUE	The initial position on the scale from which the ITEM moves away.
ITEM	The entity that has a position on the scale.
VALUE_RANGE	A portion of the scale, typically identified by its end points, along which the values of the ATTRIBUTE fluctuate.
Some Non-Core Roles	
DURATION	The length of time over which the change takes place.
SPEED	The rate of change of the VALUE.
GROUP	The GROUP in which an ITEM changes the value of an ATTRIBUTE in a specified way.

Figure 22.3 The frame elements in the **change_position_on_a_scale** frame from the FrameNet Labelers Guide (Ruppenhofer et al., 2006).

FrameNet: Roles

(22.20) [ITEM Oil] *rose* [ATTRIBUTE in price] [DIFFERENCE by 2%].

(22.21) [ITEM It] has *increased* [FINAL_STATE to having them 1 day a month].

(22.22) [ITEM Microsoft shares] *fell* [FINAL_VALUE to 7 5/8].

(22.23) [ITEM Colon cancer incidence] *fell* [DIFFERENCE by 50%] [GROUP among men].

(22.24) a steady *increase* [INITIAL_VALUE from 9.5] [FINAL_VALUE to 14.3] [ITEM in dividends]

(22.25) a [DIFFERENCE 5%] [ITEM dividend] *increase*...

Examples

All words for this frame

VERBS:	dwindle	move	soar	escalation	shift
advance	edge	mushroom	swell	explosion	tumble
climb	explode	plummet	swing	fall	
decline	fall	reach	triple	fluctuation	**ADVERBS:**
decrease	fluctuate	rise	tumble	gain	increasingly
diminish	gain	rocket		growth	
dip	grow	shift	**NOUNS:**	hike	
double	increase	skyrocket	decline	increase	
drop	jump	slide	decrease	rise	

Semantic Role Labeling

```
function SEMANTICROLELABEL(words) returns labeled tree

    parse ← PARSE(words)
    for each predicate in parse do
        for each node in parse do
            featurevector ← EXTRACTFEATURES(node, predicate, parse)
            CLASSIFYNODE(node, featurevector, parse)
```

Figure 22.4 A generic semantic-role-labeling algorithm. CLASSIFYNODE is a 1-of-*N* classifier that assigns a semantic role (or NONE for non-role constituents), trained on labeled data such as FrameNet or PropBank.

Semantic Role Labeling

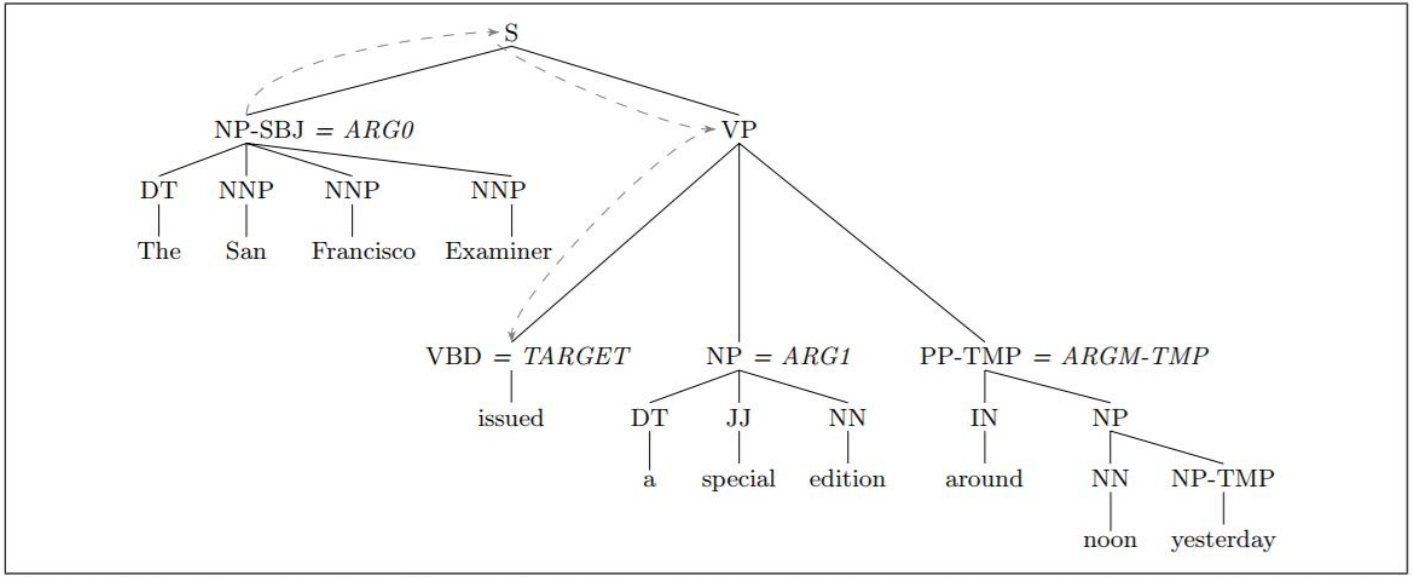

Figure 22.5 Parse tree for a PropBank sentence, showing the PropBank argument labels. The dotted line shows the **path** feature NP↑S↓VP↓VBD for ARG0, the NP-SBJ constituent *The San Francisco Examiner*.

Features for Semantic Role Labeling

- The governing **predicate**: the predicate is a crucial feature since labels are defined only with respect to a particular predicate;
- The **phrase type** of the constituent: some semantic roles tend to appear as NPs, others as S or PP, and so on;
- The **headword** of the constituent;
- The **headword part of speech** of the constituent;
- The **voice of the clause** in which the constituent appears: passive sentences tend to have strongly different linkings of semantic roles to surface form than do active ones;
- The **binary linear position of the constituent with respect to the predicate**, either before or after;
- The **named entity type** of the constituent;
- The **first words** and the **last word** of the constituent;

A Neural Algorithm for Semantic Role Labeling

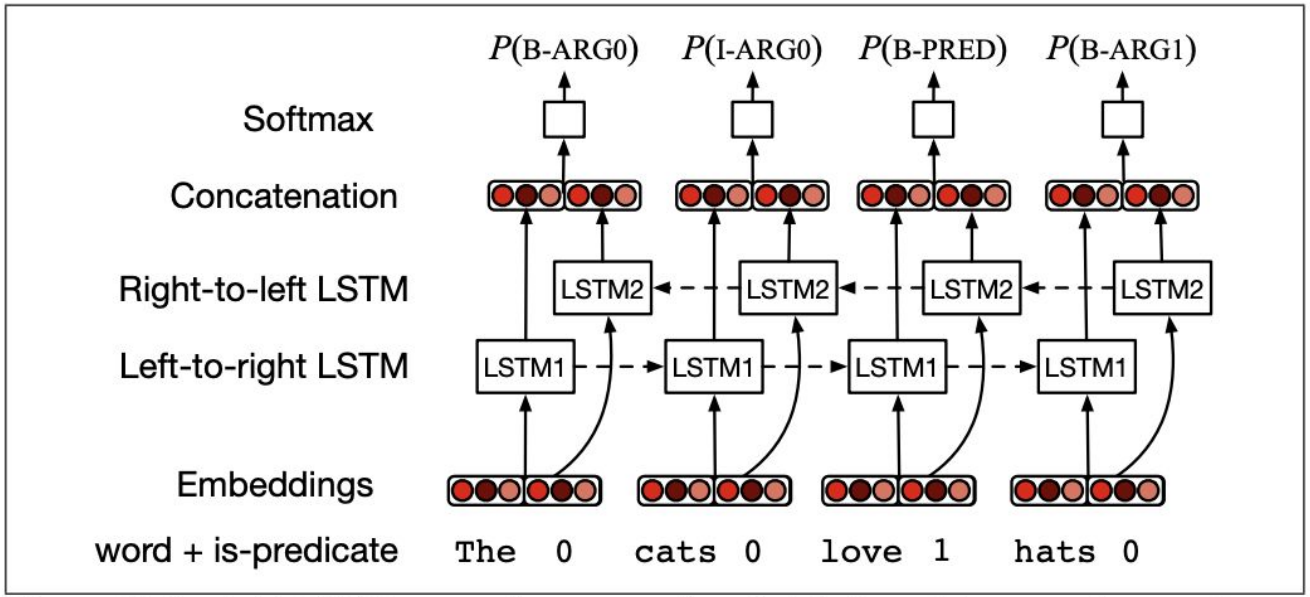

Figure 18.6 A bi-LSTM approach to semantic role labeling. Most actual networks are much deeper than shown in this figure; 3 to 4 bi-LSTM layers (6 to 8 total LSTMs) are common. The input is a concatenation of an embedding for the input word and an embedding of a binary variable which is 1 for the predicate to 0 for all other words. After He et al. (2017).

Evaluation of Semantic Role Labeling

Metrics:

- Precision;
- Recall;
- F-measure

Data sets:

- CoNLL-2005;
- CoNLL-2012

Selectional Restrictions

A selectional restriction is a semantic type constraint that a verb imposes on the kind of concepts that are allowed to fill its argument roles.

I want to eat someplace nearby.

Selectional restrictions are associated with senses, not entire lexemes:

*The restaurant **serves** green-lipped mussels.*

*Which airlines **serve** Denver?*

Selectional Restrictions

*In rehearsal, I often ask the musicians to **imagine** a tennis game.*

*Radon is an **odorless** gas that can't be detected by human senses.*

*To **diagonalize** a matrix is to find its eigenvalues.*

Some links

Semantic Role Labeling Demo: http://cogcomp.org/page/demo_view/srl

Semantic Role Labeler: http://barbar.cs.lth.se:8081/