

Natural Language Processing

Lecture 18b: Semantic Roles

Semantics Roadmap

- You should already have been convinced that grammatical structure is an important aspect of language
- Now we are discussing *semantics* or *meaning*
- Up until today, we have talked about meaning as something that individual words have (whether in isolation or in context)
- So far today, we have talked about representing the meanings of propositions/sentences in meaning representation languages
- Now, we are going to discuss an enhancement to this view, the notion that individual noun phrases can be characterized as having **roles** relative to a **predicate** or **frame**

- Noah built an ark out of gopher wood.
- He loaded two of every animal onto the ark.
- Noah piloted the ark into stormy weather.
- When the skies cleared, all rejoiced.

- Noah₁ built an ark₂ out of gopher wood.
- He₁ loaded two of every animal onto the ark₂.
- Noah₁ piloted the ark₂ into stormy weather.
- When the skies₃ cleared, all₄ rejoiced.

Paraphrase

- Noah built an ark out of gopher wood.
- An ark was built by Noah. It was made from gopher wood.
- Noah constructed an ark with wood from a gopher tree.
- Using gopher wood, Noah managed to put together an ark.
- Noah built an ark.
- ...

Traditional Semantic Roles

- In the linguistics literature, one sees a number of common terms for semantic roles
 - Agent
 - Patient
 - Theme
 - Force
 - Experiencer
 - Stimulus
 - Recipient
 - Source
 - Goal
 - etc.
- These have their place, and are useful to know if you want to understand what a semantic role is, but are not widely used in NLP
- In NLP, we tend to use finer-grained (and sometimes cryptically named) semantic role labels

Traditional Semantic Roles

- **David** *threw* **the midterms** from **Pausch Bridge** to **the hillside below**.
 - **David**—agent
 - **the midterms**—theme
 - **Pausch Bridge**—source
 - **the hillside below**—goal

Neo-Davidsonian Representation

- David *threw* the *midterms* from *Pausch Bridge* to the *hillside below*
 - $\text{THROW}(\text{David}, \text{midterms}, \text{PauschBridge}, \text{hillside})$
 - $\exists e \text{ THROW}(e) \wedge \text{AGENT}(e, \text{David}) \wedge \text{THEME}(e, \text{midterms}) \wedge \text{SOURCE}(e, \text{PauschBridge}) \wedge \text{GOAL}(e, \text{hillside})$
- The *midterms* were *thrown* from *Pausch Bridge*
 - $\text{THROW}(\text{midterms}, \text{PauschBridge})$
 - $\exists e \text{ THROW}(e) \wedge \text{THEME}(e, \text{midterms}) \wedge \text{SOURCE}(e, \text{PauschBridge})$

Semantic Role Labeling

Input: a sentence, paragraph, or document

Output: for each predicate*, labeled spans identifying each of its arguments.

*Predicates are sometimes identified in the input, sometimes not.

Predicates

- Noah **built** an ark out of gopher wood.
- An ark was **built** by Noah. It was **made** from gopher wood.
- Noah **constructed** an ark with wood from a gopher tree.
- Using gopher wood, Noah managed **to put together** an ark.

Predicates and Arguments

- Noah built an ark out of gopher wood.
- An ark was built by Noah. It was made from gopher wood.
- Noah constructed an ark with wood from a gopher tree.
- Using gopher wood, Noah managed to put together an ark.

Breaking, Eating, Opening

- John **broke** the window.
- The window **broke**.
- John is always **breaking** things.
- The **broken** window testified to John's malfeasance.

- **Eat!**
- We **ate** dinner.
- We already **ate**.
- The pies were **eaten** up quickly.
- Our **gluttony** was complete.

- **Open up!**
- Someone left the door **open**.
- John **opens** the window at night.

Introducing PropBank

- Corpus (PTB) with propositions annotated
 - Predicates (verbs)
 - Arguments (semantic roles)
- Semantic roles are Arg0, Arg1, etc., each with a description
 - Arg0 is typically the most agent-like argument
 - Labels for other arguments are somewhat arbitrary

“Agree” in PropBank

- **arg0**: agreeer
- **arg1**: proposition
- **arg2**: other entity agreeing
- **The group** agreed **it wouldn't** make an offer.
- Usually **John** agrees with **Mary** on **everything**

“Fall (move downward)” in PropBank

- **arg1**: logical subject, patient, thing falling
- **arg2**: extent, amount fallen
- **arg3**: starting point
- **arg4**: ending point
- **argM-loc**: medium
- Sales fell to **\$251.2 million** from **\$278.8 million**.
- The average junk bond fell by **4.2%**.
- The meteor fell through **the atmosphere**, crashing into **Cambridge**.

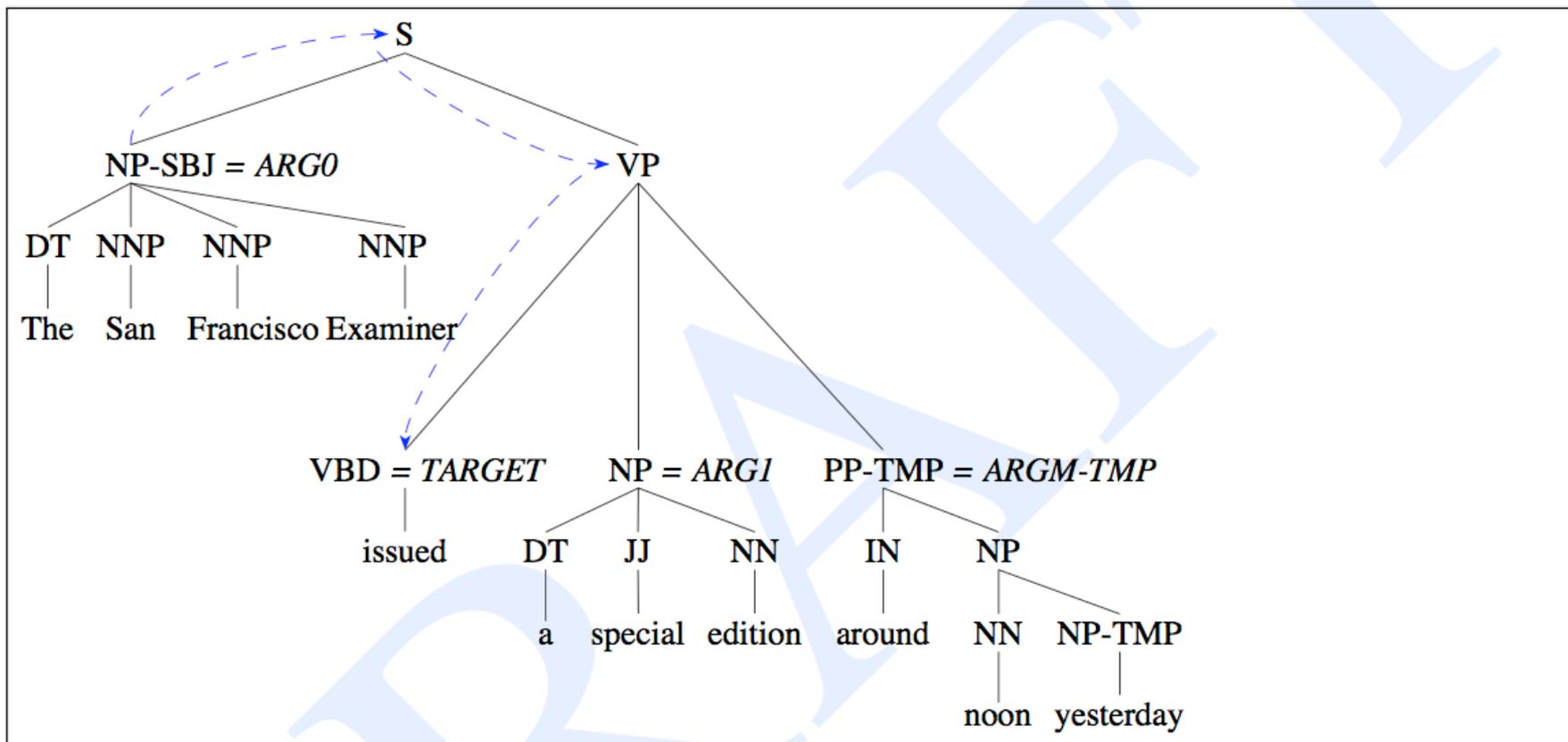


Figure 20.16 Parse tree for a PropBank sentence, showing the PropBank argument labels. The dotted line shows the **path** feature $\text{NP}\uparrow\text{S}\downarrow\text{VP}\downarrow\text{VBD}$ for ARG0, the NP-SBJ constituent *the San Francisco Examiner*.

FrameNet

- A **frame** is a schematic representation of a situation involving various participants, and other conceptual roles
- In FrameNet, frames—not verbs—are first-class citizens
 - To a first approximation, verbs that relate to the same situation belong to the same frame
 - Roles are given fine-grained labels that are specific to the frame, but not the verb
 - Frames can center around words other than verbs

change_position_on_a_scale

<i>Core roles</i>	
ATTRIBUTE	scalar property that the ITEM possesses
DIFFERENCE	distance by which an ITEM changes its position
FINAL_STATE	ITEM's state after the change
FINAL_VALUE	position on the scale where ITEM ends up
INITIAL_STATE	ITEM's state before the change
INITIAL_VALUE	position on the scale from which the ITEM moves
ITEM	entity that has a position on the scale
VALUE_RANGE	portion of the scale along which values of ATTRIBUTE fluctuate
<i>Some non-core roles ...</i>	
DURATION	length of time over which the change occurs
SPEED	rate of change of the value
GROUP	the group in which an ITEM changes the value of an ATTRIBUTE

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

Demo

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

How Can We Build an SRL System?

(1) Parse

(2) For each predicate word in the parse:

 For each node in the parse:

 Classify the node with respect to the predicate