# Algorithm for NLP: Homework 4b

Instructed by *Dr. Alon Lavie, Dr. Noah Smith and Dr. Bob Frederking*

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**Bowen Low** blow

## Derivation Semirings

**Answer:**

- Semiring 4
  0: It is a 2-tuple with the integer 0 in the first position and an empty set in the second position.
  1: It is a 2-tuple with the integer 1 in the first position and an empty set in the second position.
  SemiPlus: It performs the union between 2 2-tuples.
  SemiTimes: It performs the union between 2 2-tuples.
  Space: There could be $XL^2R$

- Semiring 5
  0: It is a 3-tuple with the integer 0 in the first position, and a empty tuple in the second position and an empty string in the third position.
  1: It is a 3-tuple with the integer 1 in the first position, and empty tuple in the second position and an empty string in the third position.
  SemiPlus: Given 2 3-tuples, it checks which has the higher value in the 1st position. It will return the 3-tuple with the higher value in the 1st position.
  SemiTimes: Given 2 3-tuples $a$ and $b$, it will return a 3-tuple where the first value is the result of mutiplying the numerical value of both 3-tuples. The tuple returned is the tuple of $a$ less the first item. The string returned is the concatenation of the string from $a$ to the string from $b$. If the string from $b$ is from the right child, then parentheses are added around the string.
  Space: $O(XL^3(N+W))$
  Time: $O(X^3 * L^3)$.

- Semiring 6
  0: It is an array, containing a single semiZero from SemiRing 5.
  1: It is an array, containing a single semiOne from SemiRing 5.
  SemiPlus: Given 2 arrays $a$ and $b$, it performs a concatenation of the two arrays, then it sorts the new array by the numerical values in each 3-tuple and retains the top 10. It then returns the array of 10 items.
  SemiTimes: Given 2 arrays $a$ and $b$, for each element in $a$, it performs the semiTimes of Semiring 5 for every element in $b$. Then given the new array containing all resulting 3-tuples, it sorts the new array by the numerical values in each 3-tuple and retains the top 10. It then returns the array of 10 items.
  Space: $O(L^2K)$.

- Semiring 7
  0: It is a 3-tuple, with the integer 0 in the first position, a 3-tuple in the 2nd position, and an empty array in the third position. As for the 3-tuple in the 2nd position, it has an empty string in the first position, integer max in the 2nd and 0 in the third. This represents the word for a given span. The 2nd integer represents the start position and the 3rd integer represents the end position.
  1: It is a 3-tuple, with the integer 1 in the first position, a 3-tuple in the 2nd position and an empty array in the third position. As for the 3-tuple in the 2nd position, it has an empty string in the first position, integer max in the 2nd and 0 in the third position. This represents the word for a given span. The 2nd integer represents the start position and the 3rd position
  SemiPlus: Given 2 3-tuples $a$ and $b$, it returns the 3-tuple with the higher weight value in the first position.
  SemiTimes: Given 2 3-tuples $a$ and $b$, it returns the 3-tuple where the the 1st position stores the multiplicative result of the numerical values in $a$ and $b$. The array in the 3rd position stores the result after appending the word in $b$ to the array in $a$. The word in the new 3-tuple stores the word from $a$, the minimum of the two start positions and the maximum of the two end positions.
  Space: $O(XL^2)$

## Reverse CNF Transformation

**Answer:** No transforming the parse trees is sufficient. As the transformation of the Grammar to CNF is a deterministic process, the reverse transformation is also deterministic and therefore given a parse tree in CNF grammar, there can only be 1 tree after the reverse CNF process and therefore there is no need to recalculate the derivation scores.

## Agenda Pruning

**Answer:**

1. No. Agenda pruning depends on the heuristic used, and since heuristics cannot guarantee correctness, therefore it cannot guarantee to produce a parse if it exists.

2. Yes. Because the value of agenda items are calculated in a bottom-up manner items retain their values as if none of their children were pruned (for a rule to be instantiated both children have to be present) therefore any score calculated would be correct.

3. SENT 0 AGENDA ADDS: 387
   SENT 0 GOAL SCORE: None
   SENT 1 AGENDA ADDS: 31
   SENT 1 GOAL SCORE: 2.28006028891e-06
   SENT 2 AGENDA ADDS: 150
   SENT 2 GOAL SCORE: None
   SENT 3 AGENDA ADDS: 63
   SENT 3 GOAL SCORE: None
   SENT 4 AGENDA ADDS: 253
   SENT 4 GOAL SCORE: None
   SENT 5 AGENDA ADDS: 179
   SENT 5 GOAL SCORE: None

Agenda Pruning continued on next page...

SENT 6 AGENDA ADDS: 54
SENT 6 GOAL SCORE: 5.73824670126e-09
SENT 7 AGENDA ADDS: 49
SENT 7 GOAL SCORE: 1.25924395682e-08
SENT 8 AGENDA ADDS: 100
SENT 8 GOAL SCORE: None
SENT 9 AGENDA ADDS: 251
SENT 9 GOAL SCORE: None
SENT 10 AGENDA ADDS: 318
SENT 10 GOAL SCORE: None
No I did not produce parses for all sentences. No the final scores are not identical to the true scores. Pruning with a constant threshold is not a good idea as scores tend to decrease higher up the parse tree as more rule weights are multiplied together and since for this case the scores are probabilities, the score value would become very small near the root. A constant threshold would not take into account the changing values and remove agenda items in a long sentence.

4. SENT 0 AGENDA ADDS: 456
SENT 0 GOAL SCORE: 3.06412448871e-41
SENT 1 AGENDA ADDS: 31
SENT 1 GOAL SCORE: 2.28006028891e-06
SENT 2 AGENDA ADDS: 185
SENT 2 GOAL SCORE: 1.46131493773e-19
SENT 3 AGENDA ADDS: 64
SENT 3 GOAL SCORE: 4.52096543091e-13
SENT 4 AGENDA ADDS: 345
SENT 4 GOAL SCORE: 3.77079612505e-27
SENT 5 AGENDA ADDS: 198
SENT 5 GOAL SCORE: 2.20933417212e-15
SENT 6 AGENDA ADDS: 54
SENT 6 GOAL SCORE: 5.73824670126e-09
SENT 7 AGENDA ADDS: 49
SENT 7 GOAL SCORE: 1.25924395682e-08
SENT 8 AGENDA ADDS: 105
SENT 8 GOAL SCORE: 8.33570429924e-14
SENT 9 AGENDA ADDS: 330
SENT 9 GOAL SCORE: 2.21661096379e-22
SENT 10 AGENDA ADDS: 386
SENT 10 GOAL SCORE: 3.85139619145e-36
Yes parses were produced for all sentences. The final scores are identical to true scores without pruning.

**Acknowledgement:**