

Predicate-Argument Structure and Frame Semantic Parsing

11-711 Algorithms for NLP

November 2020

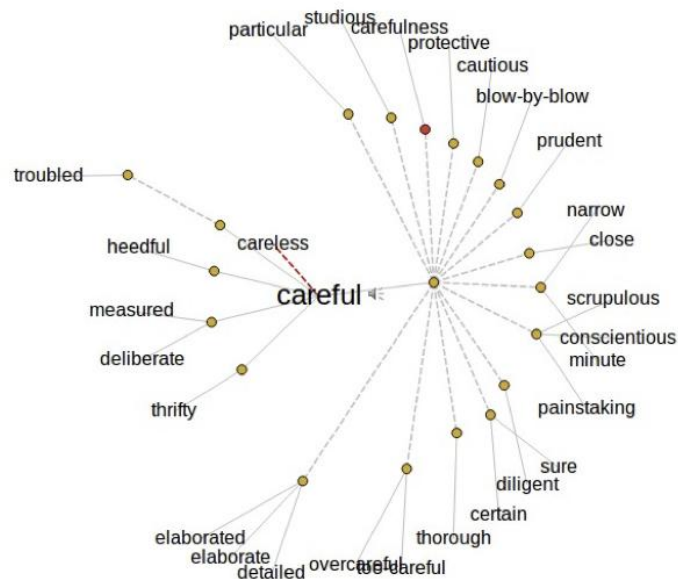
(With thanks to Noah Smith
and Lori Levin)

Semantics so far in course

- Previous semantics lectures discussed composing meanings of parts to produce the correct global sentence meaning
 - *The mailman bit my dog.*
- The “atomic units” of meaning have come from the lexical entries for words
- The meanings of words have been overly simplified (as in FOL): atomic objects in a set-theoretic model

Annotated resources for lexical semantics

- WordNet: <https://wordnet.princeton.edu/>



WordNet Search - 3.1

[WordNet home page](#) - [Glossary](#) - [Help](#)

Word to search for:

Display Options:

Key: "S:" = Show Synset (semantic) relations, "W:" = Show Word (lexical) relations

Display options for sense: (gloss) "an example sentence"

Noun

- S: (n) bank (sloping land)
pulled the canoe up; watched the currents
- S: (n) depository financial institution
a financial company (a financial money into lending a holds the mortgage)
- S: (n) bank (a long river)
- S: (n) bank (an arrangement)
operated a bank of supply emergencies)
- S: (n) bank (the fund)
- S: (n) bank, cant, car
is higher than the ins slot in the top) for ke
- S: (n) bank, bank built
transacted) "the bank
- S: (n) bank (a flight) axis
(especially in tur

Verb

- S: (v) bank (tip latera)
- S: (v) bank (enclose v)
- S: (v) bank (do business)
do you bank in this t
- S: (v) bank (act as th
- S: (v) bank (be in the
- S: (v) deposit, bank
every month"
- S: (v) bank (cover wit
- S: (v) count, bet, dep
faith or confidence in your friends for sup times of crisis"

```
from nltk.corpus import wordnet as wn
panda = wn.synset('panda.n.01')
hyper = lambda s: s.hypernyms()
list(panda.closure(hyper))
```

```
[Synset('procyonid.n.01'),
Synset('carnivore.n.01'),
Synset('placental.n.01'),
Synset('mammal.n.01'),
Synset('vertebrate.n.01'),
Synset('chordate.n.01'),
Synset('animal.n.01'),
Synset('organism.n.01'),
Synset('living_thing.n.01'),
Synset('whole.n.02'),
Synset('object.n.01'),
Synset('physical_entity.n.01'),
Synset('entity.n.01')]
```

Word senses in WordNet3.0

The noun “bass” has 8 senses in WordNet.

1. bass¹ - (the lowest part of the musical range)
2. bass², bass part¹ - (the lowest part in polyphonic music)
3. bass³, basso¹ - (an adult male singer with the lowest voice)
4. sea bass¹, bass⁴ - (the lean flesh of a saltwater fish of the family Serranidae)
5. freshwater bass¹, bass⁵ - (any of various North American freshwater fish with lean flesh (especially of the genus Micropterus))
6. bass⁶, bass voice¹, basso² - (the lowest adult male singing voice)
7. bass⁷ - (the member with the lowest range of a family of musical instruments)
8. bass⁸ - (nontechnical name for any of numerous edible marine and freshwater spiny-finned fishes)

The adjective “bass” has 1 sense in WordNet.

1. bass¹, deep⁶ - (having or denoting a low vocal or instrumental range)
*“a deep voice”; “a bass voice is lower than a baritone voice”;
“a bass clarinet”*

Synsets

- (bass6, bass-voice1, basso2)
- (bass1, deep6) (Adjective)
- (chump1, fool2, gull1, mark9, patsy1,
fall guy1, sucker1, soft touch1, mug2)

Noun relations in WordNet3.0

Relation	Also Called	Definition	Example
Hypernym	Superordinate	From concepts to superordinates	<i>breakfast</i> ¹ → <i>meal</i> ¹
Hyponym	Subordinate	From concepts to subtypes	<i>meal</i> ¹ → <i>lunch</i> ¹
Instance Hypernym	Instance	From instances to their concepts	<i>Austen</i> ¹ → <i>author</i> ¹
Instance Hyponym	Has-Instance	From concepts to concept instances	<i>composer</i> ¹ → <i>Bach</i> ¹
Member Meronym	Has-Member	From groups to their members	<i>faculty</i> ² → <i>professor</i> ¹
Member Holonym	Member-Of	From members to their groups	<i>copilot</i> ¹ → <i>crew</i> ¹
Part Meronym	Has-Part	From wholes to parts	<i>table</i> ² → <i>leg</i> ³
Part Holonym	Part-Of	From parts to wholes	<i>course</i> ⁷ → <i>meal</i> ¹
Substance Meronym		From substances to their subparts	<i>water</i> ¹ → <i>oxygen</i> ¹
Substance Holonym		From parts of substances to wholes	<i>gin</i> ¹ → <i>martini</i> ¹
Antonym		Semantic opposition between lemmas	<i>leader</i> ¹ ⇔ <i>follower</i> ¹
Derivationally Related Form		Lemmas w/same morphological root	<i>destruction</i> ¹ ⇔ <i>destroy</i> ¹

Sense 3

bass, basso --

(an adult male singer with the lowest voice)

=> singer, vocalist, vocalizer, vocaliser

=> musician, instrumentalist, player

=> performer, performing artist

=> entertainer

=> person, individual, someone...

=> organism, being

=> living thing, animate thing,

=> whole, unit

=> object, physical object

=> physical entity

=> entity

=> causal agent, cause, causal agency

=> physical entity

=> entity

Sense 7

bass --

(the member with the lowest range of a family of musical instruments)

=> musical instrument, instrument

=> device

=> instrumentality, instrumentation

=> artifact, artefact

=> whole, unit

=> object, physical object

Is a hamburger food?

Sense 1

hamburger, beefburger --

(a fried cake of minced beef served on a bun)

=> sandwich

=> snack food

=> dish

=> nutriment, nourishment, nutrition...

=> food, nutrient

=> substance

=> matter

=> physical entity

=> entity

Verb relations in WordNet3.0

Relation	Definition	Example
Hypernym	From events to superordinate events	<i>fly</i> ⁹ \rightarrow <i>travel</i> ⁵
Troponym	From events to subordinate event (often via specific manner)	<i>walk</i> ¹ \rightarrow <i>stroll</i> ¹
Entails	From verbs (events) to the verbs (events) they entail	<i>snore</i> ¹ \rightarrow <i>sleep</i> ¹
Antonym	Semantic opposition between lemmas	<i>increase</i> ¹ \iff <i>decrease</i> ¹
Derivationally Related Form	Lemmas with same morphological root	<i>destroy</i> ¹ \iff <i>destruction</i> ¹

- Not nearly as much information as for nouns:
 - 117k nouns
 - 22k adjectives
 - 11.5k verbs
 - 4601 adverbs(!)

Still no “real” semantics?

- Semantic primitives:

$\text{Kill}(x,y) = \text{CAUSE}(x, \text{BECOME}(\text{NOT}(\text{ALIVE}(y))))$

$\text{Open}(x,y) = \text{CAUSE}(x, \text{BECOME}(\text{OPEN}(y)))$

- Conceptual Dependency: PTRANS, ATRANS, ...

The waiter brought Mary the check

$\text{PTRANS}(x) \wedge \text{ACTOR}(x, \text{Waiter}) \wedge (\text{OBJECT}(x, \text{Check})$
 $\quad \wedge \text{TO}(x, \text{Mary})$

$\wedge \text{ATRANS}(y) \wedge \text{ACTOR}(y, \text{Waiter}) \wedge (\text{OBJECT}(y, \text{Check})$
 $\quad \wedge \text{TO}(y, \text{Mary})$

Semantic Cases/Thematic Roles

- Developed in late 1960's and 1970's (Fillmore and others)
- Postulate a limited set of abstract semantic relationships between a verb & its arguments: thematic roles or case roles
- Part of the verb's (predicate's) semantics

Breaking, Eating, Opening

- John broke the window.
 - The window broke.
 - John is always breaking things.
-
- We ate dinner.
 - We already ate.
 - The pies were eaten up quickly.
-
- Open up!
 - Someone left the door open.
 - John opens the window at night.

Breaking, Eating, Opening

- | | |
|-----------------------------------|-----------------------|
| • John broke the window. | breaker, |
| • The window broke. | broken thing, |
| • John is always breaking things. | breaking frequency(?) |
| | |
| • We ate dinner. | eater, |
| • We already ate. | eaten thing, |
| • The pies were eaten up quickly. | eating speed(?) |
| | |
| • Open up! | opener, |
| • Someone left the door open. | opened thing, |
| • John opens the window at night. | opening time(?) |

Related problem: Mismatch between FOPC and linguistic arguments

- *John broke the window with a hammer.*
 - Broke(j,w,h)
- *The hammer broke the window.*
 - Broke(h,w)
- *The window broke.*
 - Broke(w)
- Relationship between 1st argument and the predicate is implicit, inaccessible to the system

Thematic Role example

- *John broke the window with the hammer*
- *John*: AGENT role
window: THEME role
hammer: INSTRUMENT role
- Extend LF notation to explicitly use semantic roles

Thematic Roles

- Is there a precise way to define meaning of AGENT, THEME, etc.?
- By definition:
 - “The AGENT is an instigator of the action described by the sentence.”
- Testing via sentence rewrite:
 - *John intentionally broke the window*
 - **The hammer intentionally broke the window*

Thematic Roles [2]

- THEME
 - Describes the primary object undergoing some change or being acted upon
 - For transitive verb X, “what was Xed?”
 - *The gray eagle saw the mouse*
“What was seen?” (A: the mouse)
- (Also called “PATIENT”)

Can We Generalize?

- **Thematic roles** describe general patterns of participants in generic events.
- This gives us a kind of shallow, partial semantic representation.
- First proposed by Panini, before 400 BC!

Thematic Roles

<i>Role</i>	<i>Definition</i>	<i>Example</i>
Agent	Volitional causer of the event	The waiter spilled the soup.
Force	Non-volitional causer of the event	The wind blew the leaves around.
Experiencer		Mary has a headache.
Theme	Most directly affected participant	Mary swallowed the pill .
Result	End-product of an event	We constructed a new building .
Content	Proposition of a propositional event	Mary knows you hate her .
Instrument		You shot her with a pistol .
Beneficiary		I made you a reservation.
Source	Origin of a transferred thing	I flew in from Pittsburgh .
Goal	Destination of a transferred thing	Go to hell !

Thematic Roles

Dumb joke!

<i>Role</i>	<i>Definition</i>	<i>Example</i>
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Review: Verb Subcategorization

Verbs have sets of allowed args. Could have many sets of VP rules. Instead, have a SUBCAT feature, marking sets of allowed arguments:

+none -- Jack laughed
+np -- Jack found a key
+np+np -- Jack gave Sue the paper
+vp:inf -- Jack wants to fly
+np+vp:inf -- Jack told the man to go
+vp:ing -- Jack keeps hoping for the best
+np+vp:ing -- Jack caught Sam looking at his desk
+np+vp:base -- Jack watched Sam look at his desk
+np+pp:to -- Jack gave the key to the man

+pp:loc -- Jack is at the store
+np+pp:loc -- Jack put the box in the corner
+pp:mot -- Jack went to the store
+np+pp:mot -- Jack took the hat to the party
+adjp -- Jack is happy
+np+adjp -- Jack kept the dinner hot
+sthat -- Jack believed that the world was flat
+sfor -- Jack hoped for the man to win a prize

50-100 possible **frames** for English; a single verb can have several.

(Notation from James Allen "Natural Language Understanding")

Thematic Grid or Case Frame

- Example: break

- The child broke the vase. < agent theme >
 subj obj
- The child broke the vase with a hammer.
 < agent theme instr >
 subj obj PP
- The hammer broke the vase. < theme instr >
 obj subj
- The vase broke. < theme >
 subj

Thematic Grid or Case Frame

- Example: break

- The child broke the vase. < agent theme >
 subj obj
- The child broke the vase with a hammer.
 < agent theme instr >
 subj obj PP
- The hammer broke the vase. < theme instr >
 obj subj
- The vase broke.
 < theme >
 subj

The Thematic Grid or Case Frame shows

- How many arguments the verb has
- What roles the arguments have
- Where to find each argument
 - For example, you can find the agent in the subject position

Diathesis Alternation:

a change in the number of arguments or the grammatical relations associated with each argument

- Chris gave a book to Dana. < agent theme goal >
subj obj PP
- A book was given to Dana by Chris. < agent theme goal >
PP subj PP
- Chris gave Dana a book. < agent theme goal >
subj obj2 obj
- Dana was given a book by Chris. < agent theme goal >
PP obj subj

The Trouble With Thematic Roles

- They are not formally defined.
- Some roles generalize well, but not all.
- General roles are overly general:
 - “*agent verb theme with instrument*” and “*instrument verb theme*” ...
 - The cook opened the jar with the new gadget.
→ The new gadget opened the jar.
 - Susan ate the sliced banana with a fork.
→ #The fork ate the sliced banana.

Two Datasets

- Proposition Bank (**PropBank**): verb-specific thematic roles
- **FrameNet**: “frame”-specific thematic roles
- These are **both** lexicons containing case frames/thematic grids for each verb.

Proposition Bank (PropBank)

- A set of **verb-sense-specific** “frames” with informal English glosses describing the roles
- Conventions for labeling optional modifier roles
- Penn Treebank is labeled with those verb-sense-specific semantic roles.

“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**.
- arg0 is proto-agent, arg1 proto-patient

“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.

FrameNet

- FrameNet is similar, but abstracts from specific verbs, so that semantic **frames** are first-class citizens.
- For example, there is a single frame called **change_position_on_a_scale**.

change_position_on_a_scale

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.

Many words, not just verbs, share the same frame:

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

Oil **rose** in price by 2%

It has **increased** to having them 1 day a month.

Microsoft shares **fell** to 7 5/8.

Colon cancer incidence **fell** by 50% among men.

Conversely, one word has many frames

Example: rise

- **Change-position-on-a-scale:** Oil ROSE in price by two percent.
- **Change-posture:** a **protagonist** changes the overall position or posture of a body.
 - **Source:** starting point of the change of posture.
 - **Charles** ROSE **from his armchair**.
- **Get-up:** A **Protagonist** leaves the place where they have slept, their **Bed**, to begin or resume domestic, professional, or other activities. Getting up is distinct from Waking up, which is concerned only with the transition from the sleeping state to a wakeful state.
 - **I** ROSE **from bed**, threw on a pair of camouflage shorts and drove my little Toyota Corolla to a construction clearing a few miles away.
- **Motion-directional:** In this frame a **Theme** moves in a certain **Direction** which is often determined by gravity or other natural, physical forces. The Theme is not necessarily a self-mover.
 - **The balloon** ROSE **upward**.
- **Sidereal-appearance:** An **Astronomical_entity** comes into view above the horizon as part of a regular, periodic process of (apparent) motion of the **Astronomical_entity** across the sky. In the case of the sun, the appearance begins the day.
 - At the time of the new moon, **the moon** RISES at about the same time the sun rises, and it sets at about the same time the sun sets.Each day **the sun's** RISE offers us a new day.

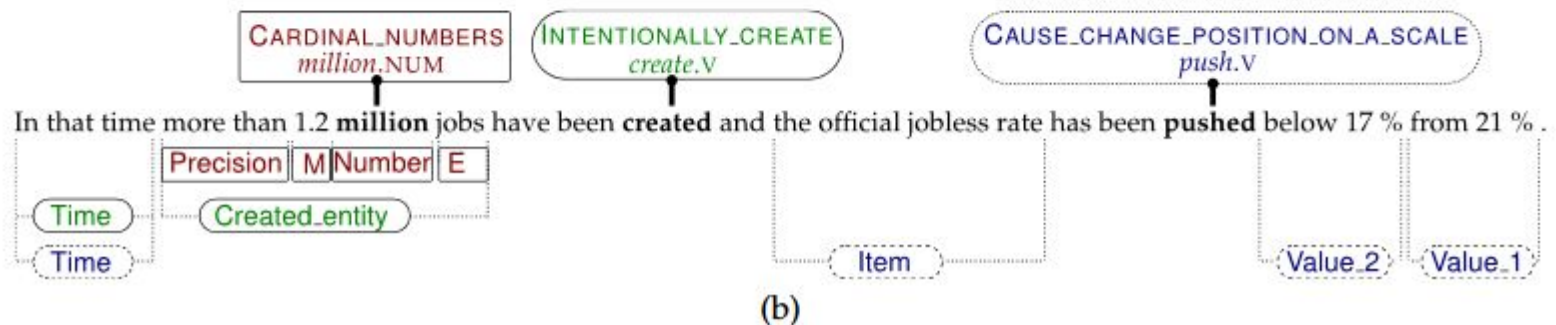
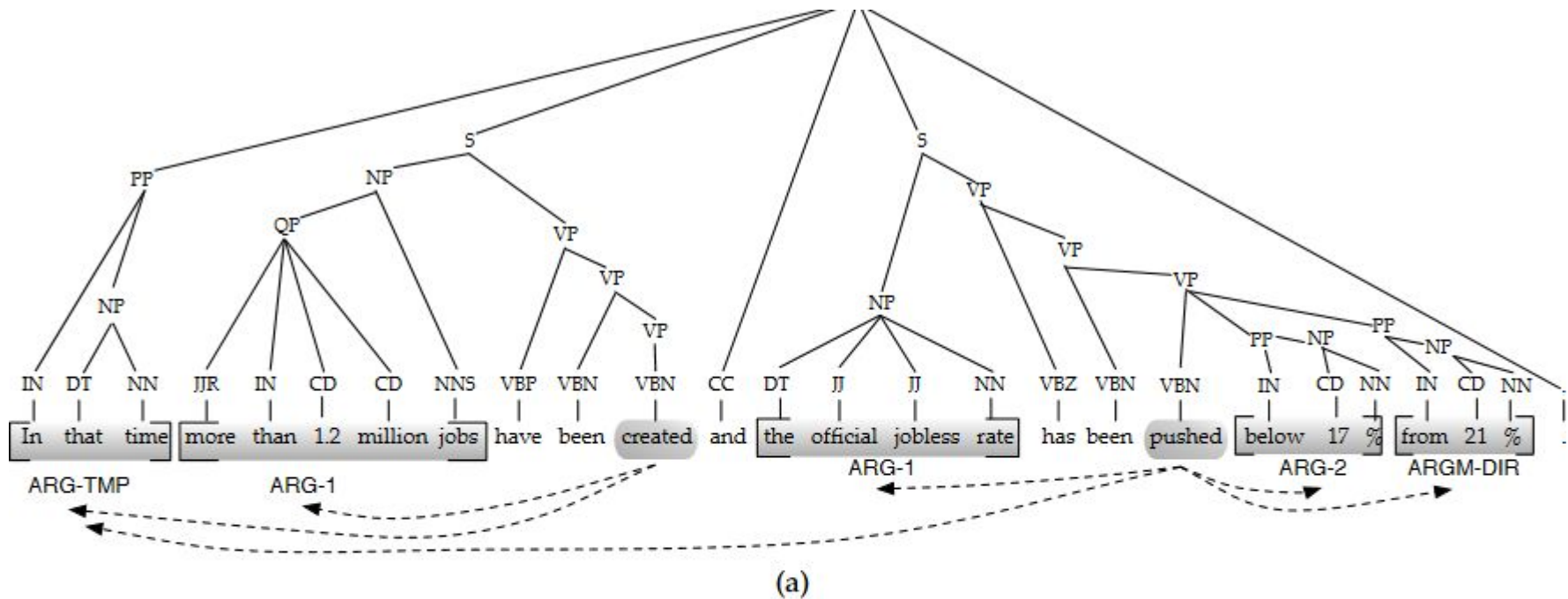
FrameNet

- Frames are not just for verbs!
- **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

FrameNet

- Includes inheritance and causation relationships among frames.
- Examples included, but little fully-annotated corpus data.

PropBank vs FrameNet



SemLink

- It would be really useful if these different resources were interconnected in a useful way.
- SemLink project is (was?) trying to do that
- Unified Verb Index (UVI) connects
 - PropBank
 - VerbNet
 - FrameNet
 - WordNet/OntoNotes

Semantic Role Labeling

- Input: sentence
- Output: for each **predicate***, labeled spans identifying each of its **arguments**.
- Example:
[_{agent} The batter] hit [_{patient} the ball] [_{time} yesterday]
- Somewhere between syntactic parsing and full-fledged compositional semantics.

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

But wait. How is this different from dependency parsing?

- Semantic role labeling
 - [_{agent} The batter] hit [_{patient} the ball] [_{time} yesterday]
- Dependency parsing
 - [_{subj} The batter] hit [_{obj} the ball] [_{mod} yesterday]

But wait. How is this different from dependency parsing?

- Semantic role labeling
 - [_{agent} The batter] hit [_{patient} the ball] [_{time} yesterday]
- Dependency parsing
 - [_{subj} The batter] hit [_{obj} the ball] [_{mod} yesterday]

□ These are not the same task.

□ Semantic role labeling is much harder.

Subject vs agent

- **Subject** is a grammatical relation
- **Agent** is a semantic role
- In English, a **subject** has these properties
 - It comes before the verb
 - If it is a pronoun, it is in nominative case (in a finite clause)
 - I/he/she/we/they hit the ball.
 - *Me/him/her/us/them hit the ball.
 - If the verb is in present tense, it agrees with the subject
 - She/he/it hits the ball.
 - I/we/they hit the ball.
 - *She/he/it hit the ball.
 - *I/we/they hits the ball.
 - I hit the ball.
 - I hit the balls.

Subject vs agent

- In the most **typical** sentences (for some definition of “typical”), the **agent** is the **subject**:
 - The batter hit the ball.
 - Chris opened the door.
 - The teacher gave books to the students.
- Sometimes the **agent** is **not** the subject:
 - The ball was hit by the batter.
 - The balls were hit by the batter.
- Sometimes the **subject** is **not** the agent:
 - The door opened.
 - The key opened the door.
 - The students were given books.
 - Books were given to the students.

Semantic Role Labeling

- Input: sentence
- Output: segmentation into roles, with labels
- Example from J&M II book:
 - [_{arg0} The Examiner] issued [_{arg1} a special edition] [_{argM-tmp} yesterday]
 - (In Propbank notation, **arg0** is proto-agent, **arg1** is proto-patient.)

Semantic Role Labeling: How It Works

- First, parse.
- For each predicate word in the parse:
 - For each node in the parse:
 - Classify** the node with respect to the predicate.

Yet Another Classification Problem!

- As before, there are many techniques (e.g., Naïve Bayes)
- Key: what features?
- (Or, use deep learning...)

Features for Semantic Role Labeling

- What is the predicate?
- Phrase type of the constituent
- Head word of the constituent, its POS
- Path in the parse tree from the constituent to the predicate
- Active or passive
- Is the phrase before or after the predicate?
- Subcategorization (\approx grammar rule) of the predicate

Feature example

- Example sentence:

[_{arg0} The Examiner] issued [_{arg1} a special edition] [_{argM-tmp} yesterday]

- Arg0 features:

issued, NP, Examiner, NNP, *path*, active, before, VP->VBD NP PP

Example *path*

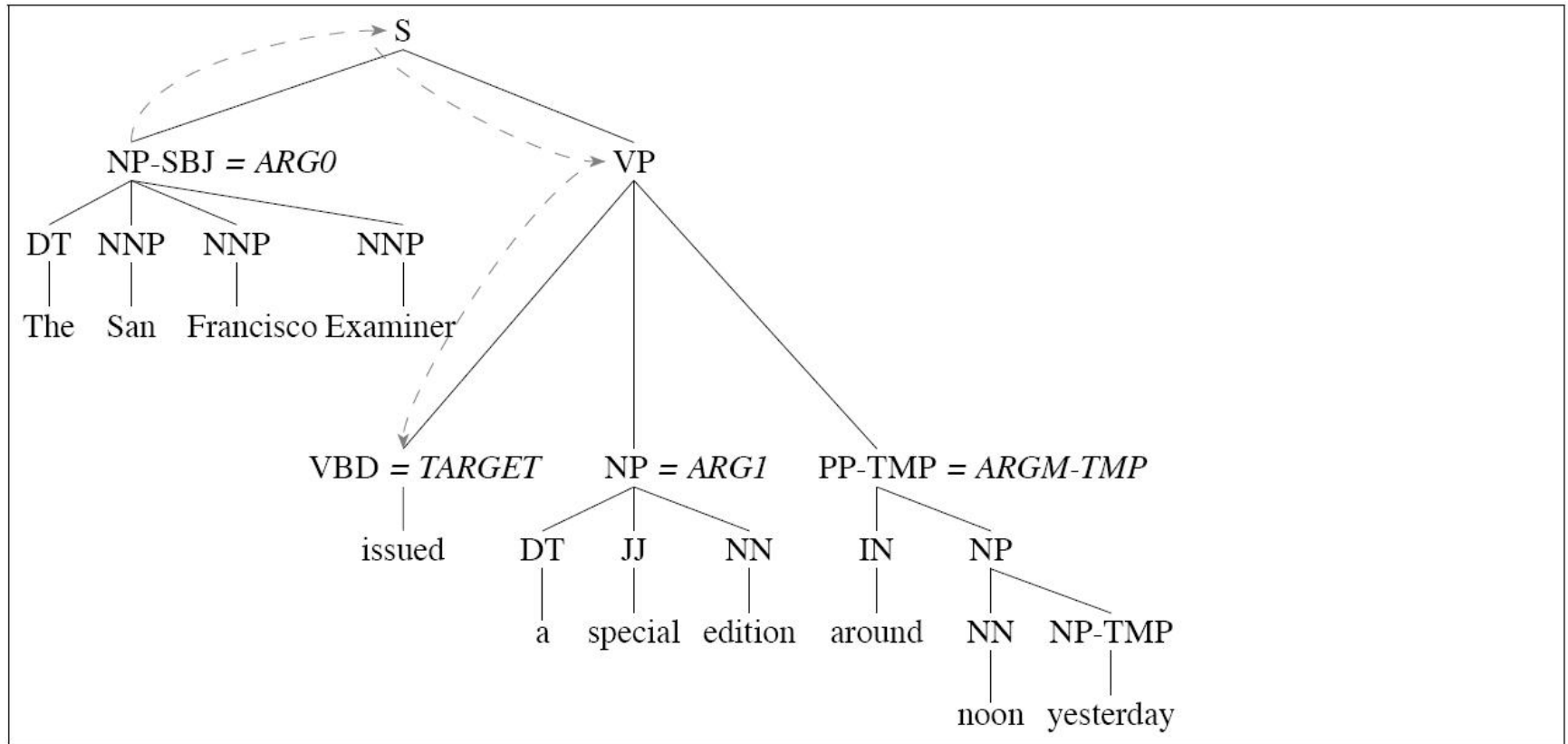


Figure 20.16: Parse tree for a PropBank sentence, showing the PropBank argument labels. The dotted line shows the **path** feature **NP ↑ S ↓ VP ↓ VBD** for **ARG0**, the NP-SBJ constituent *The San Francisco Examiner*.

Additional Issues

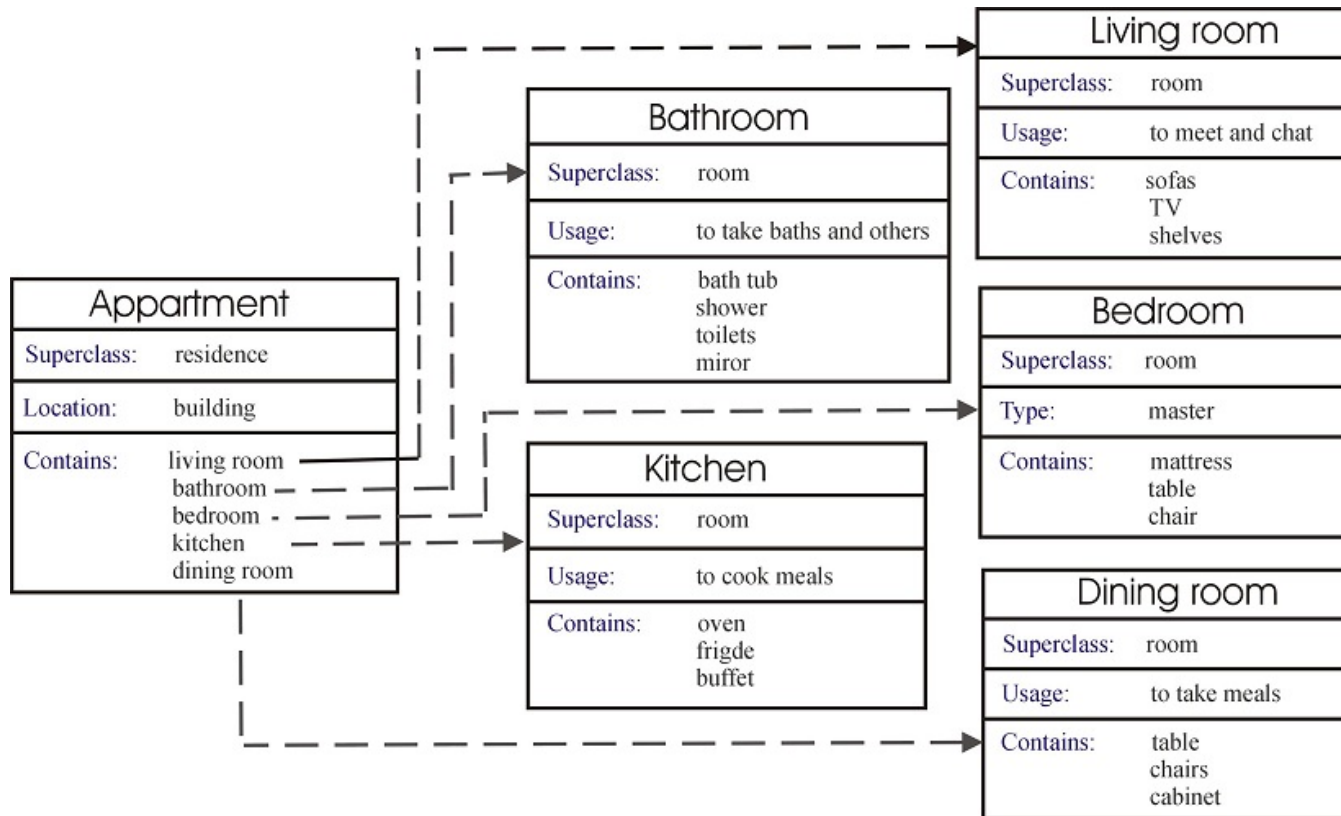
- Initial filtering of non-arguments
- Using chunking or partial parsing instead of full parsing
- Enforcing consistency (e.g., non-overlap, only one arg0)
- Phrasal verbs, support verbs/light verbs
 - *take a nap*: verb *take* is syntactic head of VP, but predicate is **napping**, not **taking**

Shallow approaches to deep problems

- For many problems:
 - Shallow approaches much easier to develop
 - As in, *possible at all* for unlimited vocabularies
 - Not wonderful performance yet
 - Sometimes claimed to help a particular system, but often doesn't seem to help
 - Definitions are not crisp
 - There clearly is *something* there, but the granularity of the distinctions is very problematic
- Deep Learning will fix everything?

Questions?

Frame based Knowledge Rep.



- Organize relations around concepts
- Lexical semantics vs. general semantics?
- Equivalent to (or weaker than) FOPC

– Image from *futurehumanevolution.com*

Similarities to WSD

- Pick correct choice from N ambiguous possibilities
- Definitions are not crisp
- Need to pick a labelling scheme, corpus
 - Choices have big effect on performance, usefulness

Shallow approaches to deep problems

- For both WSD and SRL:
 - Shallow approaches much easier to develop
 - As in, *possible at all* for unlimited vocabularies
 - Not wonderful performance yet
 - Sometimes claimed to help a particular system, but often doesn't seem to help
 - Definitions are not crisp
 - There clearly is *something* there, but the granularity of the distinctions very problematic
- Deep Learning will fix everything?

Two datasets, two systems

- Example from book uses PropBank
- Locally-developed system SEMAFOR works on SemEval problem, based on FrameNet

SEMAFOR

- A FrameNet-based semantic role labeling system developed within Noah's research group
 - It uses a dependency parser (the MST Parser) for preprocessing
 - Identifies and disambiguates predicates; then identifies and disambiguates each predicate's arguments
 - Trained on frame-annotated corpora from SemEval 2007/2010 tasks. Domains: weapons reports, travel guides, news, Sherlock Holmes stories.

Noun compounds

- A very flexible (*productive*) syntactic structure in English
 - The noun noun pattern is easily applied to name new concepts (**Web browser**) and to disambiguate known concepts (**fire truck**)
 - Can also combine two NPs: incumbent protection plan, [**undergraduate** [**computer science**] [**lecture course**]]
 - Sometimes creates ambiguity, esp. in writing where there is no phonological stress: *Spanish teacher*
 - People are creative about interpreting even nonsensical compounds
- Also present in many other languages, sometimes with special morphology
 - German is infamous for loving to merge words into compounds. e.g. *Fremdsprachenkenntnisse*, ‘knowledge of foreign languages’

Noun compounds

- SemEval 2007 task: **Classification of Semantic Relations between Nominals**
 - *7 predefined relation types*
 1. Cause-Effect: flu virus
 2. Instrument-User: laser printer
 3. Product-Producer: honeybee
 4. Origin-Entity: rye whiskey
 5. Purpose-Tool: soup pot
 6. Part-Whole: car wheel
 7. Content-Container: apple basket
- <http://nlp.cs.swarthmore.edu/semeval/tasks/task04/description.shtml>

Noun compounds

- SemEval 2010 task: **Noun compound interpretation using paraphrasing verbs**
 - A dataset was compiled in which subjects were presented with a noun compound and asked to provide a verb describing the relationship
 - ***nut bread*** elicited: contain(21); include(10); be made with(9); have(8); be made from(5); use(3); be made using(3); feature(2); be filled with(2); taste like(2); be made of(2); come from(2); consist of(2); hold(1); be composed of(1); be blended with(1); be created out of(1); encapsulate(1); diffuse(1); be created with(1); be flavored with(1)
- <http://semeval2.fbk.eu/semeval2.php?location=tasks#T12>

Thesaurus/dictionary-based similarity measures

$$\text{sim}_{\text{path}}(c_1, c_2) = -\log \text{pathlen}(c_1, c_2)$$

$$\text{sim}_{\text{Resnik}}(c_1, c_2) = -\log P(\text{LCS}(c_1, c_2))$$

$$\text{sim}_{\text{Lin}}(c_1, c_2) = \frac{2 \times \log P(\text{LCS}(c_1, c_2))}{\log P(c_1) + \log P(c_2)}$$

$$\text{sim}_{\text{jc}}(c_1, c_2) = \frac{1}{2 \times \log P(\text{LCS}(c_1, c_2)) - (\log P(c_1) + \log P(c_2))}$$

$$\text{sim}_{\text{eLesk}}(c_1, c_2) = \sum_{r, q \in \text{RELS}} \text{overlap}(\text{gloss}(r(c_1)), \text{gloss}(q(c_2)))$$

