CSC485/2501 A1 Tutorial 2

Zixin Zhao

UNIVERSITY OF TORONTO

Assignment 1

Updated code available on MarkUs

Due on **Thursday Oct. 3rd, at 11:59 pm**.

You should work on your code through the `teach.cs` server, details here. The instructor also has information on how to use GPUs on the server.

Assignment 1

Part 1: Implement your own transition-based dependency parser

Part 2: Implement your own graph-based dependency parser

Assignment 1

Part 1: Implement your own transition-based dependency parser

Part 2: Implement your own graph-based dependency parser

Part 1: Transition-based parser

Tutorial overview

Dependency parsing example with a transition-based parser

Gap degree example

Neural dependency parser with 👉PyTorch👈 pointers

Dependency parser

Dependency parser: when given a sentence, it outputs a dependency parse tree.

Three things to keep track of:

1. A **stack of words** being processed.
2. A **buffer of words** to be eventually pushed onto the stack.
3. A **list of predicted dependencies** (i.e. arcs).

Transition-based Parser

Three possible operations:

1. **SHIFT**: removes the first word from the buffer and pushes it onto the stack.
2. **LEFT-ARC**: marks the second-from-top item (i.e., second-most recently added word) on the stack as a dependent of the first item and removes the second item from the stack.
3. **RIGHT-ARC**: marks the top item (i.e., most recently added word) on the stack as a dependent of the second item and removes the first item from the stack.

SHIFT Operation

Removes the first word from the buffer and pushes it onto the stack.

- Step T:
  - Stack: [ROOT, Stacy, ran]; Buffer: [5k, today]
- Step T+1:
  - Stack: [ROOT, Stacy, ran, 5k]; Buffer: [today]
  - Action: SHIFT

LEFT-ARC Operation

Marks the second-from-top item (i.e., second-most recently added word) on the stack as a dependent of the first item and removes the second item from the stack.

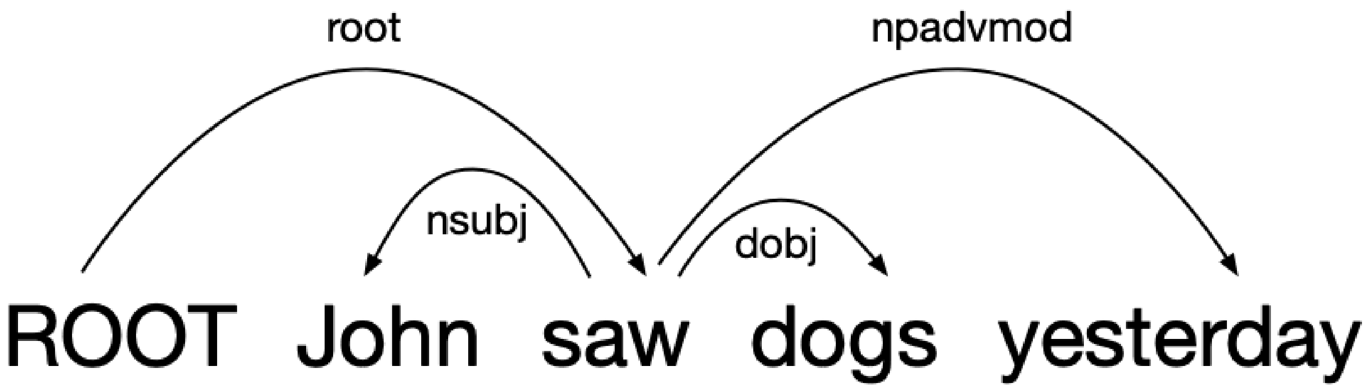
- Step T:
  - Stack: [ROOT, Stacy, ran]; Buffer: [5k, today]
- Step T+1:
  - Stack: [ROOT, ran]; Buffer: [5k, today]
  - New Dependency: ran -> Stacy, nsubj
  - Action: LEFT-ARC

RIGHT-ARC Operation

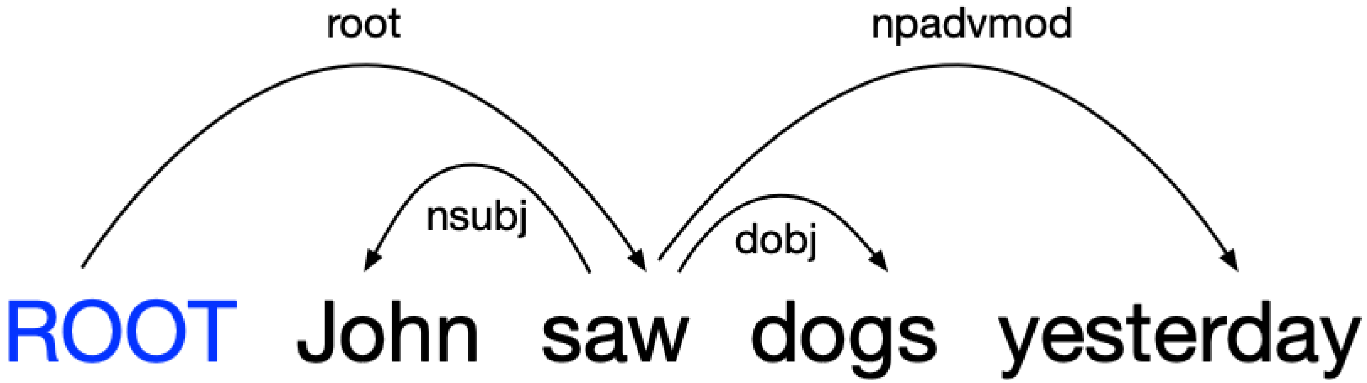
Marks the top item (i.e., most recently added word) on the stack as a dependent of the second item and removes the first item from the stack.

- Step T:
  - Stack: [ROOT, ran, 5k]; Buffer: [today]
- Step T+1:
  - Stack: [ROOT, ran]; Buffer: [today]
  - New Dependency: ran -> 5k, dobj
  - Action: RIGHT-ARC

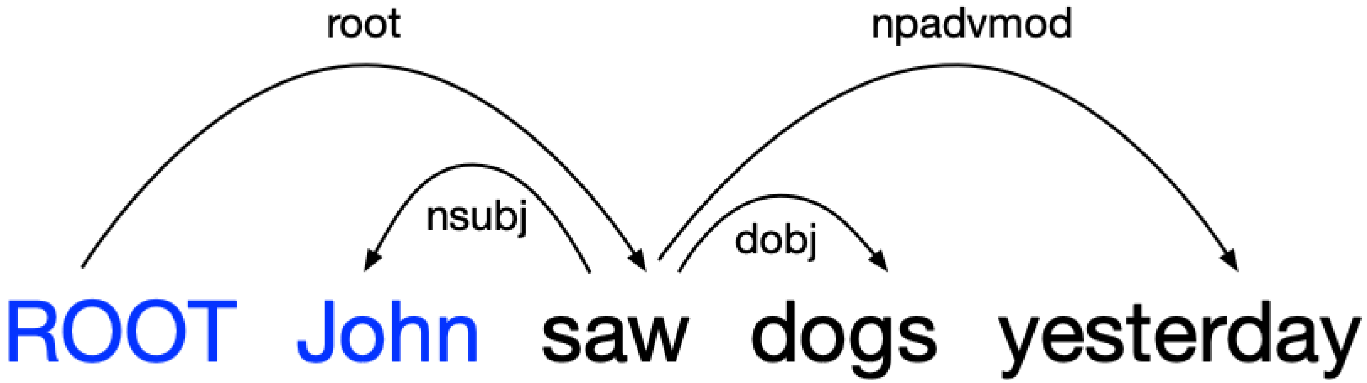
Dependency Parsing Example



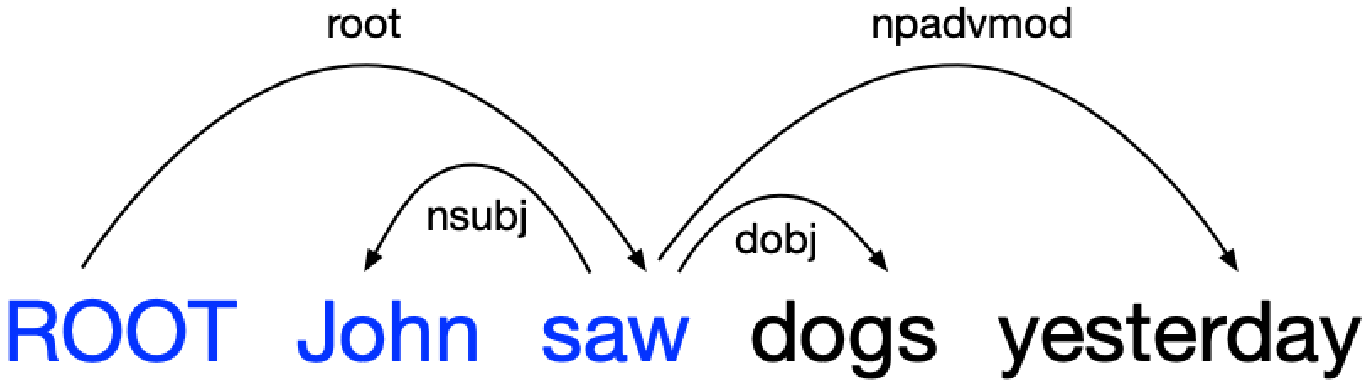
- Given a dependency tree, figure out the intermediate parsing steps.
- Check the top of your stack to see whether it is appropriate to create an arc.
- After creating an arc, record it, and then remove the dependent word from the stack.



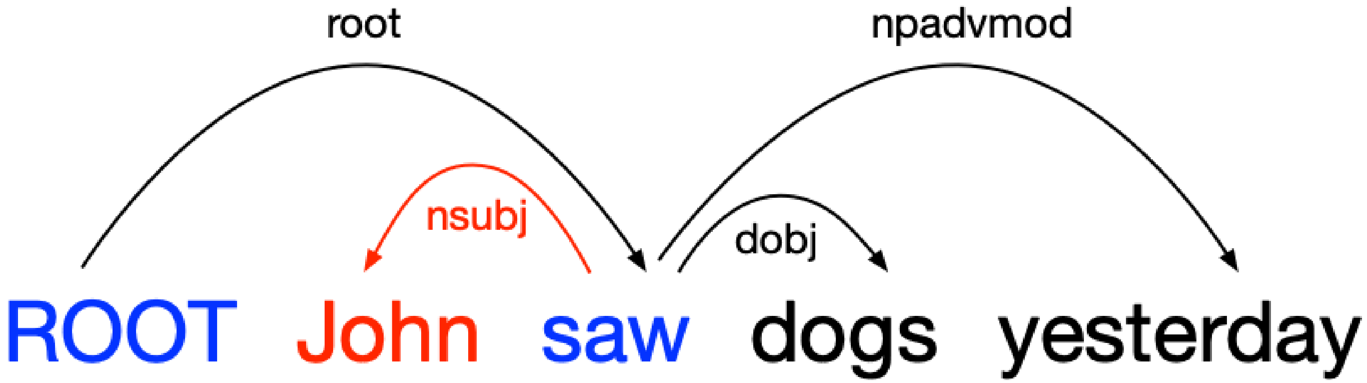
- Step 0:
  - Stack: [ROOT]; Buffer: [John, saw, dogs, yesterday]



- Step 0:
  - Stack: [ROOT]; Buffer: [John, saw, dogs, yesterday]
- Step 1:
  - Stack: [ROOT, John]; Buffer: [saw, dogs, yesterday]
  - New Dependency: None
  - Action: SHIFT

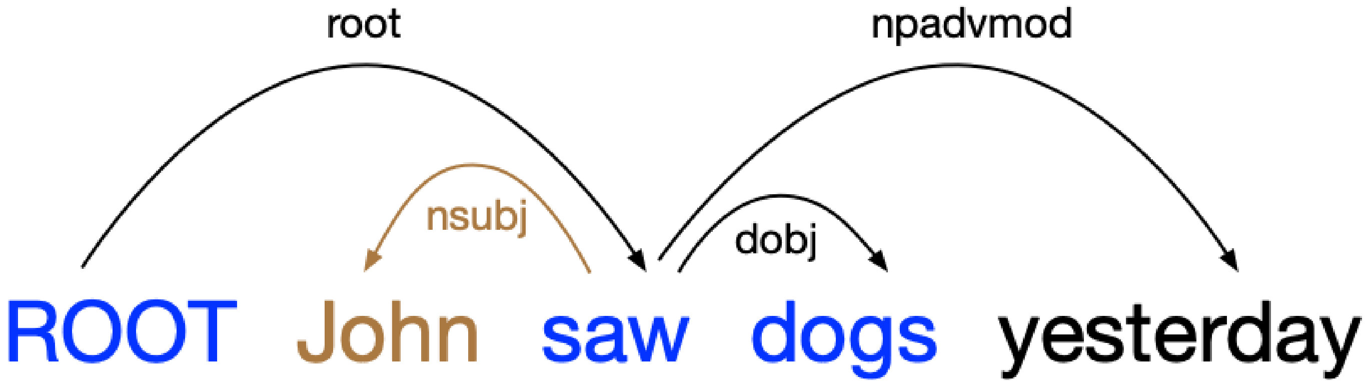


- From Step 1:
  - Stack: [ROOT, John]; Buffer: [saw, dogs, yesterday]
- Step 2:
  - Stack: [ROOT, John, saw]; Buffer: [dogs, yesterday]
  - New Dependency: None
  - Action: SHIFT

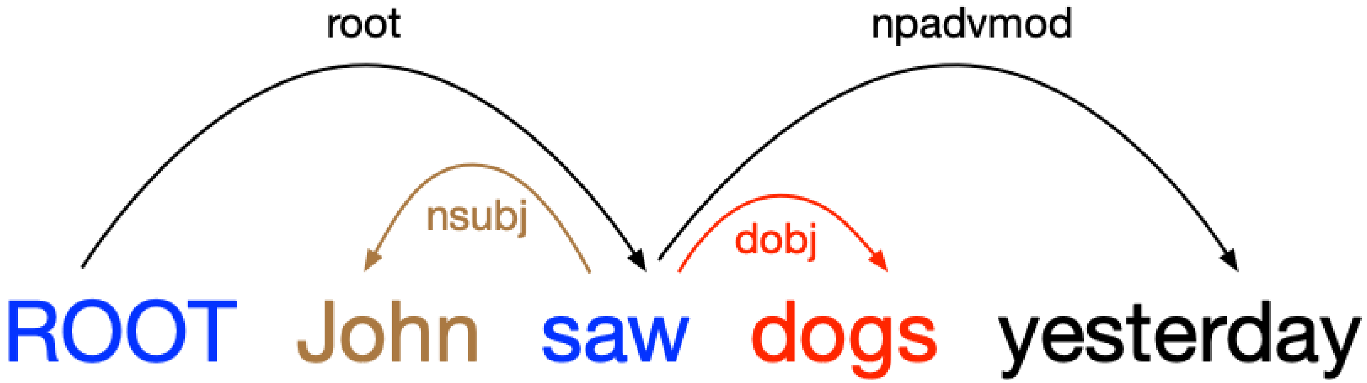


- From Step 2:
  - Stack: [ROOT, John, saw]; Buffer: [dogs, yesterday]
- Step 3:
  - Stack: [ROOT, saw]; Buffer: [dogs, yesterday]
  - New Dependency: saw -> John, nsubj
  - Action: LEFT-ARC

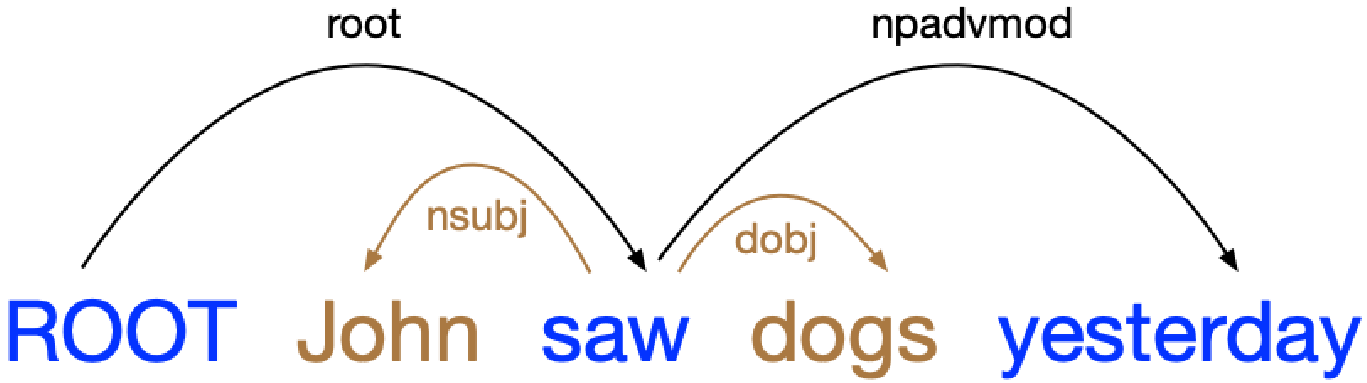
For this assignment:
Choose LEFT-ARC over SHIFT when both are valid and generate the same tree.



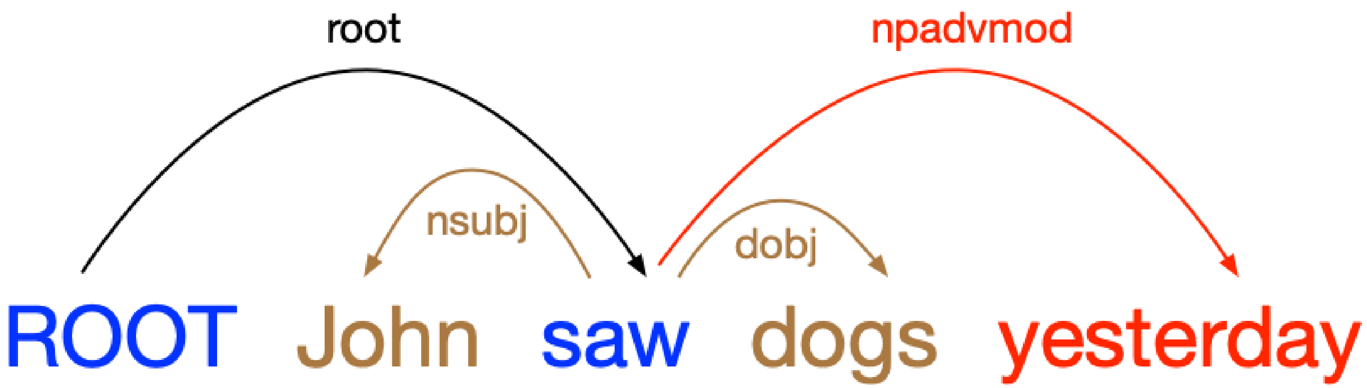
- From Step 3:
  - Stack: [ROOT, saw]; Buffer: [dogs, yesterday]
- Step 4:
  - Stack: [ROOT, saw, dogs]; Buffer: [yesterday]
  - New Dependency: None
  - Action: SHIFT



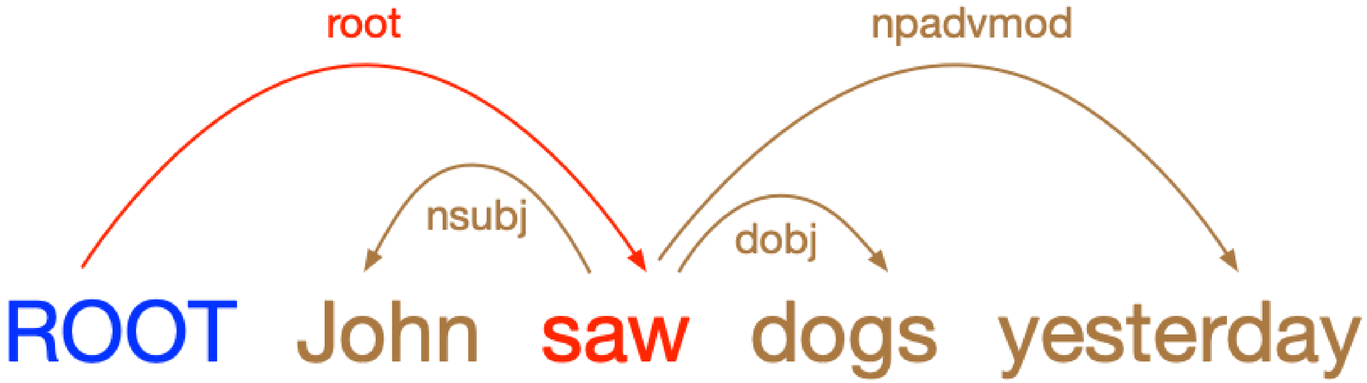
- From Step 4:
  - Stack: [ROOT, saw, dogs]; Buffer: [yesterday]
- Step 5:
  - Stack: [ROOT, saw]; Buffer: [yesterday]
  - New Dependency: saw -> dogs, dobj
  - Action: RIGHT-ARC



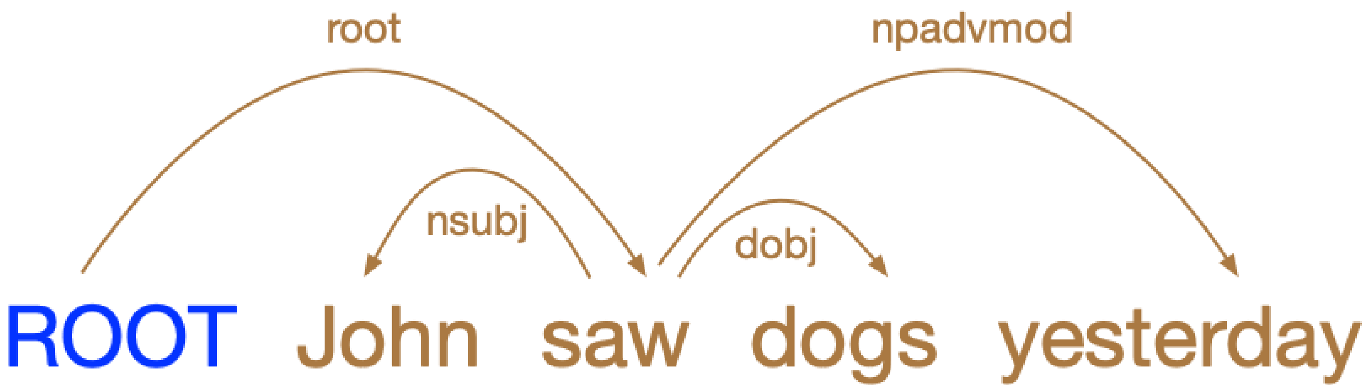
- From Step 5:
  - Stack: [ROOT, saw]; Buffer: [yesterday]
- Step 6:
  - Stack: [ROOT, saw, yesterday]; Buffer: []
  - New Dependency: None
  - Action: SHIFT



- From Step 6:
  - Stack: [ROOT, saw, yesterday]; Buffer: []
- Step 7:
  - Stack: [ROOT, saw]; Buffer: []
  - New Dependency: saw -> yesterday, npadvmod
  - Action: RIGHT-ARC

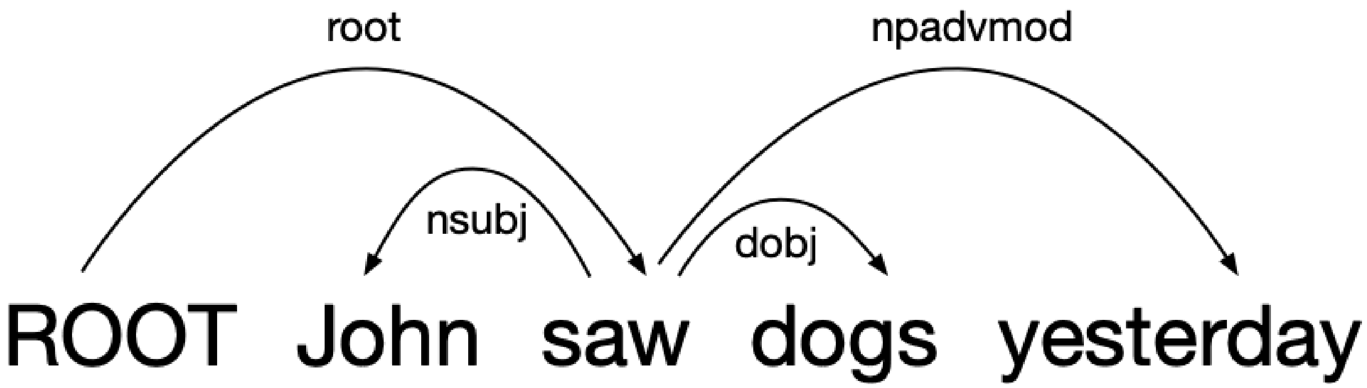


- From Step 7:
  - Stack: [ROOT, saw]; Buffer: []
- Step 8:
  - Stack: [ROOT]; Buffer: []
  - New Dependency: ROOT -> saw, root
  - Action: RIGHT-ARC



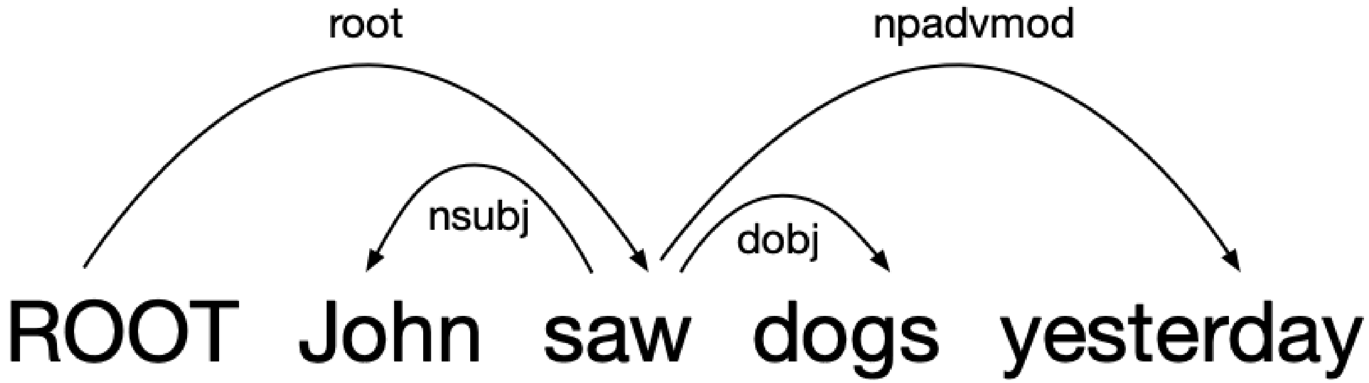
- We’ve figured out all the parsing steps!
- Similar exercise in the assignment.
- How to do this algorithmically? What are the conditions?

Gap Degree Example



- The **gap degree of a word** in a dependency tree is the least *k* for which the subsequence consisting of the word and its descendants (both direct and indirect) is entirely comprised of *k* + 1 maximally contiguous substrings.
- The gap degree of a word is the *number of gaps* in the subsequence formed by the word and all its descendants, regardless of the *size* of the gaps.
- The **gap degree of a dependency tree** is the greatest gap degree of any word in the tree.

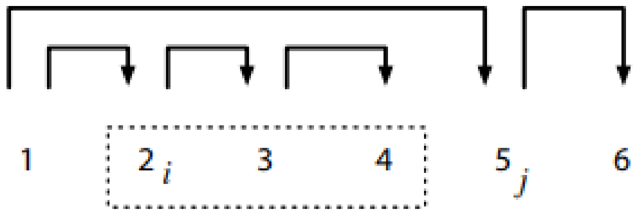
Gap Degree



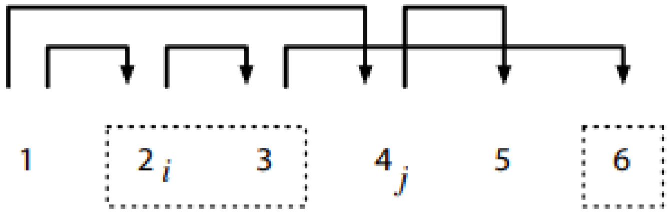
- For each word, check the substring consisting itself and all its descendants:
  - – ROOT: ROOT John saw dogs yesterday
  - – John: John
  - – saw: John saw dogs yesterday
  - – dogs: dogs
  - – yesterday: yesterday

All substrings are contiguous
k=0

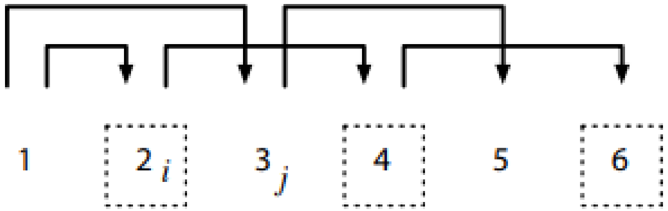
Gap Degree



Gap degree = 0



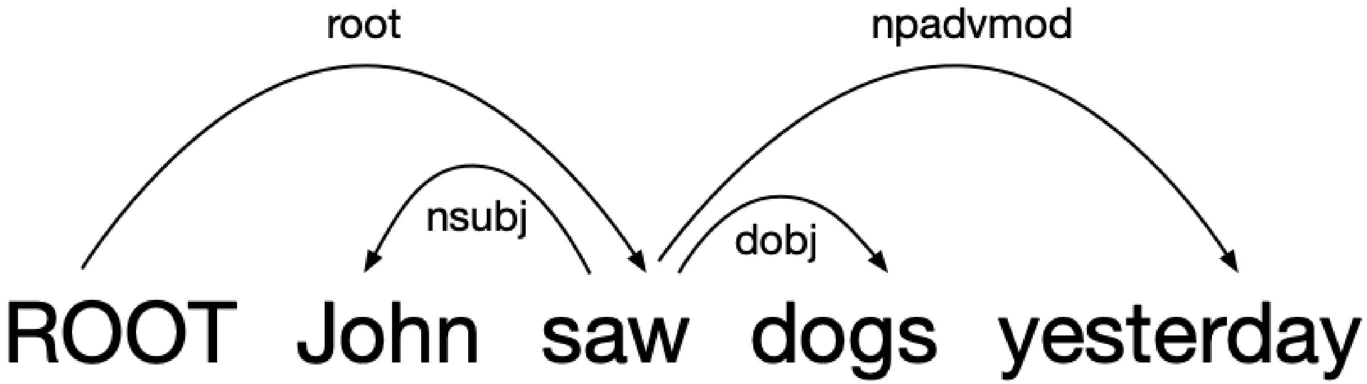
Gap degree = 1



Gap degree = 2

Marco Kuhlmann and Joakim Nivre. 2006. Mildly Non-Projective Dependency Structures. In *Proceedings of the COLING/ACL 2006 Main Conference Poster Sessions*, pages 507–514, Sydney, Australia. Association for Computational Linguistics.

Neural Dependency Parser



- Now assume we don’t have the dependency tree.

Neural Dependency Parser

ROOT John saw dogs yesterday

- Now assume we don’t have the dependency tree.
- When do we need to make decisions when parsing?

Neural Dependency Parser

ROOT John saw dogs yesterday

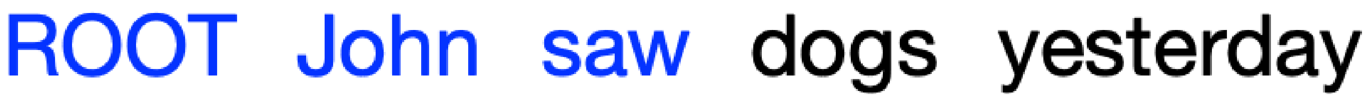
- Suppose we have the following partial parse:
  - Stack: [ROOT, John, saw]; Buffer: [dogs, yesterday]
- Now we need to decide which transition to do next:

a) SHIFT: Shift dogs onto the stack

b) LEFT-ARC: create the arc: saw -> john

c) RIGHT-ARC: create the arc john -> saw

Neural Dependency Parser



ROOT John saw dogs yesterday

- Use a neural network to make a prediction at each parse step.
- Implement this in PyTorch, read the docs and refer back to the tutorial if you’re not familiar:
  - https://pytorch.org/docs/stable/index.html

Neural Dependency Parser

ROOT John saw dogs yesterday

- **Input**: Word level features (e.g. word embeddings) for each word in the sentence.
- One linear (fully-connected) **hidden layer**.
- A **softmax layer** to obtain a probability distribution over transitions.

Neural Dependency Parser

ROOT John saw dogs yesterday

- **Input**: Word level features (e.g. word embeddings) for each word in the sentence.
  - `torch.nn.Embedding(size, shape)`
  - `torch.nn.Embedding.from_pretrained(…)`
    - Make sure you DON'T freeze the pre-trained embeddings!!

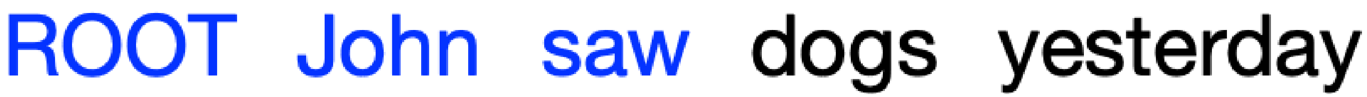
Neural Dependency Parser

ROOT John saw dogs yesterday

- One linear (fully-connected) **hidden layer**.
  - `hidden_layer = torch.nn.Linear(input_size, output_size)`
  - To apply: `hidden_layer(features)`

You can also checkout `torch.nn.relu(…)` and `torch.nn.dropout(…)`

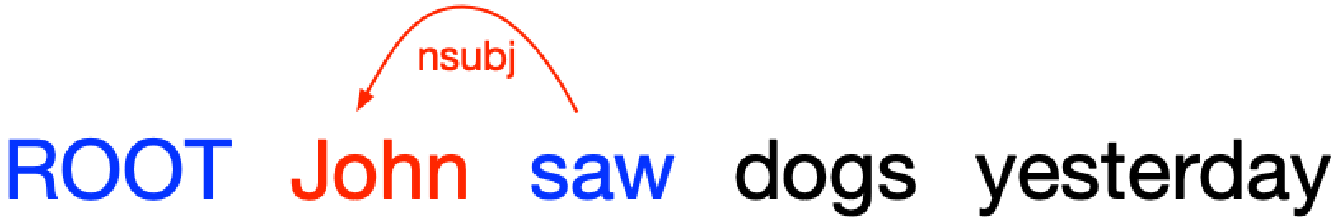
Neural Dependency Parser



ROOT John saw dogs yesterday

- A **softmax layer** to obtain a probability distribution over transitions.
  - `torch.nn.CrossEntropyLoss / torch.nn.functional.CrossEntropy`

Neural Dependency Parser



nsubj

ROOT John saw dogs yesterday

- Suppose our neural network gives us an answer:

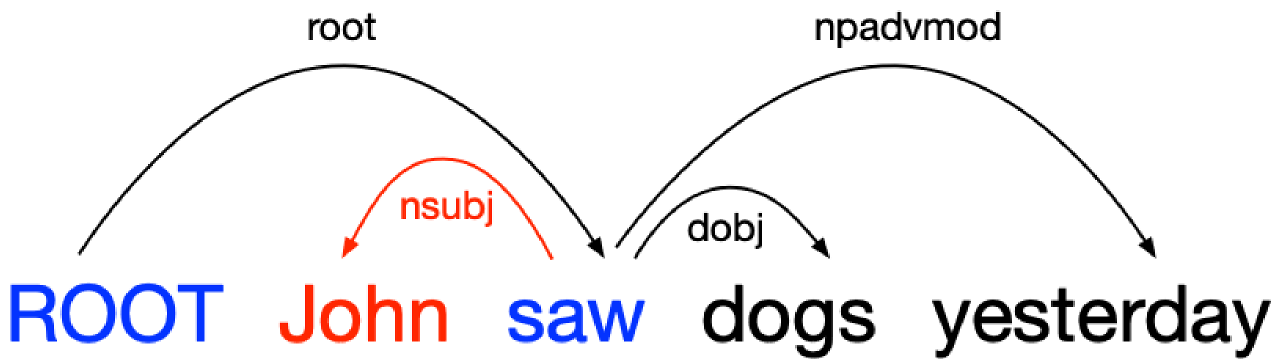
  a) SHIFT: Shift dogs onto the stack

  b) LEFT-ARC: create the arc: saw -> john

  c) RIGHT-ARC: create the arc john -> saw

- How can we tell whether we have made the right choice?

Neural Dependency Parser



- How can we tell whether we have made the right choice?
  - Implement an "**oracle**" that peaks into the parsed tree and tells us the correct transition to make.
- Think about the first example we did in this tutorial.
  - How to make the process automatic?
  - What conditions need to be met to make a particular transition?

So…

One pitfall of the transition-based parser is that it can only handle projective parse trees (you can try to think about why this is)

Next time, we will look at graph-based dependency parsing, which accounts for non-projective trees.