Tackling Error Propagation through Reinforcement Learning: A Case of Greedy Dependency Parsing

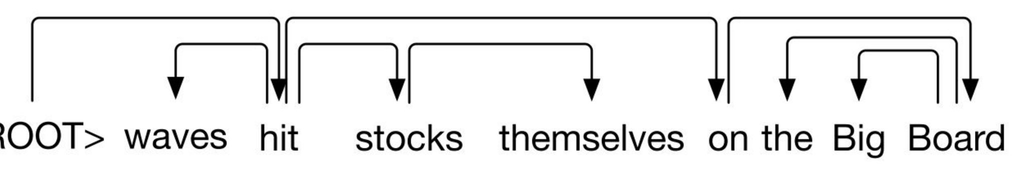
Minh Le and Antske Fokkens

Transition-based Dependency Parsing

Starting with a sentence and an empty parse, a parser adds one arc at a time until a complete parse is built.

Example: arc-standard parser

```
Start: [ROOT] [ sentence ]
S: [A B] [C]  ⇒  [A B C] [ ]
L: [A B] [C]  ⇒  [B] [C]
                  A
R: [A B] [C]  ⇒  [A] [C]
                  B
End: [ROOT] [ ]
```



= Shift Shift Left Shift Shift Right Right …

Error propagation: an error leads to an unusual configuration which makes further errors more likely.

Reinforcement Learning

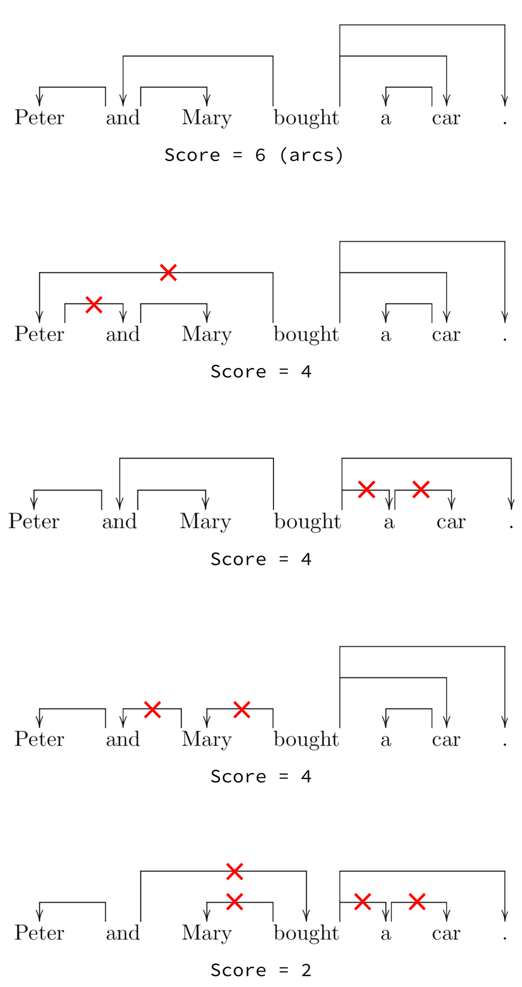
During training: Train on both totally correct and partially correct examples.

Expected reward = sum(score*prob)

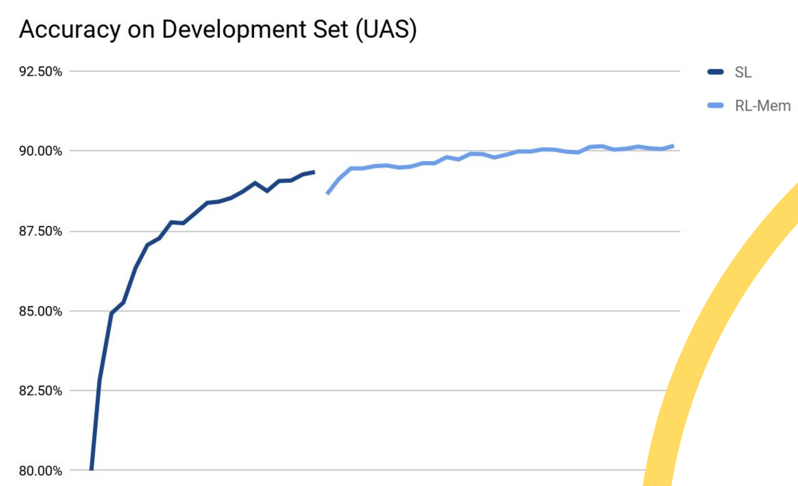
Follows gradient w.r.t. parameters: ∂(Expected reward)/∂(θ)

During testing: greedy as usual (fast)

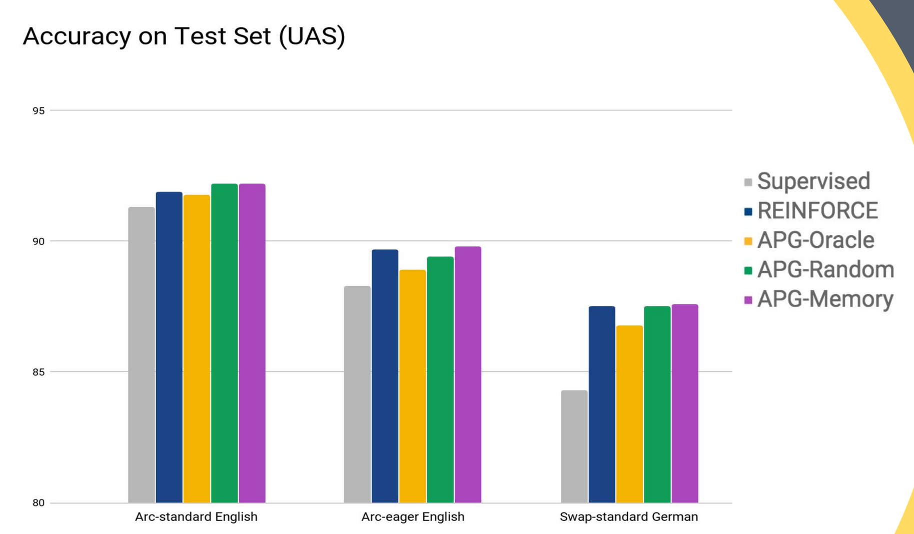
Sampling:
- `REINFORCE`: one sample at a time, unbiased estimate
- `Oracle`: control setting, uses only the optimal sequence of actions for each sentence
- `Random`: *k* examples per sentence
- `Memory`: random + remember samples with high scores



Training

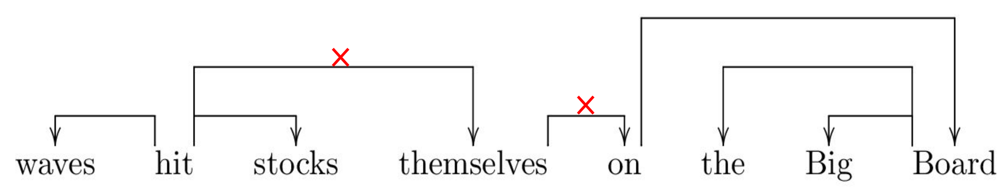


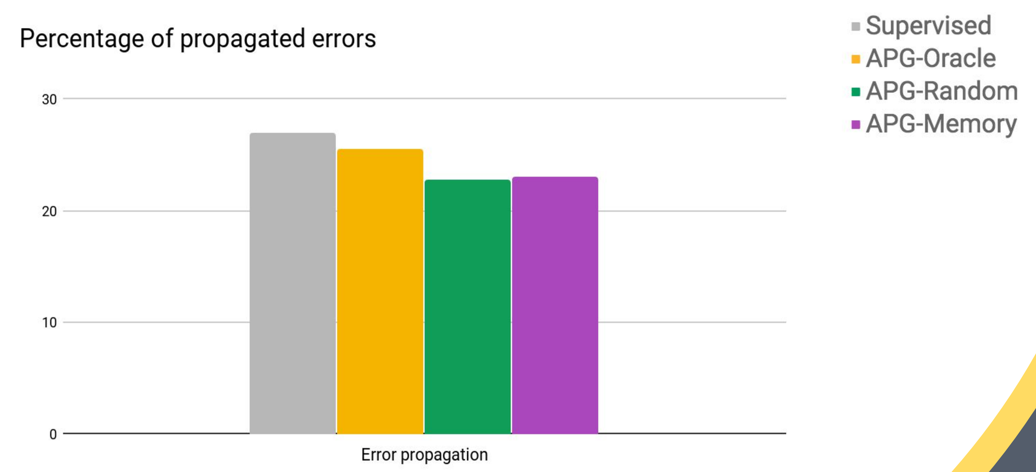
Accuracy



Number of Errors

Counting Error Propagation

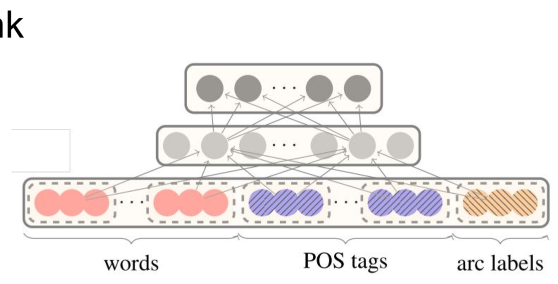




Experimental Design

Corpora:
- English: Penn Treebank
- German: SPMRL

Transition systems:
- Arc-standard
- Arc-eager
- Swap-standard



Chen and Manning (2014)

Questions:
- Oracle vs. Supervised: is reward maximization better than negative log likelihood?
- Sampling: which method performs the best?
- RL vs. Supervised: does RL improve performance?
- Error propagation: does RL reduce error propagation?

Conclusions

- Reinforcement learning improves performance of a greedy dependency parser
- It does so by reducing error propagation

Other observations:
- Reward maximization is better than negative log likelihood, even with the same number of training examples
- More samples is better (higher accuracy, lower variance)
- Training: slower; testing: equal running time

Future work:
- Reinforcement learning for other natural language processing tasks
- Efficiency: faster training time

Source code: `bitbucket.org/cltl/redep-java`

Check out our paper! (EACL'17)