

Title: Viterbi and Beam Search
Module: COM6513 Natural Language Processing
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Description:

In this lab, a named entity recognition tool is implemented, in the prediction function, standard perceptron, Viterbi and beam search are used. The performance will be described and discussed in this report. The script is edited and compiled under Windows OS.

The f1 score of three algorithms are the same, which is 0.87678. The training speed of each algorithm is shown in table 1.

Table 1. Execution Time (each epoch)

Algorithm	Standard	Viterbi	Beam 1
Epoch 1	15.19	0.21	0.11
Epoch 2	15.33	0.19	0.12
Epoch 3	15.43	0.20	0.12
Epoch 4	15.52	0.20	0.12
Epoch 5	15.70	0.21	0.10
Average time	15.43	0.20	0.11

In table 1, Beam 1 means that using beam search with 1 beam width. Viterbi's average execution time is 0.20 s while the standard algorithm's is 15.43 s. The Viterbi algorithm is 77.15 times faster than standard algorithm. Beam search 1 is 1.82 times faster than Viterbi. With the beam width increases, the execution time gets longer, which is same as Viterbi when beam width is 4 and slower than Viterbi when the beam width is greater than 4.

Discussion:

Theoretically, beam search's f1 score is expected to be lower than Viterbi's score when the beam width is low. However, the f1 score of both algorithms are the same, beam search does not affect accuracy whatever the beam width is. This is because tag sequence is not considered. The best choice for each step is also the global optimization.

However, the beam width affects the execution time, the detailed information is shown in table 2.

Table 2. Execution Time (Different Beam Width)

Beam width	Beam 1	Beam 2	Beam 3	Beam 4	Beam 5
Epoch 1	0.11	0.14	0.18	0.22	0.21
Epoch 1	0.12	0.14	0.15	0.20	0.23
Epoch 1	0.12	0.13	0.17	0.19	0.20
Epoch 1	0.12	0.13	0.16	0.19	0.22
Epoch 1	0.10	0.14	0.17	0.18	0.22
Average Time	0.11	0.14	0.17	0.20	0.22

With beam width increasing, the execution time is longer while the f1 score is not affected. In this case, to get the shortest execution time, the best beam width is 1.

Notably, beam search with beam width of 5 is slower than Viterbi. The reason is that the complexity of beam 5 is very close to Viterbi's, and in this python script, the Viterbi is highly optimized while the beam search is not.