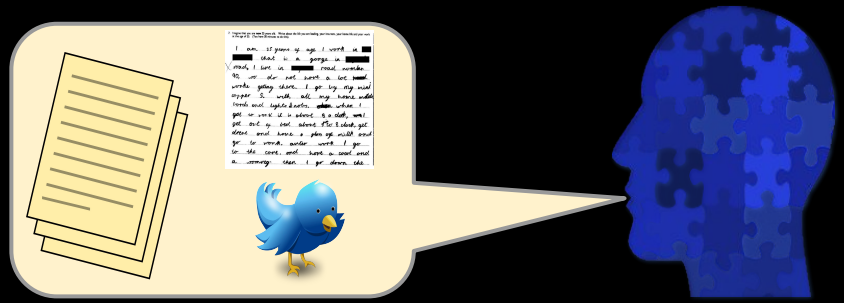
Semantics Avalanche:

Word Sense Disambiguation, Dependency Parsing, Semantic Role Labeling/Verb Predicates.

CSE392 - Spring 2019
Special Topic in CS

Tasks



- Word Sense Disambiguation
- Dependency Parsing
- Semantic Role Labeling

how?

- Traditionally:
  - Probabilistic models
  - Discriminant Learning: e.g. Logistic Regression
  - Transition-Based Parsing
  - Graph-Based Parsing
- Current:
  Recurrent Neural Network

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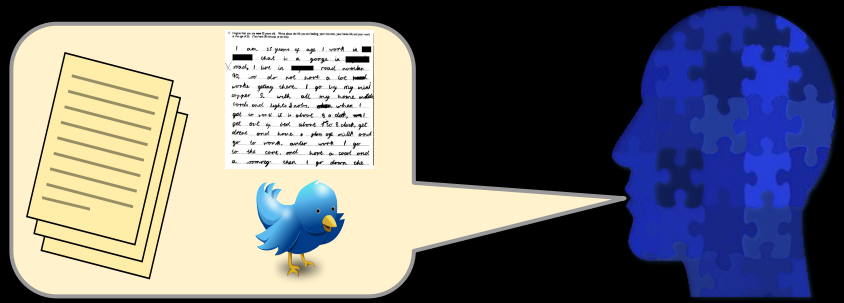

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Preliminaries (From SLP, Jurafsky et al., 2013)

Terminology: lemma and wordform

- A **lemma** or **citation form**
  - Same stem, part of speech, rough semantics
- A **wordform**
  - The inflected word as it appears in text

Wordform	Lemma
banks	bank
sung	sing
duermes	dormir

Preliminaries (From SLP, Jurafsky et al., 2013)

Lemmas have senses

- One lemma "bank" can have many meanings:

Sense 1: • …a **bank**[1] can hold the investments in a custodial account…

Sense 2: • "…as agriculture burgeons on the east **bank**[2] the river will shrink even more"

- **Sense** (or **word sense**)
  - A discrete representation of an aspect of a word's meaning.
- The lemma **bank** here has two senses

Preliminaries (From SLP, Jurafsky et al., 2013)

Homonymy

Homonyms: words that share a form but have unrelated, distinct meanings:

- $bank_1$: financial institution, $bank_2$: sloping land
- bat_1: club for hitting a ball, bat_2: nocturnal flying mammal

1. Homographs (bank/bank, bat/bat)
2. Homophones:
    1. Write and right
    2. Piece and peace

Preliminaries (From SLP, Jurafsky et al., 2013)

Homonymy causes problems for NLP applications

- Information retrieval
  - "bat care"
- Machine Translation
  - bat: murciélago (animal) or bate (for baseball)
- Text-to-Speech
  - bass (stringed instrument) vs. bass (fish)

Word Sense Disambiguation

He put the **port** on the ship.

He walked along the **port** of the steamer.

He walked along the **port** next to the steamer.

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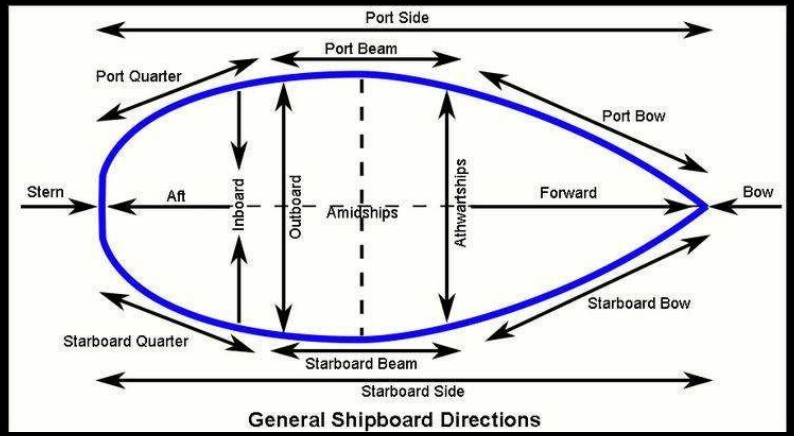

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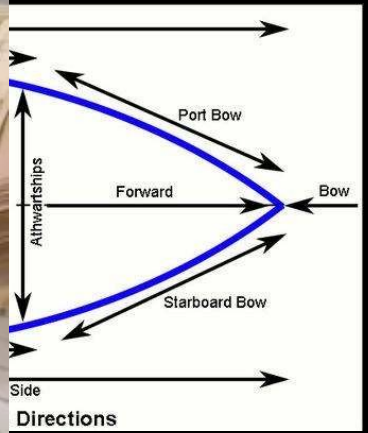

Word Sense Disambiguation

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port.n.1 (a place (seaport or airport) where people and merchandise can enter or leave a country)

port.n.2 port wine (sweet dark-red dessert wine originally from Portugal)

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interface, **port**.n.5 ((computer science) computer circuit consisting of the hardware and associated circuitry that links one device with another (especially a computer and a hard disk drive or other peripherals))

Word Sense Disambiguation

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As a verb…

1. **port** (put or turn on the left side, of a ship) *"port the helm"*
2. **port** (bring to port) *"the captain ported the ship at night"*
3. **port** (land at or reach a port) *"The ship finally ported"*
4. **port** (turn or go to the port or left side, of a ship) *"The big ship was slowly porting"*
5. **port** (carry, bear, convey, or bring) *"The small canoe could be ported easily"*
6. **port** (carry or hold with both hands diagonally across the body, especially of weapons) *"port a rifle"*
7. **port** (drink port) *"We were porting all in the club after dinner"*
8. **port** (modify (software) for use on a different machine or platform)

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Word Sense Disambiguation: Approaches

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1. Bag of context / collocations
2. Surrounding window
3. Lesk algorithm
   (use word definitions)
4. Selectors
5. Context Embeddings

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An Approach to WSD

https://prezi.com/m86pd1zbe_fy/?utm_campaign=share&utm_medium=copy

Covers a few approaches plus more background on “lexical semantics” in general.

Supervised Selectors

	base	w/ sels	*mfs*	*tests*
noun	87.9	**91.7**	*80.9*	*2559*
verb	83.3	**83.7**	*76.5*	*2292*
both	85.7	**87.9**	*78.8*	*4851*

Accuracy over SemEval-2007: Task 17.

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Accuracy over SemEval-2007: Task 17.

	base	w/ sels	*mfs*	*tests*
noun	68.5	**72.1**	*54.1*	*1766*
verb	72.0	*72.4*	*57.9*	*1927*
adjective	49.4	**53.4**	*54.7*	*148*
all	69.4	**71.5**	*56.1*	*3841*

Accuracy over seneval-3 Lexical Sample.
(fine-grained senses compared to SemEval)

Why Are Selectors Effective?

Sets of selectors tend to vary extensively by word sense:

bill-n.1	*bill-n.2*	*bill-n.3*
bill	bill	**market**
it	**staff**	system
legislation	system	**paper**
system	**money**	**note**
program	**time**	bill
law	it	**bond**
plan	**tax**	**stock**
you	**work**	**debt**
measure	**rent**	**rate**
project	**tuition**	**report**

occur-v.1	*occur-v.2*	*occur-v.3*
be	go	go
happen	get	**look**
occur	Come	**break**
go	have	**remove**
take	**try**	**find**
work	**lead**	get
come	**listen**	**place**
see	work	**keep**
have	be	**stick**
change	**belong**	**stop**

- *Polls show wide, generalized support for some vague concept of service, but the **bill** now under discussion lacks any passionate public backing.*
  training set never contained: “but the _ now under”
- *… in his lecture, refers to the “startling experience which almost every person confesses, that particular passages of conversation and action have **occurred** to him in the same order before, whether dreaming or waking …*
  small context is contradictory:
  “action have occurred” => occur-v.1 (“to happen or take place”)
  “occurred to him” => occur-v.2 (“to come to mind”)

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occur-v.1	*occur-v.2*	*occur-v.3*
be	go	go
happen	get	**look**
occur	Come	**break**
go	have	**remove**
take	**try**	**find**
work	**lead**	get
come	**listen**	**place**
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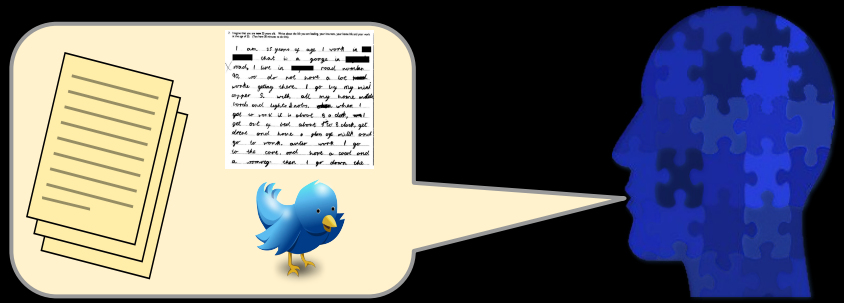

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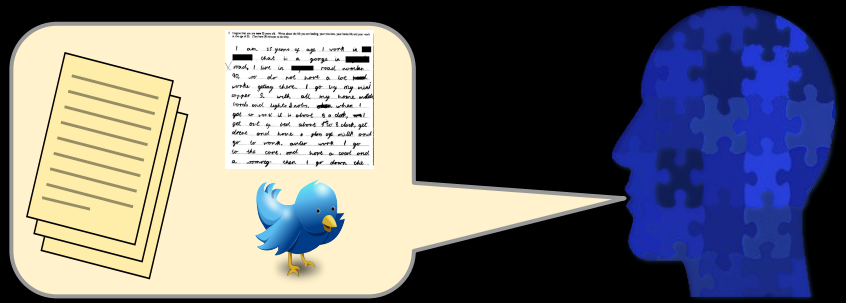

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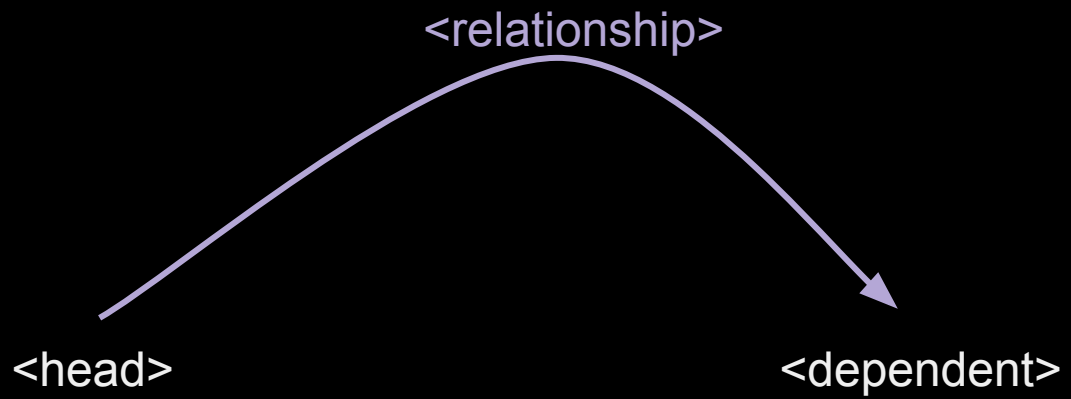
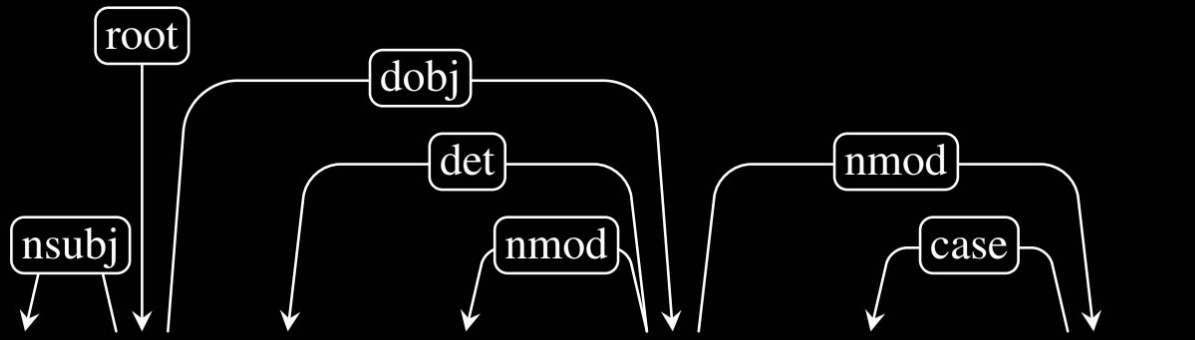
Dependency Parsing



dependency -- binary asymmetrical relation between tokens

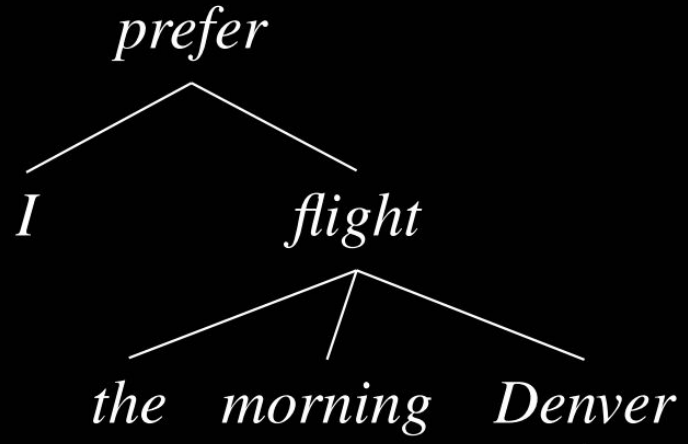
Dependency Parsing

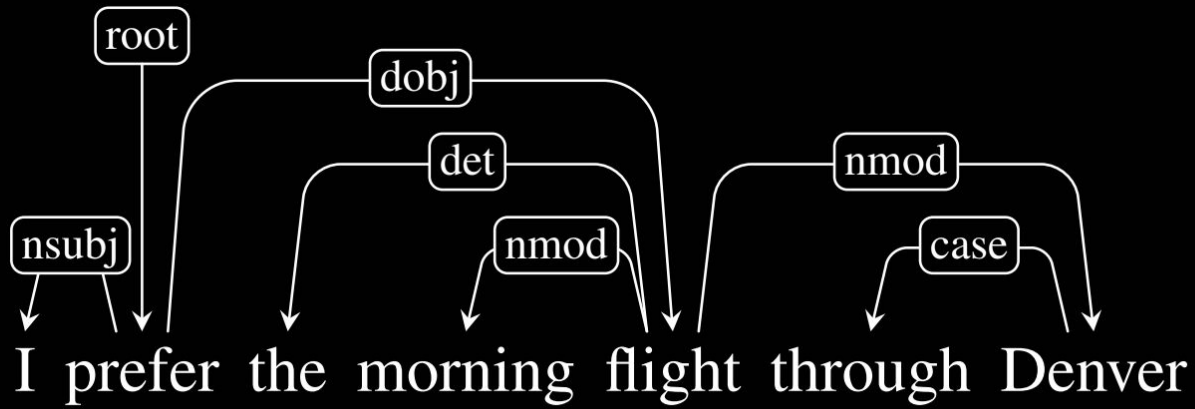


(13.1)

(From SLP 3rd ed., Jurafsky and Martin 2018)

Dependency Parsing





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Dependency Parsing

Clausal Argument Relations	Description
NSUBJ	Nominal subject
DOBJ	Direct object
IOBJ	Indirect object
CCOMP	Clausal complement
XCOMP	Open clausal complement
Nominal Modifier Relations	**Description**
NMOD	Nominal modifier
AMOD	Adjectival modifier
NUMMOD	Numeric modifier
APPOS	Appositional modifier
DET	Determiner
CASE	Prepositions, postpositions and other case markers
Other Notable Relations	**Description**
CONJ	Conjunct
CC	Coordinating conjunction

Figure 13.2 Selected dependency relations from the Universal Dependency set. (de Marneffe et al., 2014)

(From SLP 3rd ed., Jurafsky and Martin 2018)

Dependency Parsing

Relation	Examples with *head* and **dependent**
NSUBJ	**United** *canceled* the flight.
DOBJ	United *diverted* the **flight** to Reno.
	We *booked* her the first **flight** to Miami.
IOBJ	We *booked* **her** the flight to Miami.
NMOD	We took the **morning** *flight*.
AMOD	Book the **cheapest** *flight*.
NUMMOD	Before the storm JetBlue canceled **1000** *flights*.
APPOS	*United*, a **unit** of UAL, matched the fares.
DET	**The** *flight* was canceled.
	Which *flight* was delayed?
CONJ	We *flew* to Denver and **drove** to Steamboat.
CC	We flew to Denver **and** *drove* to Steamboat.
CASE	Book the flight **through** *Houston*.

Figure 13.3 Examples of core Universal Dependency relations.

(From SLP 3rd ed., Jurafsky and Martin 2018)

Dependency Parsing

Verbal Predicate -- like a function, takes arguments: “United” and “the flight” in this case.

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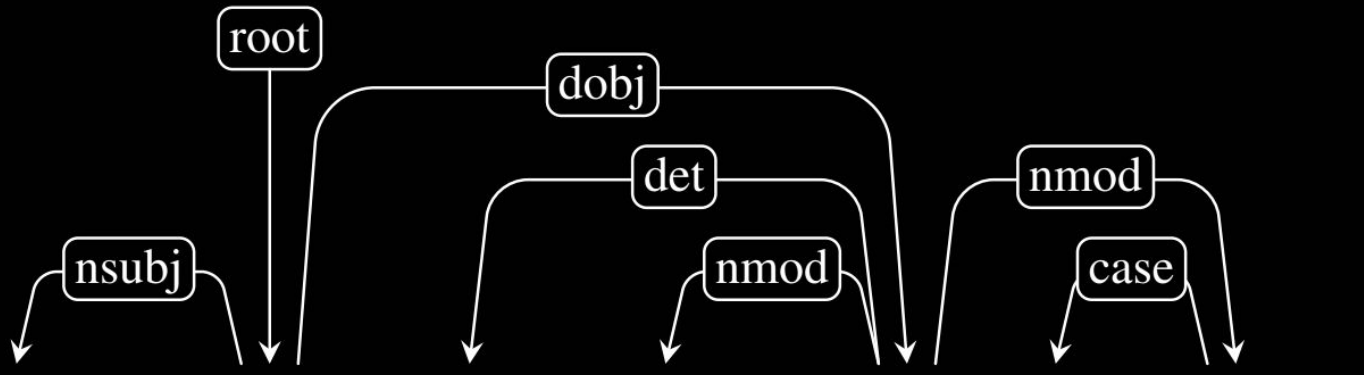
Dependency Parsing -- Verbal Predicates



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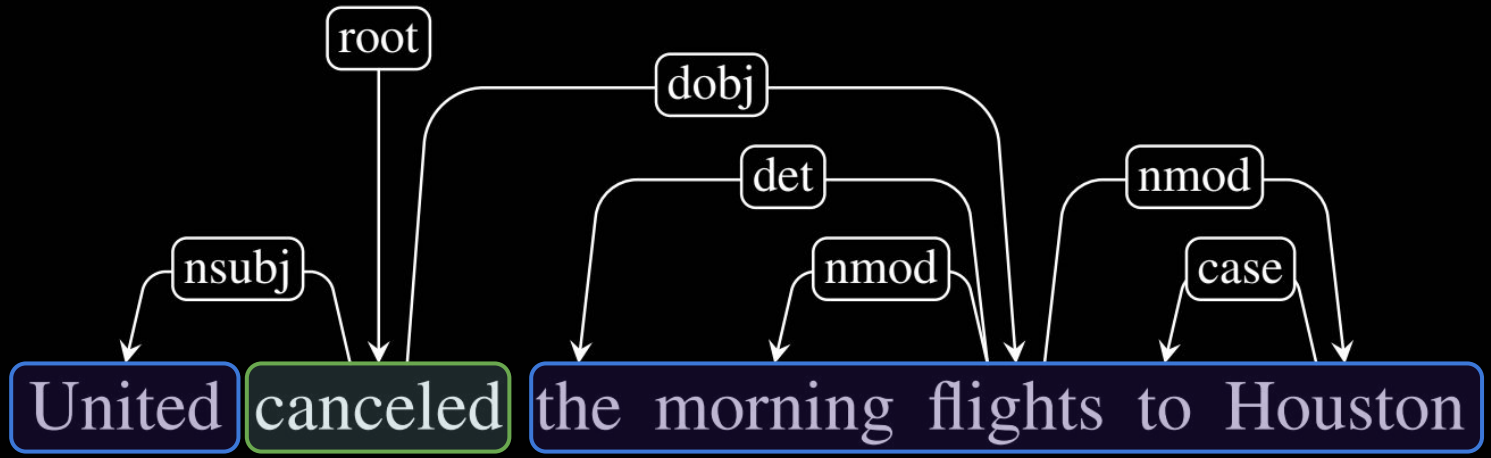
Dependency Parsing -- Verbal Predicates

cancel(“United”, “the morning flights to Houston”)



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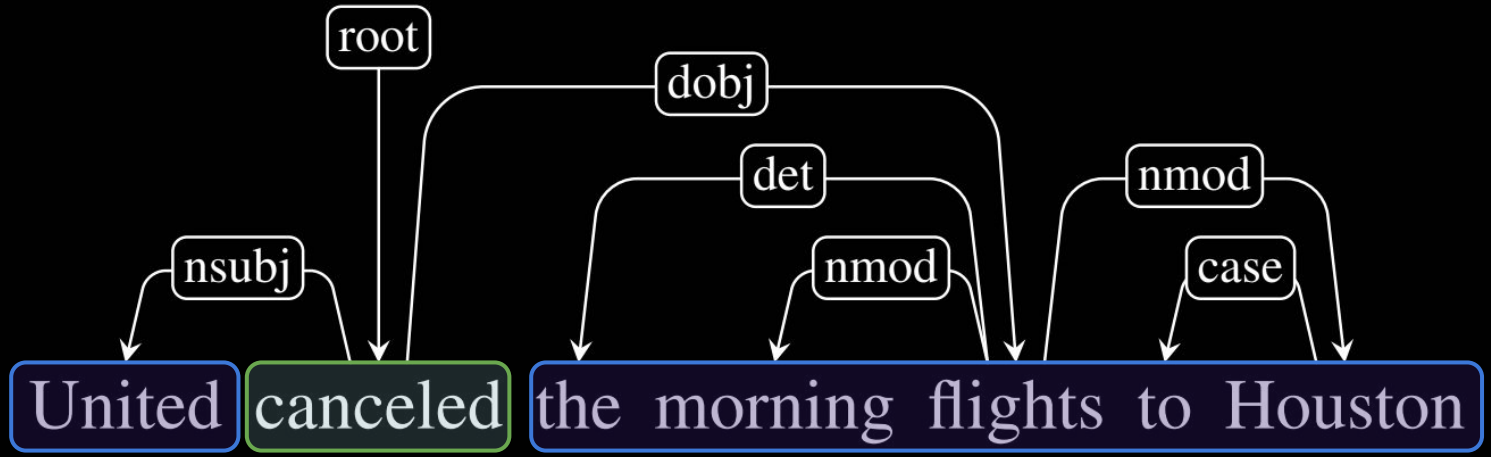
Dependency Parsing -- Verbal Predicates

to_call_off(“United”, “the morning flights to Houston”)



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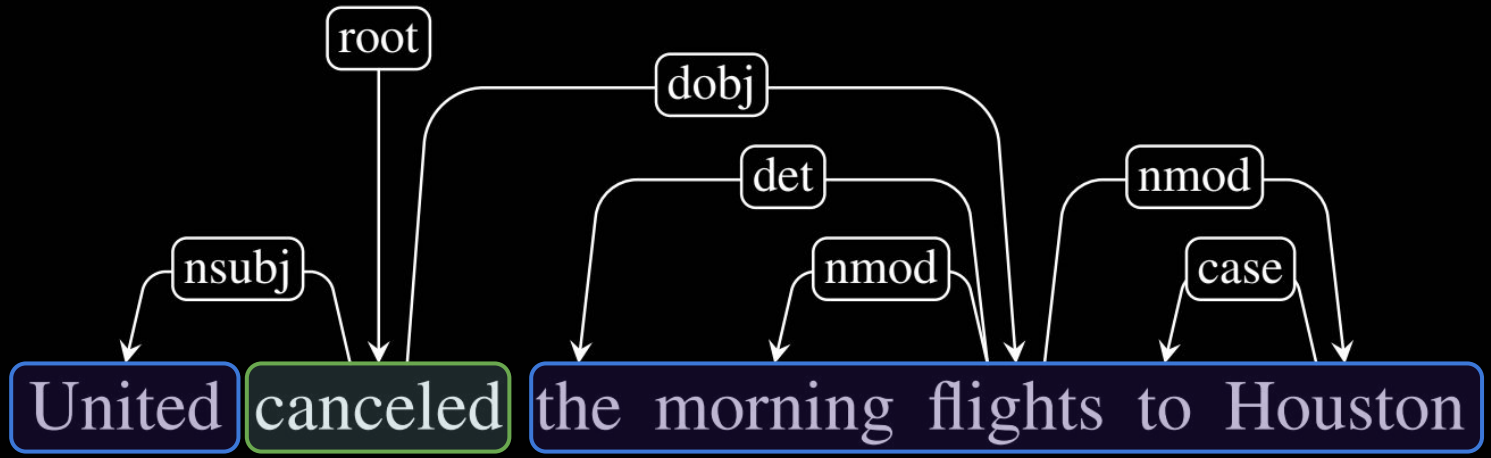
Dependency Parsing -- Verbal Predicates
Semantic Roles

to_call_off(agent="United", event="the morning flights to Houston")



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Dependency Parsing -- How to Represent?

A Graph: G = [(V1, A1), (V1, A2), …] (vertices and arcs)

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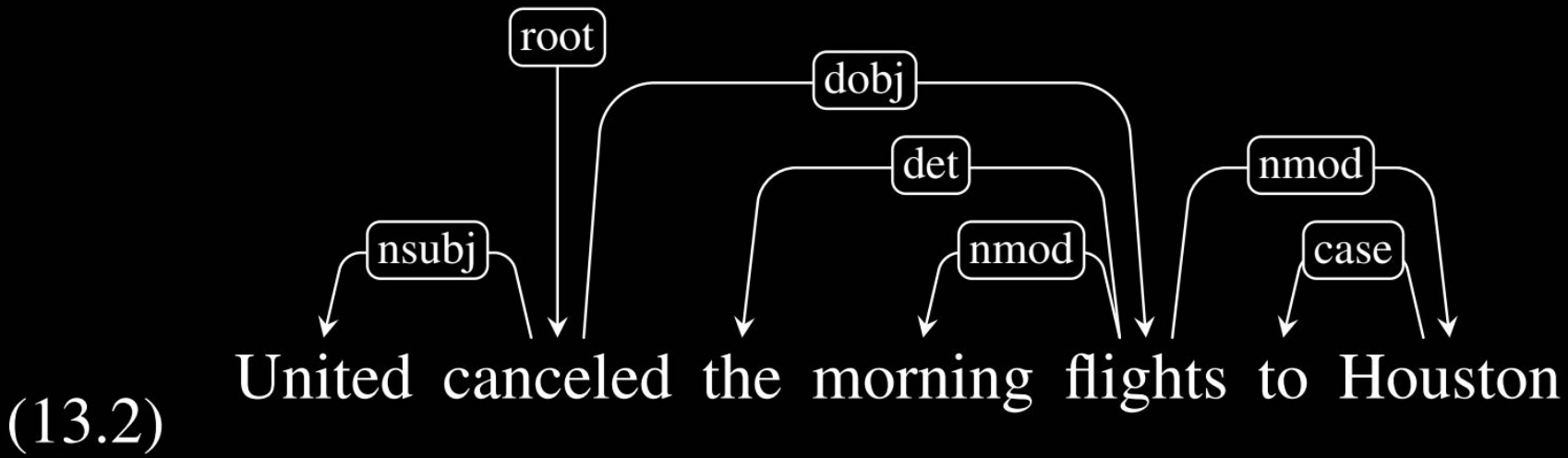

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Transition-based Dependency Parsing

Inspired by “Shift-reduce parsing” -- process one word at a time, using a stack to keep some sort of memory.

Elements:

- *S*: stack, initialized with “ROOT”
- *B*: input buffer, initialized with tokens (w1, w2, ….) of sentence
- *A:* set of dependency arcs, initialized empty
- *T:* Actions, given *wi* (next token in stack)

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- *B*: input buffer, initialized with tokens (w1, w2, ….) of sentence
- *a:* set of dependency arcs, initialized empty
- Actions, given *wi* (next token in stack)
  - *shift*(*B,S*): move w from *B* to *S*
  - *left-arc(S,A):* make top of stack **head** of next item: add to A; remove dependent from stack
  - *right-arc(S,A):* make top of stack **dependent** of next item: add to A; remove dep from stack

Using discriminative classifiers (i.e. logistic regression) to make decisions.

Transition-based Dependency Parsing

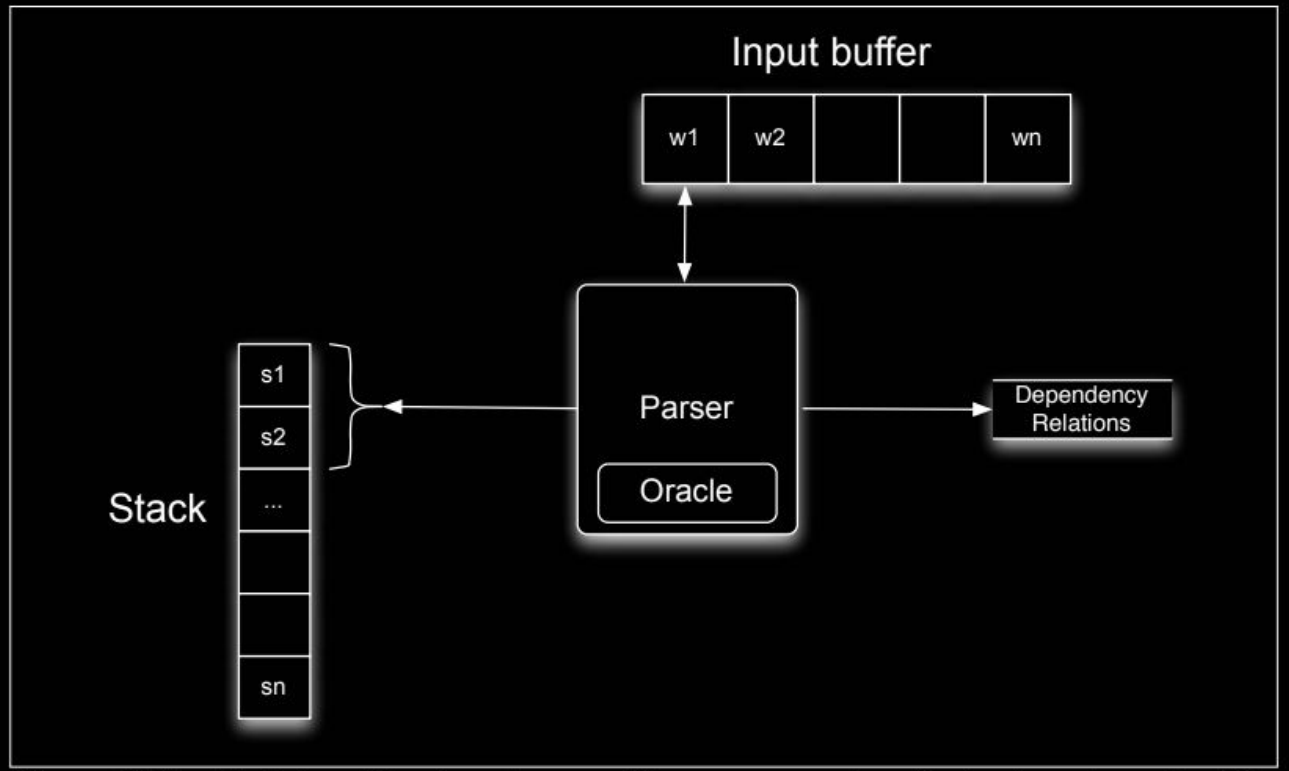


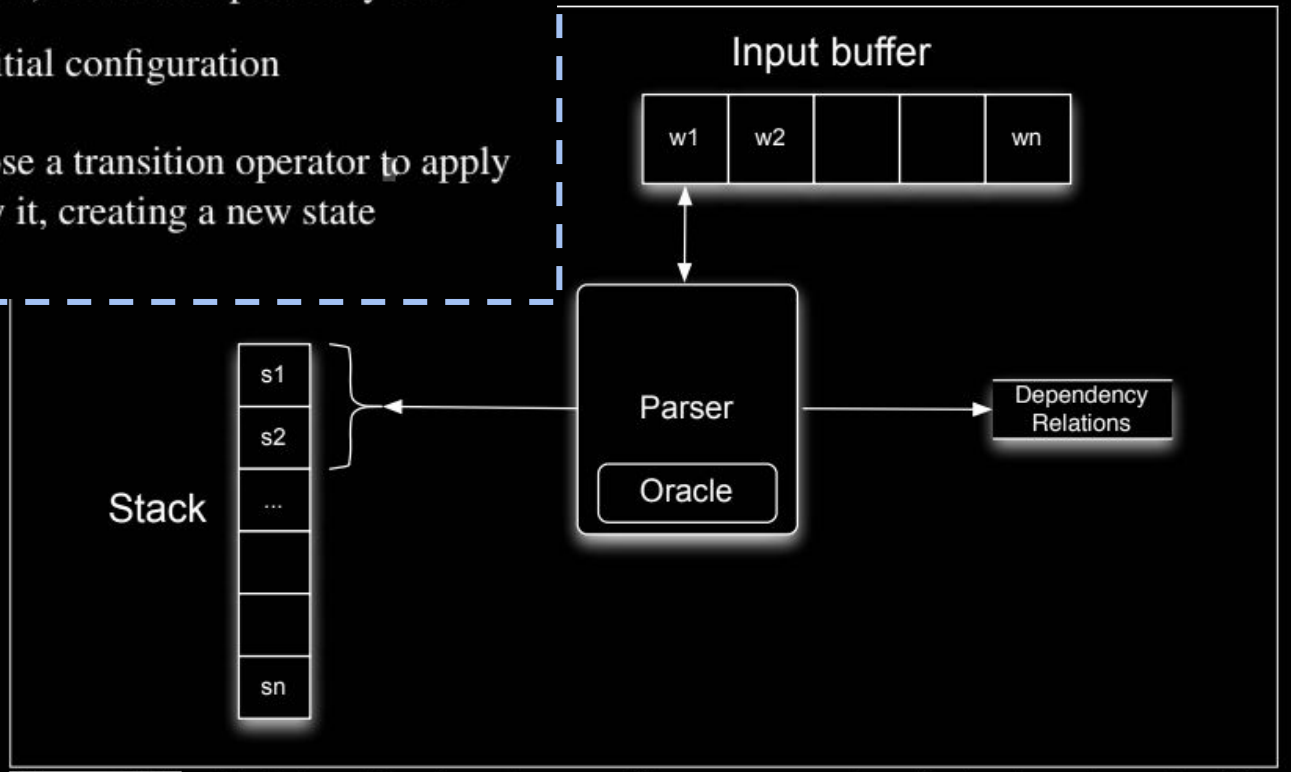
Figure 13.5 Basic transition-based parser. The parser examines the top two elements of the stack and selects an action based on consulting an oracle that examines the current configuration.

(From SLP 3rd ed., Jurafsky and Martin 2018)

Transition-based Dependency Parsing

```
function DEPENDENCYPARSE(words) returns dependency tree

  state ← {[root], [words], [] }  ; initial configuration
  while state not final
    t ← ORACLE(state)             ; choose a transition operator to apply
    state ← APPLY(t, state)       ; apply it, creating a new state
  return state
```



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(13.5) Book me the morning flight

Let's consider the state of the configuration at Step 2, after the word *me* has been pushed onto the stack.

Stack	Word List	Relations
[root, book, me]	[the, morning, flight]	

The correct operator to apply here is RIGHTARC which assigns *book* as the head of *me* and pops *me* from the stack resulting in the following configuration.

Stack	Word List	Relations
[root, book]	[the, morning, flight]	(book → me)

(From SLP 3rd ed., Jurafsky and Martin 2018)

Transition-based Dependency Parsing

Step	Stack	Word List	Action	Relation Added
0	[root]	[book, me, the, morning, flight]	SHIFT	
1	[root, book]	[me, the, morning, flight]	SHIFT	
2	[root, book, me]	[the, morning, flight]	RIGHTARC	(book → me)
3	[root, book]	[the, morning, flight]	SHIFT	
4	[root, book, the]	[morning, flight]	SHIFT	
5	[root, book, the, morning]	[flight]	SHIFT	
6	[root, book, the, morning, flight]	[]	LEFTARC	(morning ← flight)
7	[root, book, the, flight]	[]	LEFTARC	(the ← flight)
8	[root, book, flight]	[]	RIGHTARC	(book → flight)
9	[root, book]	[]	RIGHTARC	(root → book)
10	[root]	[]	Done	

Figure 13.7 Trace of a transition-based parse.

(From SLP 3rd ed., Jurafsky and Martin 2018)

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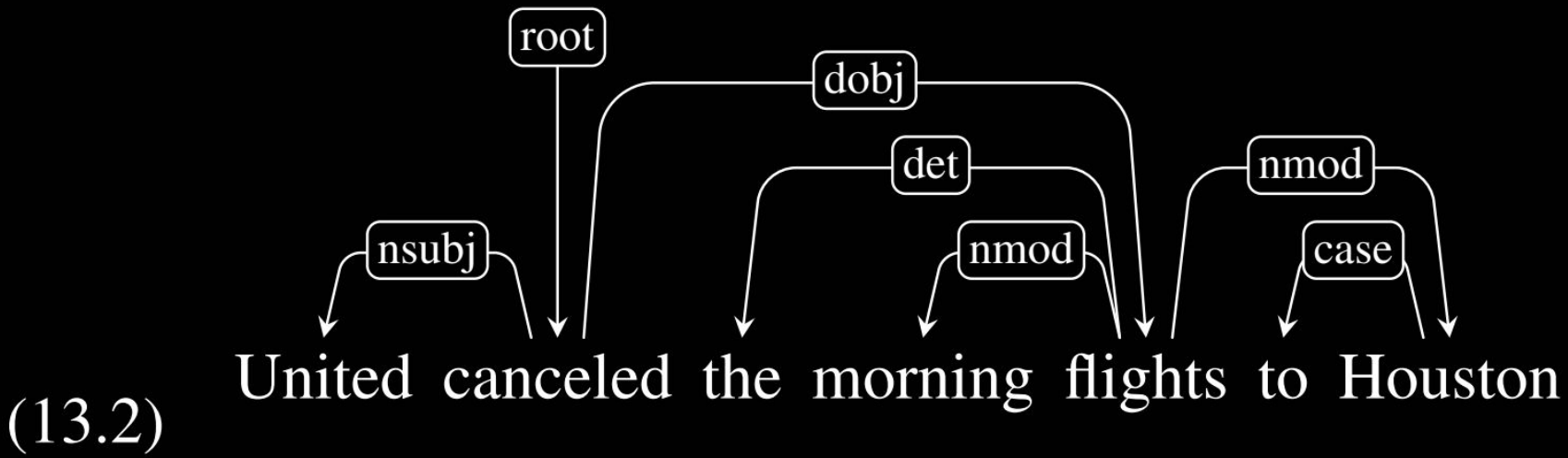

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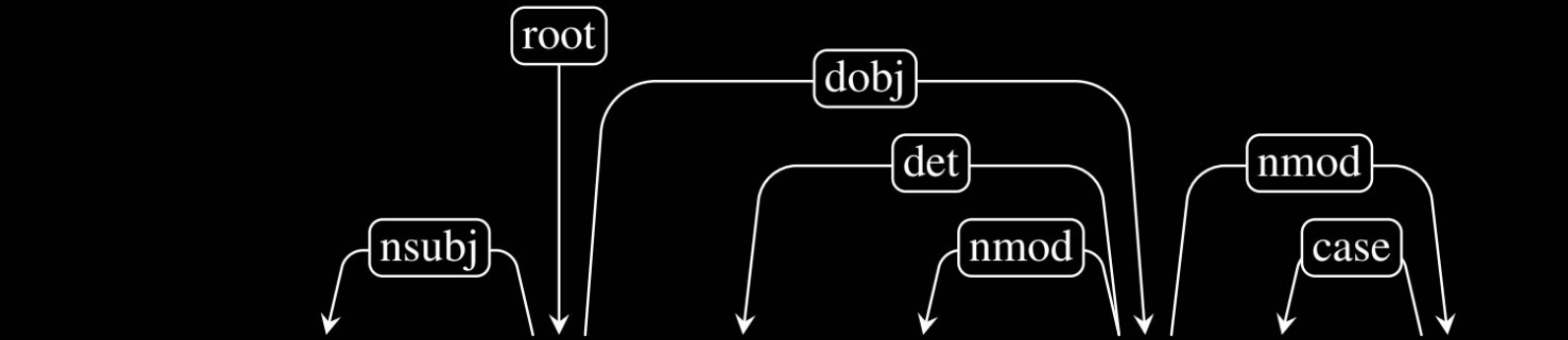
Projectivity: Given head, dependent; for every word between head and dependent there exists a path from head to that word



(13.2)

(From SLP 3rd ed., Jurafsky and Martin 2018)

Dependency Parsing -- How to Represent?

A Graph: G = [(V1, A1), (V1, A2), …] (vertices and arcs)

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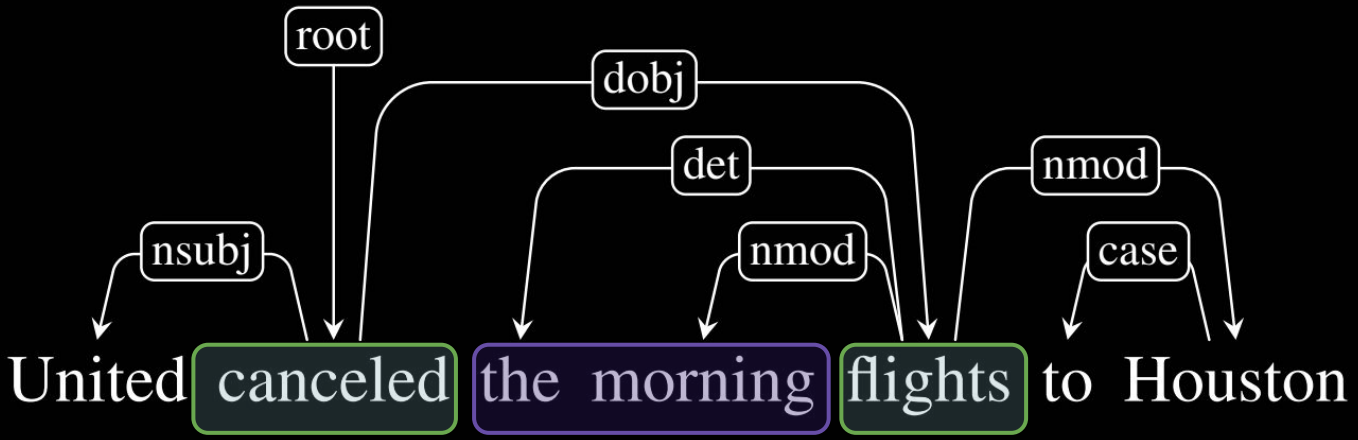

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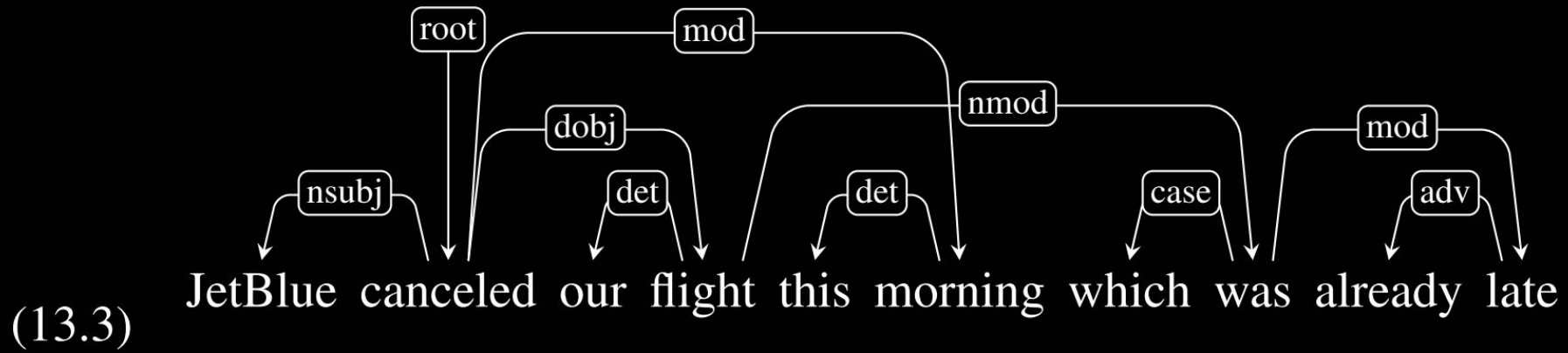

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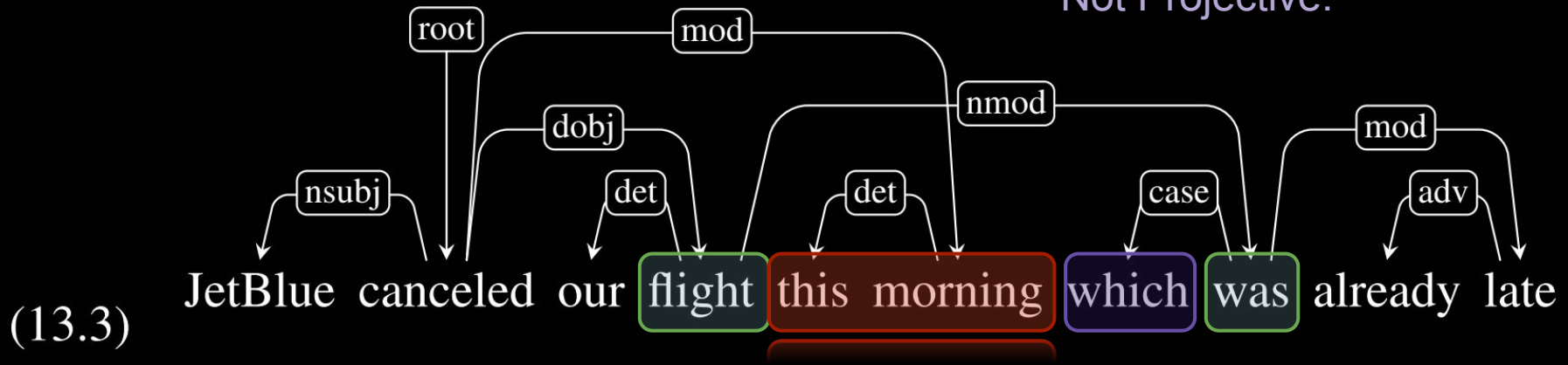

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Why do we care? Dependency trees from Context-Free Grammars are guaranteed to be projective; Thus, transition based techniques are certain to have errors occasionally on non-projective dependency graphs.

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Graph-based Approaches

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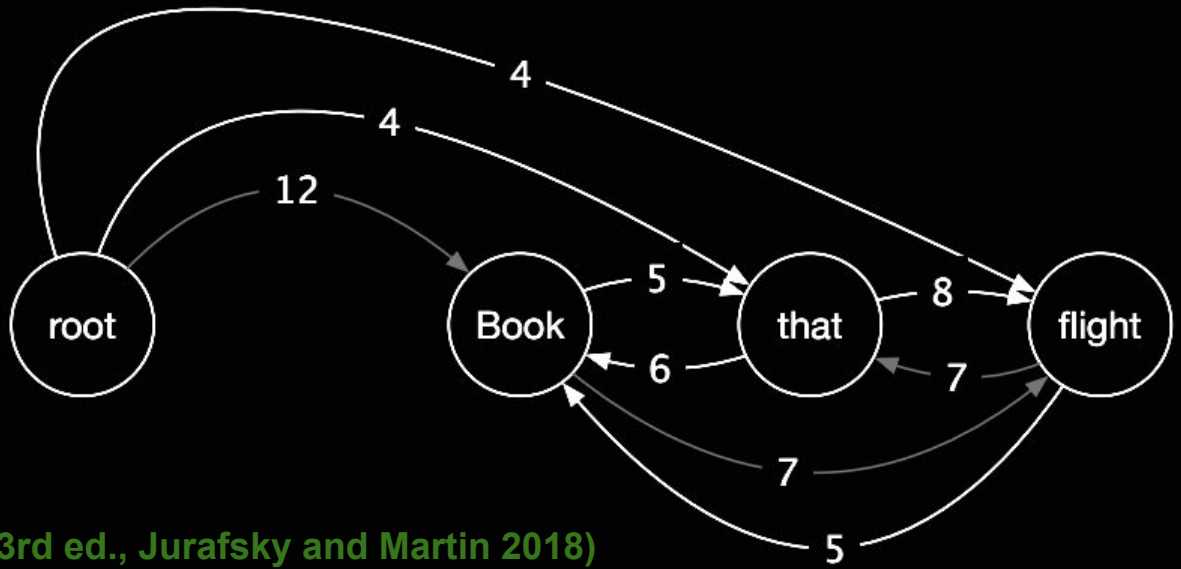

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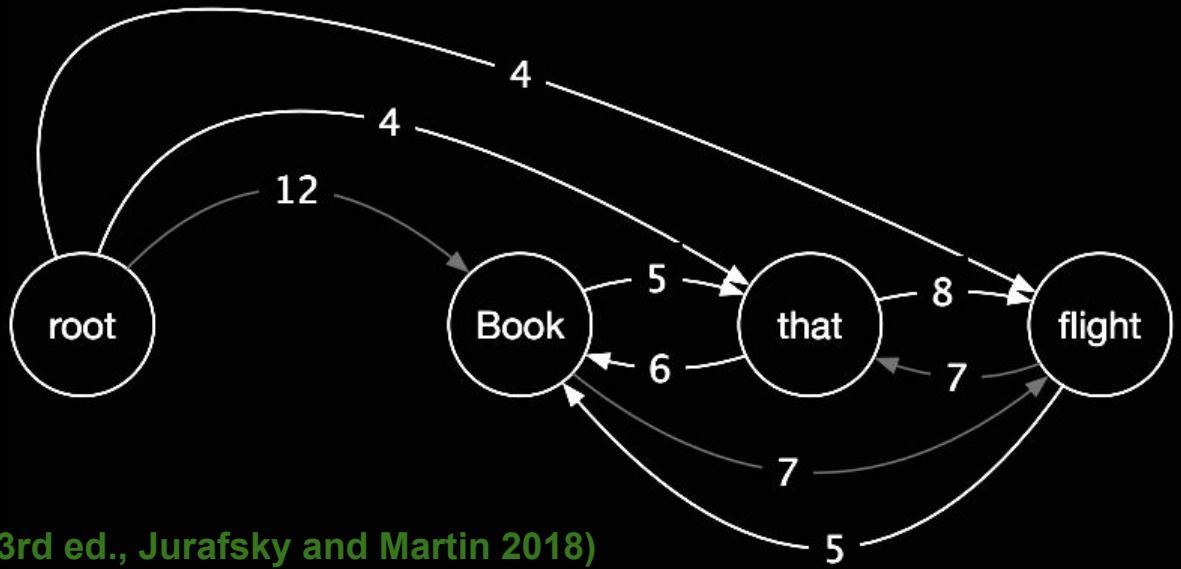

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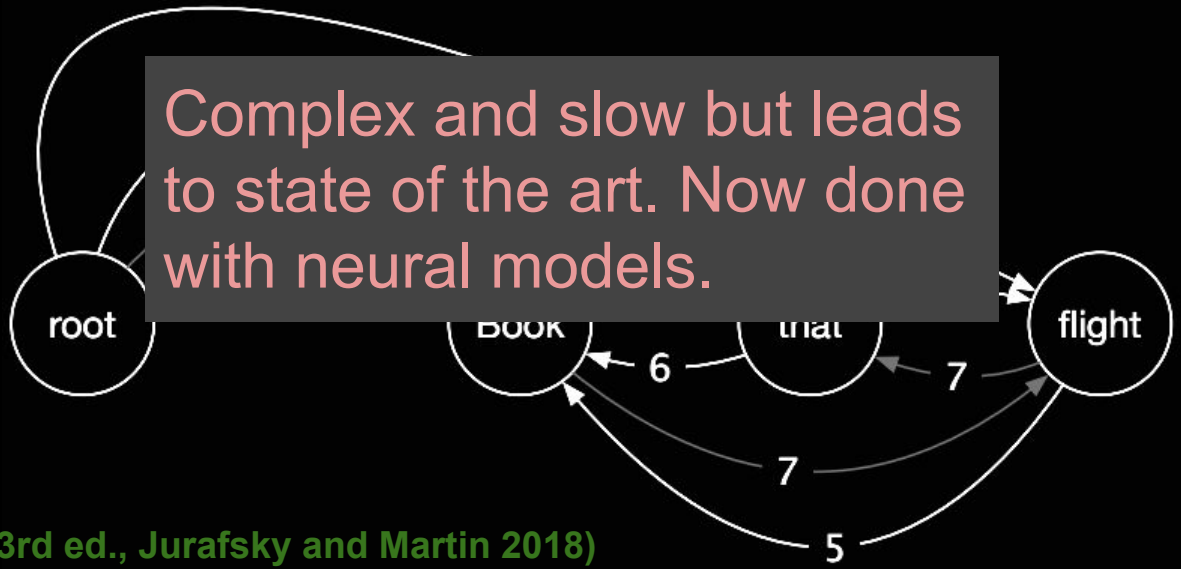
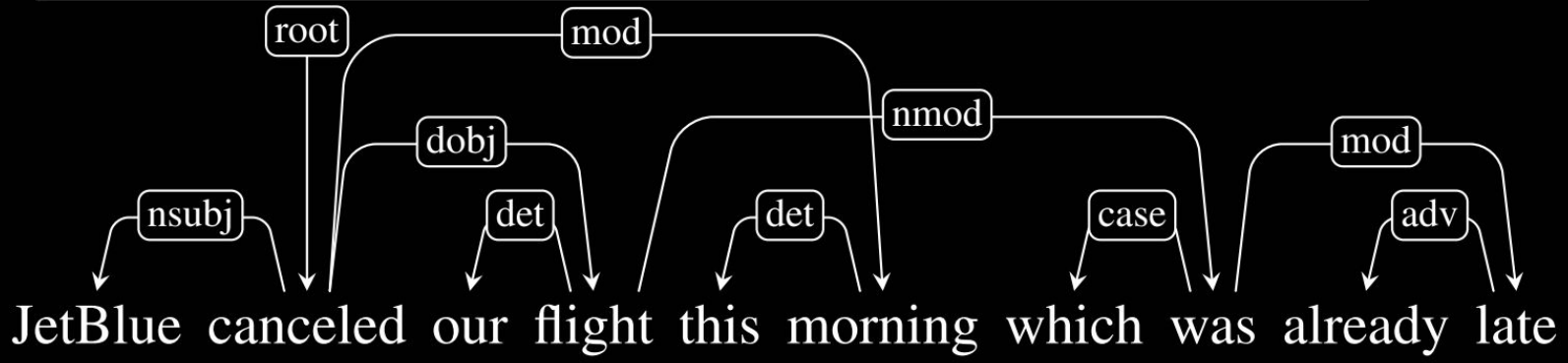


(From SLP 3rd ed., Jurafsky and Martin 2018)

Relation to Semantic Roles

Thematic Role	Definition
AGENT	The volitional causer of an event
EXPERIENCER	The experiencer of an event
FORCE	The non-volitional causer of the event
THEME	The participant most directly affected by an event
RESULT	The end product of an event
CONTENT	The proposition or content of a propositional event
INSTRUMENT	An instrument used in an event
BENEFICIARY	The beneficiary of an event
SOURCE	The origin of the object of a transfer event
GOAL	The destination of an object of a transfer event

(13.3)



(From SLP 3rd ed., Jurafsky and Martin 2018)

Semantics Avalanche

Key Takeaways:

- Words have many meanings.
  - Context is key
  - Selectors can represent context
- Verbs can been seen as functions (predicates) that take arguments.
  - Arguments fulfill semantic roles
- Words have implicit relationships with each other in given sentences.
  - Dependency Parsing: each word has one head
  - Easily constructed through 3 actions of shift-reduce parsing.
- There is an interplay between word meaning and sentence structure