Linear Average Time Extraction of Phrase-structure Fragments

Andreas van Cranenburgh

Huygens ING
Royal Netherlands Academy of Arts and Sciences

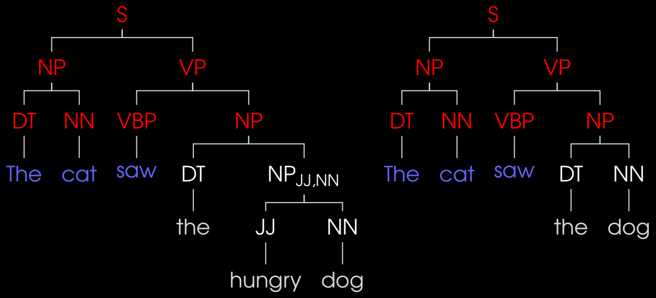
Institute for Logic, Language and Computation
University of Amsterdam

January 17, 2014

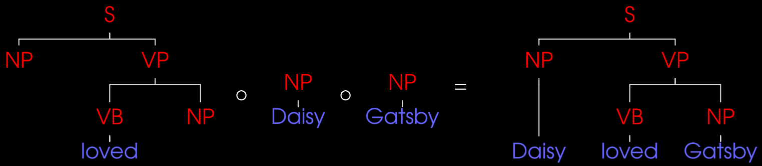
CLIN 2014, Leiden

Overview

- Given a pair of trees, we can extract their **overlapping fragments** (compare Longest Common Subsequence of strings)
- When applied to a treebank, this yields a **set of recurring patterns**
- Fragments can be seen as **building blocks of the treebank**



Applications



- Statistical parsing: Sangati & Zuidema (2011)
  ⇒ Use fragments as a tree-substitution grammar (Data-Oriented Parsing; DOP)
- Stylometry, e.g., authorship attribution
  ⇒ Use fragments as features to recognize the style of an author
- Research into linguistic constructions, Multi-word Expressions (MWE)

Sangati & Zuidema (2011). Accurate parsing with compact (...): Double-DOP
van Cranenburgh (2012). Literary authorship attribution (...) fragments

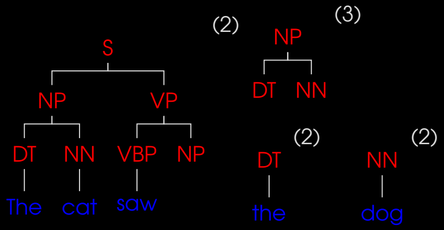
Contributions

- Complexity of the previously available algorithm is quadratic in the number of nodes in the treebank
- The present implementation works in linear average time
- and supports treebanks with discontinuous constituents

Sangati et al. (2010). Efficiently extract recurring fragments from large treebanks

Definition: tree fragment

- A tree can be seen as a sequence of productions
- A tree fragment is a connected subsequence of productions from a tree

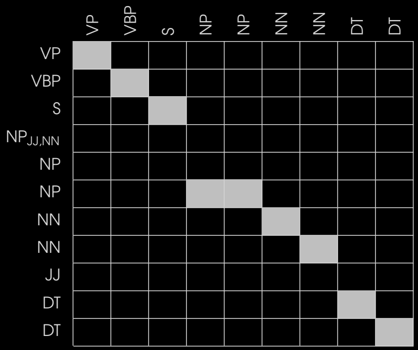


Tree kernels

Given a pair of trees, return multiset of matching nodes

Pseudocode of Quadratic Tree Kernel (QTK):

- For each node of tree *a*
  - For each node of tree *b*
    - Are the productions of the node pair equivalent?

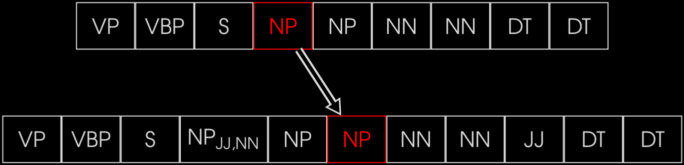


Collins & Duffy (2002). New ranking algorithms for parsing and tagging: Kernels over discrete structures, and the voted perceptron

The fast tree kernel (FTK)

Most of these comparisons can be avoided by applying a preprocessing step:

- Sort the nodes of trees by the productions they contain (for some arbitrarily defined ordering)
- Exploit this ordering in a set intersection; i.e., loop over nodes in a and b, move to next node of *a* as soon as $a_i < b_j$



Moschitti (2006), Making tree kernels practical for natural lang. learning

Maximal subsets

Turn bitset of matching nodes into a representation of the tree fragment:

- Traverse tree in depth-first order
- For each matching node, extract a fragment, and don't use its node for other fragments
- Resulting fragments are maximal and connected subgraphs

Fragment frequencies

It is useful to know the occurrence frequency of the extracted fragments

- Index treebank by productions; i.e., we can obtain the set of all trees with production $A \to B\ C$
- For a given fragment, take intersection of trees with the productions in that fragment
- Exhaustively scan the resulting candidate trees for occurrences of the fragment

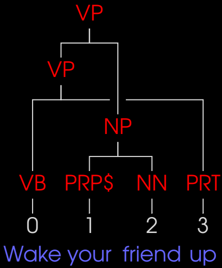
Discontinuous constituents

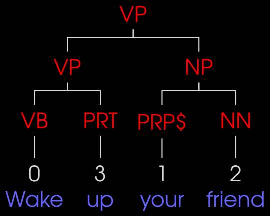
Several treebanks contain discontinuous constituents as part of their annotation (e.g., Alpino / Lassy treebank).

Using some pre- and postprocessing such trees can be supported:

Pre: Replace leaves with indices, apply canonical order to leaves

Post: Canonicalize indices in fragments





van Cranenburgh (2013), Discontinuous Parsing with an Efficient and Accurate DOP Model

Implementation

- Cython: superset of Python, translated to C code
- Trees represented as arrays of node structs, labels mapped to integers
- Fragments represented as bitsets of trees, bitset operations using macros
- Fragment extraction with (mostly) native code, Python for gluing things together (multiprocessing)

Benchmark

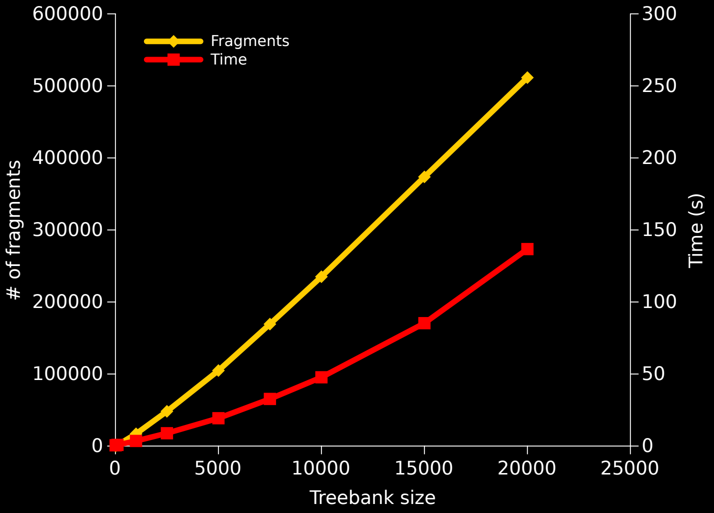
Implementation	Time (hr:min) CPU	Wall	fragments
Sangati et al. (2010), QTK, WSJ	160:00	10:00	1,023,092
This work, QTK, WSJ	93:00	6:15	1,032,568
This work, FTK, WSJ	2:18	0:09	1,023,880

Table: Extracting fragments from WSJ treebank

- training section, binarized with $h = 1$, $v = 2$ markovization
- Work is divided over 16 cores

Sangati et al. (2010). Efficiently extract recurring fragments from large treebanks

Plot



Fragments
Time
600000
500000
400000
300000
200000
100000
0
# of fragments
300
250
200
150
100
50
0
Time (s)
0
5000
10000
15000
20000
25000
Treebank size

Conclusion

- Fragment extraction now 70 times faster!
  i.e., a treebank 70 times larger than WSJ is now feasible
  - More efficient implementation ($2\times$)
  - Algorithmic speedup ($35\times$)
- Publicly available implementation;
  cf. `https://github.com/andreasvc/disco-dop`