CSC485/2501 A1 Tutorial #1

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Assignment 1

- Is now available!
- Asks you to implement a set of neural dependency parsers.
- Due on Oct. 8th, at 11:59 pm.

Assignment 1

- Part 1: Transition-based dependency parser
- Part 2: Graph-based dependency parser

Assignment 1

- Part 1: Transition-based dependency parser
  - We will focus on this part today.

- Part 2: Graph-based dependency parser

Outline

- Dependency Parsing Example
  - Obtaining the necessary parsing steps for a dependency tree.
- Gap Degree Example
- Neural Dependency Parser
  - With PyTorch pointers ☺

Transition-based Parser - Review

- Dependency parser: Given a sentence, output 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 - Review

- 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, John, saw]; Buffer: [dogs, yesterday]
- Step T+1:
  - Stack: [ROOT, John, saw, dogs]; Buffer: [yesterday]
  - 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, John, saw]; Buffer: [dogs, yesterday]

- Step T+1:
  - Stack: [ROOT, saw]; Buffer: [dogs, yesterday]
  - New Dependency: saw -> John, nsubj
  - Action: LEFT-ARC

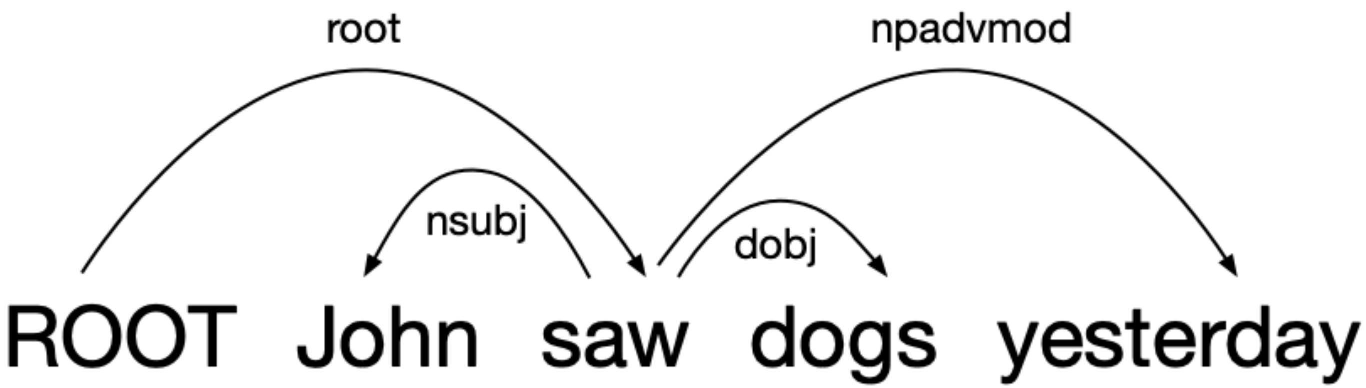
RIGHT-ARC Operation

- 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, saw, dogs]; Buffer: [yesterday]

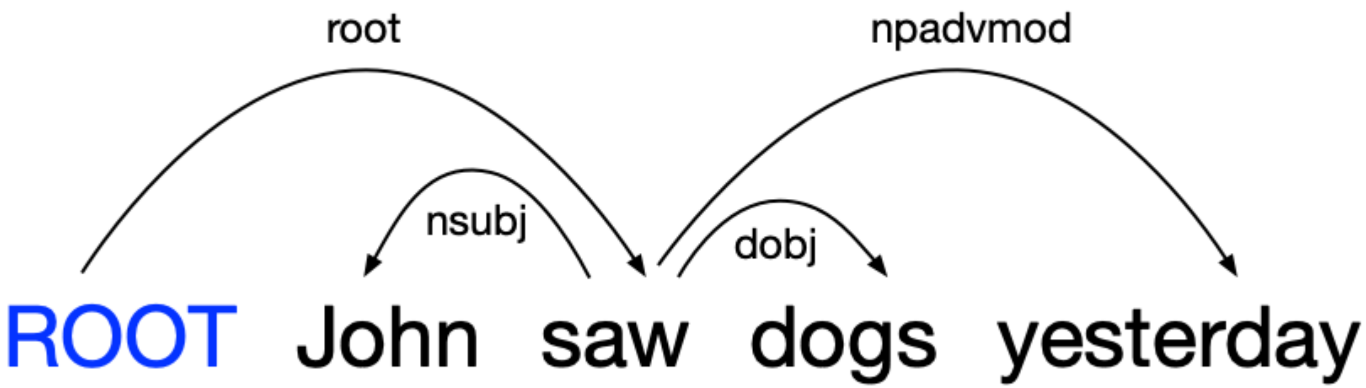
- Step T+1:
  - Stack: [ROOT, saw]; Buffer: [yesterday]
  - New Dependency: saw -> dogs, dobj
  - Action: RIGHT-ARC

Dependency Parse Example



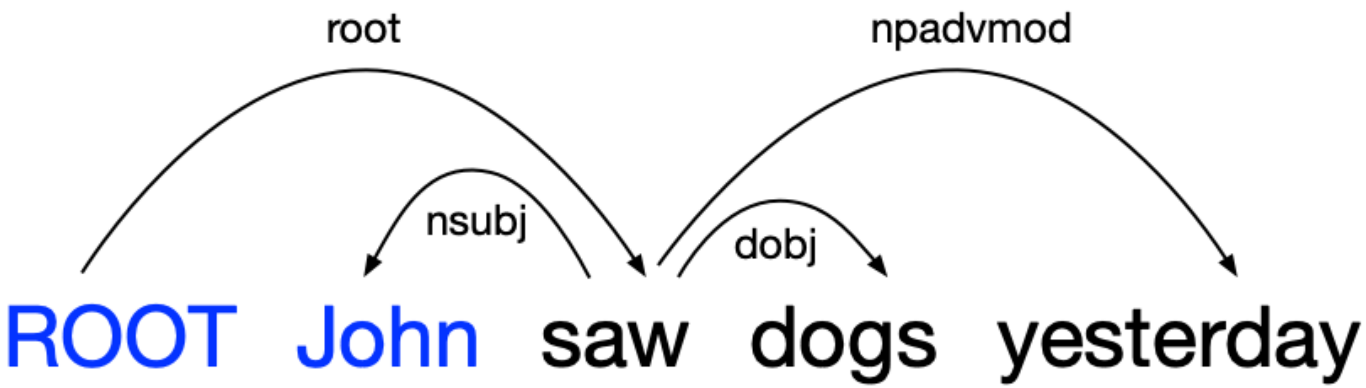
- Given a dependency tree, figure out the intermediate parsing steps.
- Check the top of your stack to see whether it is appropriate to create an arc.
- After creating an arc, record it, and then remove the dependent word from the stack.

Dependency Parse Example



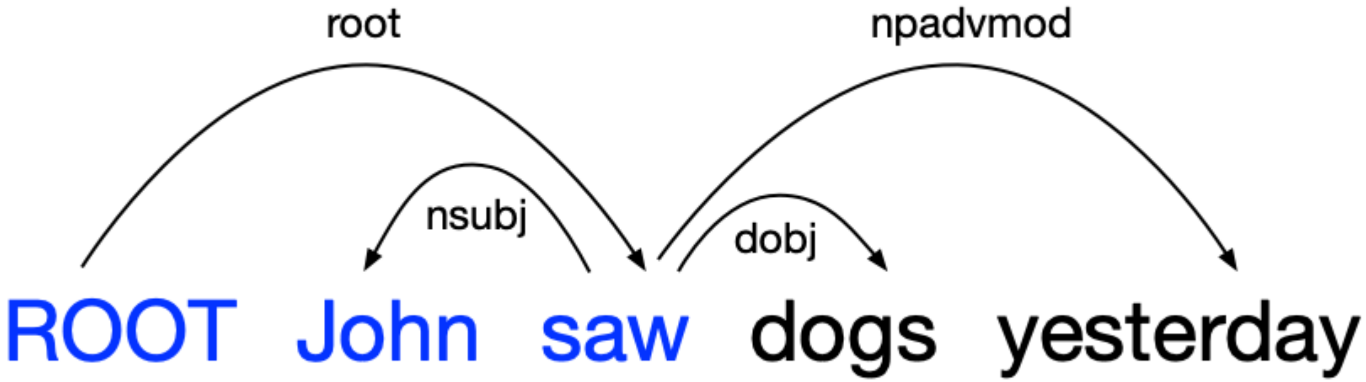
- Step 0:
  - Stack: [ROOT]; Buffer: [John, saw, dogs, yesterday]

Dependency Parse Example



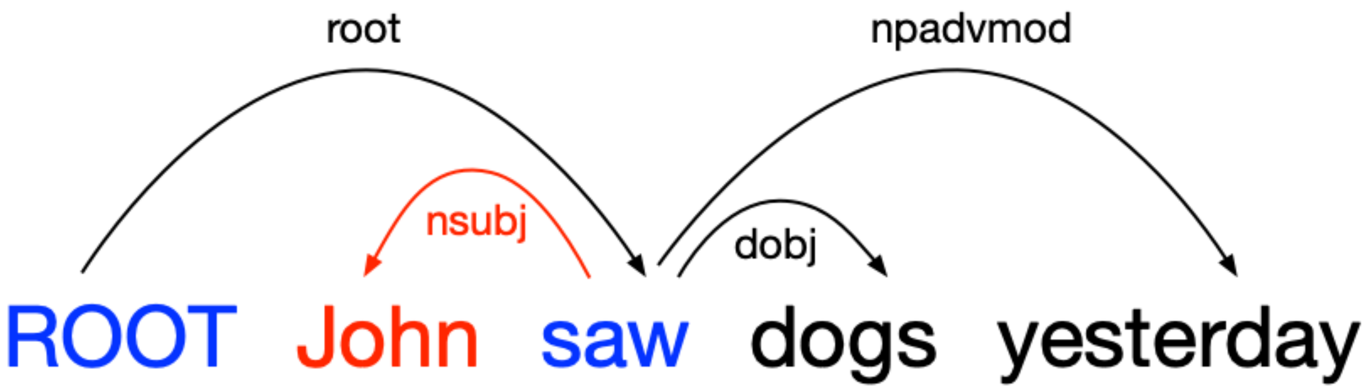
- Step 0:
  - Stack: [ROOT]; Buffer: [John, saw, dogs, yesterday]
- Step 1:
  - Stack: [ROOT, John]; Buffer: [saw, dogs, yesterday]
  - New Dependency: None
  - Action: SHIFT

Dependency Parse Example



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

Dependency Parse Example

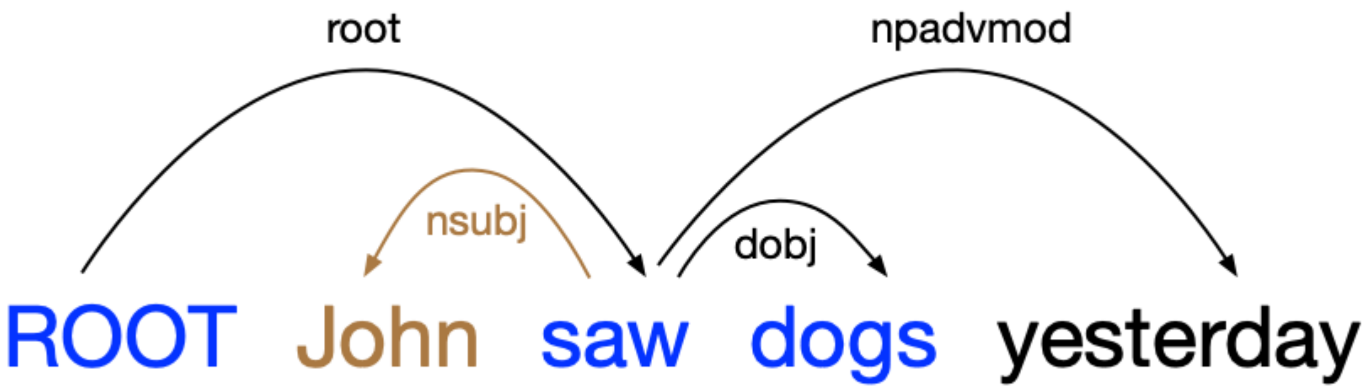


- From Step 2:
  - Stack: [ROOT, John, saw]; Buffer: [dogs, yesterday]
- Step 3:
  - Stack: [ROOT, saw]; Buffer: [dogs, yesterday]
  - New Dependency: saw -> John, nsubj
  - Action: LEFT-ARC

For this assignment:

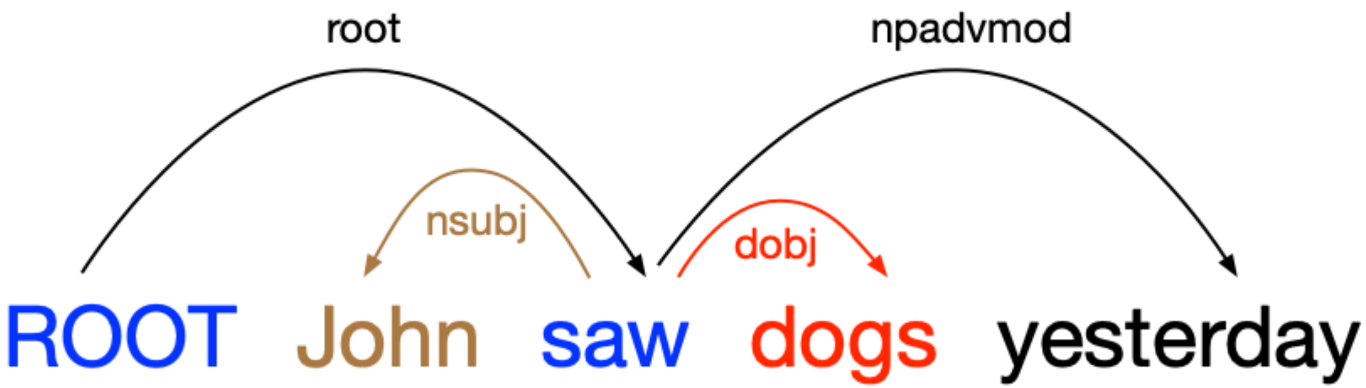
Choose LEFT-ARC over SHIFT when both are valid and generate the same tree.

Dependency Parse Example



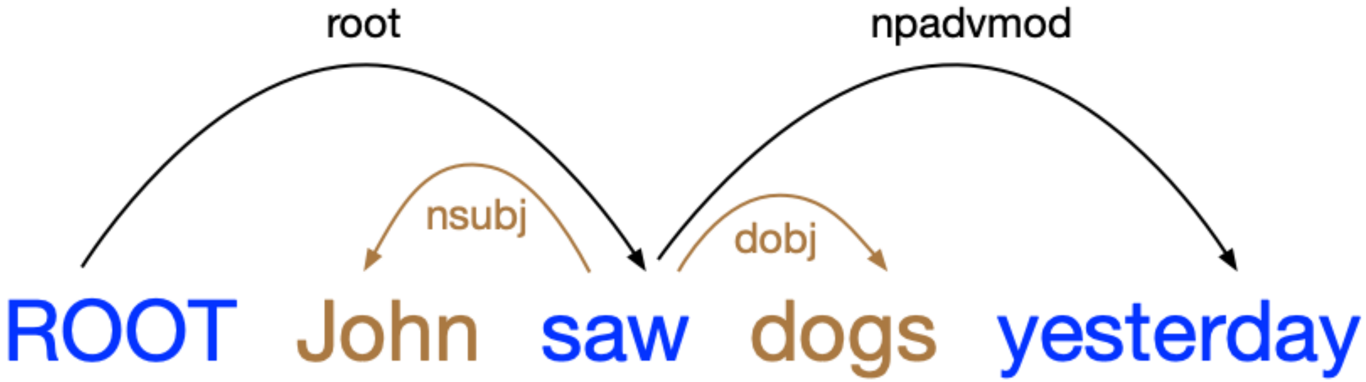
- From Step 3:
  - Stack: [ROOT, saw]; Buffer: [dogs, yesterday]
- Step 4:
  - Stack: [ROOT, saw, dogs]; Buffer: [yesterday]
  - New Dependency: None
  - Action: SHIFT

Dependency Parse Example



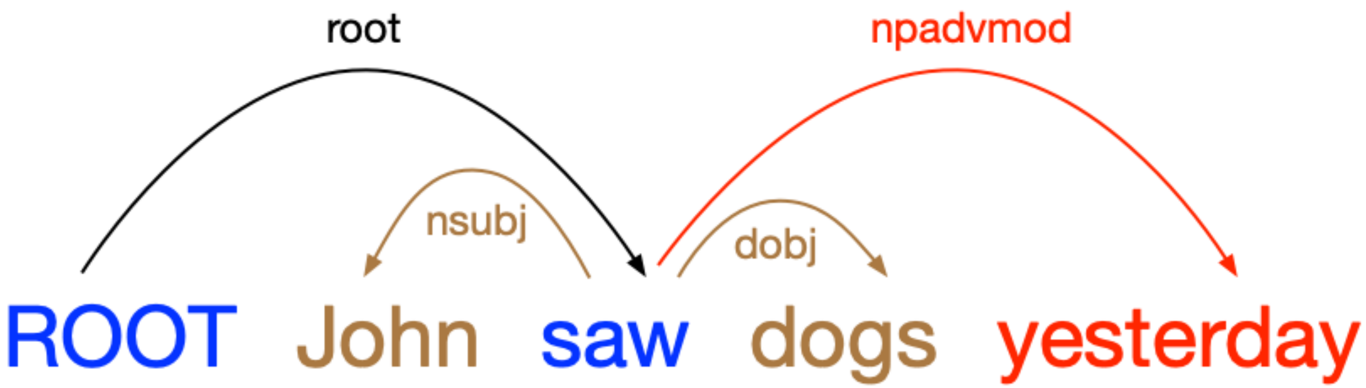
- From Step 4:
  - Stack: [ROOT, saw, dogs]; Buffer: [yesterday]
- Step 5:
  - Stack: [ROOT, saw]; Buffer: [yesterday]
  - New Dependency: saw -> dogs, dobj
  - Action: RIGHT-ARC

Dependency Parse Example



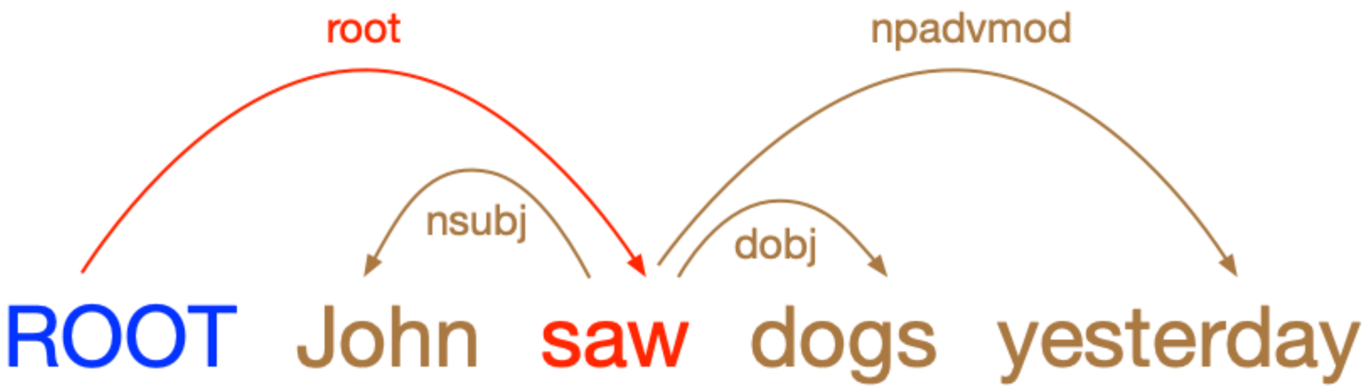
- From Step 5:
  - Stack: [ROOT, saw]; Buffer: [yesterday]
- Step 6:
  - Stack: [ROOT, saw, yesterday]; Buffer: []
  - New Dependency: None
  - Action: SHIFT

Dependency Parse Example



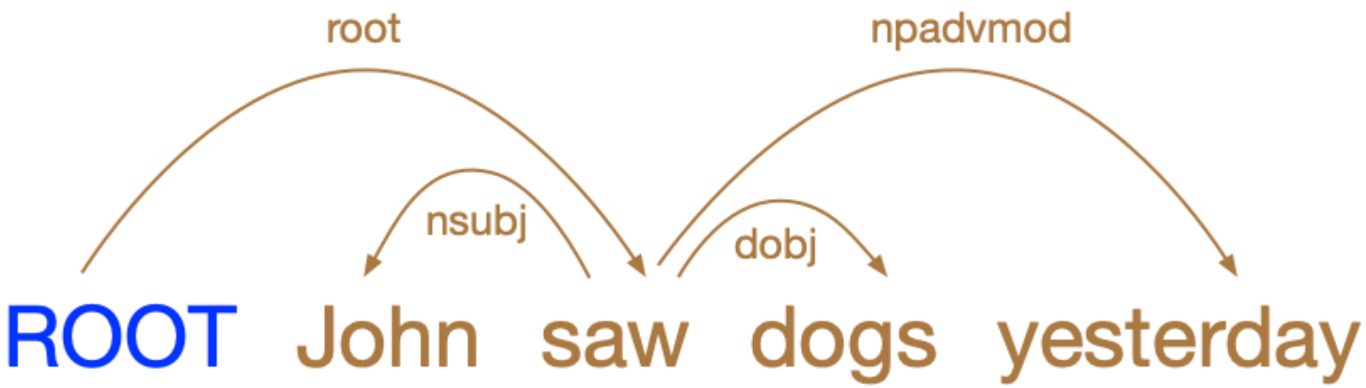
- From Step 6:
  - Stack: [ROOT, saw, yesterday]; Buffer: []
- Step 7:
  - Stack: [ROOT, saw]; Buffer: []
  - New Dependency: saw -> yesterday, npadvmod
  - Action: RIGHT-ARC

Dependency Parse Example



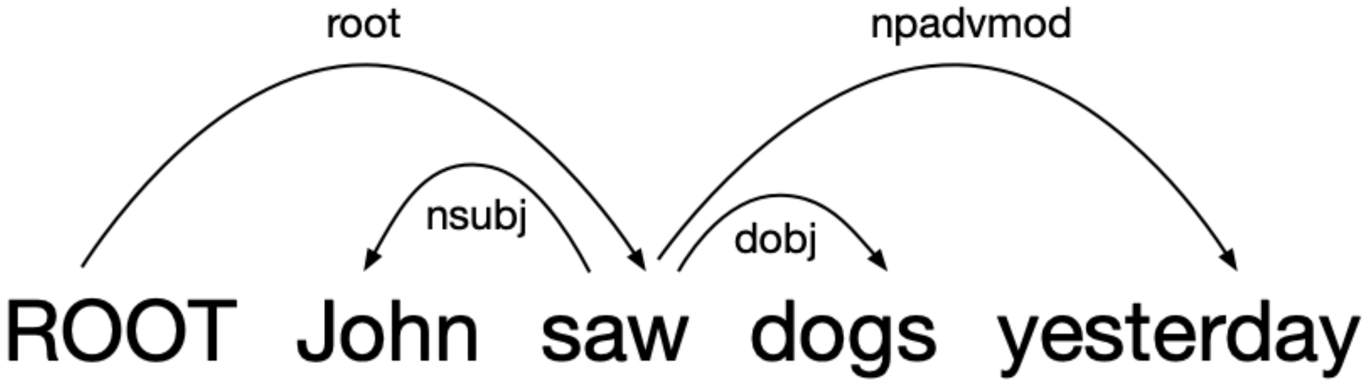
- From Step 7:
  - Stack: [ROOT, saw]; Buffer: []
- Step 8:
  - Stack: [ROOT]; Buffer: []
  - New Dependency: ROOT -> saw, root
  - Action: RIGHT-ARC

Dependency Parse Example



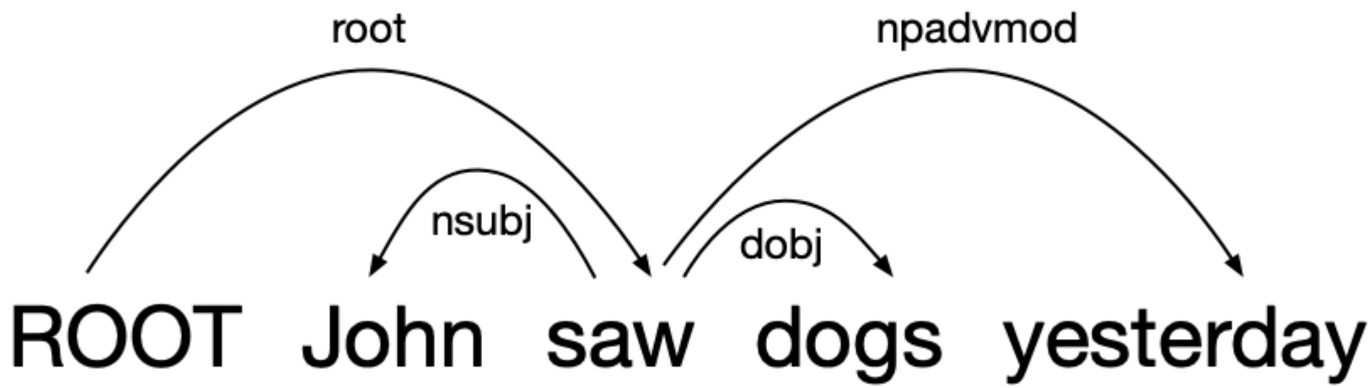
- We've figured out all the parsing steps!
- Similar exercise in the assignment.
- How to do this algorithmically? What are the conditions?

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. Equivalently, the gap degree of a word is the *number* of gaps in the subsequence formed by the word and all of 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.

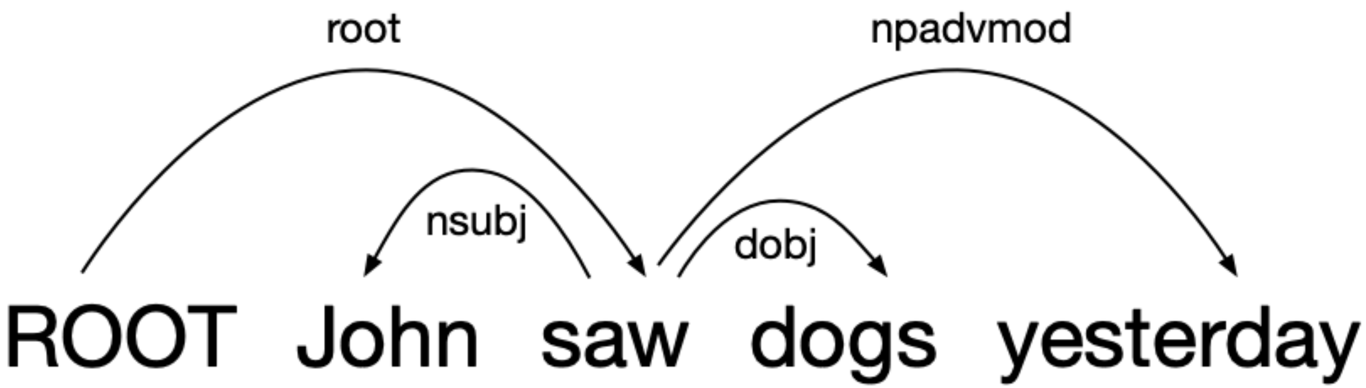
Gap Degree Example



- 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

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 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.
  - – *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

- Input: Word level features (e.g. word embeddings) for each word in the sentence.
- One linear (fully-connected) hidden layer.
  - *hidden_layer = torch.nn.Linear(input_size, output_size)*
  - To apply: *hidden_layer(features)*
- Also checkout *torch.nn.functional.relu(...)* and *torch.nn.functional.dropout(...).*

Neural Dependency Parser

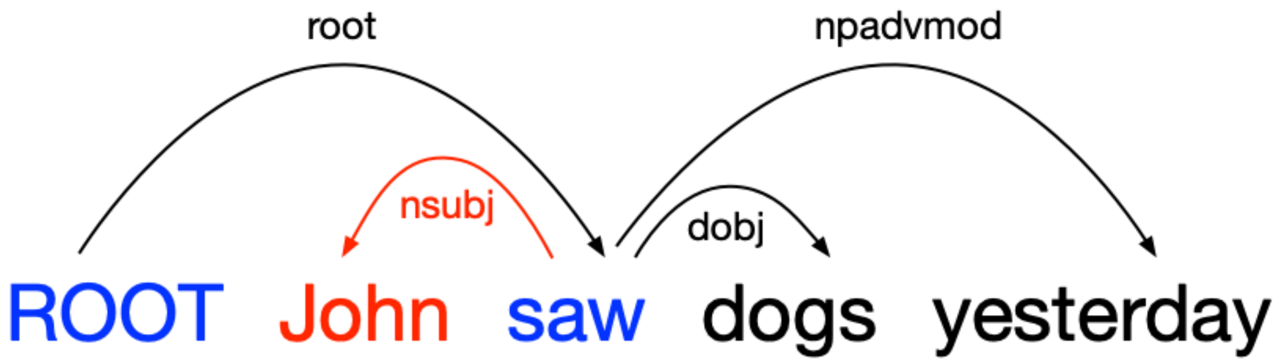
ROOT John saw dogs yesterday

- 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.
  – *torch.nn.CrossEntropyLoss / torch.nn.functional.CrossEntropy*

Neural Dependency Parser

- 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?

To be continued…

- The transition-based parser can only handle projective parse trees (think about why this is the case).
- Next time, we will take a look at graph-based dependency parsing, which takes into account the non-projective cases.
  - Another A1 tutorial Friday next week (Oct 1) **on Zoom**.