Step 4: POS tagging

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In this exercise we will implement a Markov POS tagger using the some of the outcomes of the preceding three steps.

1 The Tagger

Corpus: Use the training and test corpora which are given on 'blackboard'. The training corpus consists of sections 02-21 of the Wall Street Journal corpus (WSJ02-21.pos.gz) and the test corpus consists of section 23 of the Wall Street Journal corpus (WSJ23.pos.gz).

POS Tagger: This is a standard probabilistic POS tagger:

Language model: condition every POS on the two POS tags of the two preceding words (2nd order Markov model on POS tags – tri-grams).

Lexical model: every word depends only on its own POS (see the slides).

Tasks:

- Program the tagger in two steps:

  step 1: a trainings step in which the training corpus is used to estimate the probabilities for the models.

  step 2: a tagging step in which the program receives a sentence as input and outputs the most probable POS tag sequence for the sentence (given the estimated models), that is:

$$argmax_{tags} P(tags \mid input\ sentence)$$

- Test the tagger on the sentences of the test corpus and evaluate the output (compared with the 'correct' tagging given in the test corpus). Report precision and recall (see definitions below).
- Smooth both the lexical and the language model of the tagger using the Good-Turing method (previous exercise). Report precision and recall (compared with the 'correct' tagging given in the test corpus). For the language model, smooth only frequencies no greater than $k = 4$ (use the formulas of step 3).

  Smooth the lexical model separately for each tag (explain why?). Consider as unknown words only words which do not appear at all in the training corpus. (That is, if a word w appears in the training corpus but not with the tag t, then $P(w|t)$ remains 0 after smoothing.) When you smooth in this way, it does not matter how many unknown words there are and you can assume 1 unknown word when calculating the Good-Turing smoothing (i.e., $n_0 = 1$).

  Because many POS tags have a very low frequency, it is best to smooth the lexical model $P(word \mid tag)$ only for events with frequencies of 0 and 1. In this case we only give half of the frequency of events of frequency 1 to events of frequency 0. The formula is for this smoothing is:

  $$0^* = \frac{1}{2}\frac{n_1(t)}{n_0}$$

  $$1^* = \frac{1}{2}$$

  Because we assume that $n_0 = 1$ (the number of unknown words is 1) we get that for an unknown word u with tag T, $P(u|t) = \frac{1}{2}\frac{n_1(t)}{N(t)}$ which results in a higher probability for tags which have many words with frequency 1.

Definitions: The correctness of a tagger on a test corpus of length N words (sum of lengths of all sentences in the corpus) is given by:

$$Accuracy(tagger) = \frac{(number\ of\ words\ correctly\ tagged\ by\ tagger)}{N}$$

Here we only count words (that is, not the START and STOP symbols).

2 Instructions for the experiments

- Consider "./." or "============" as the end of a sentence. An empty line does not indicate the end of a sentence.
- Ignore, both in the training and the test corpus, all pairs X/Y where Y does not begin with an alphanumeric character (that is, all POS tags, such as punctuation, which do not begin with an alphanumeric character can be thrown out of the corpora).
- You may ignore all sentences in the *test* file longer than 15 words. Don't do this for the training corpus, so as not to lose valuable statistics.

3 To submit

- The program (incl source files), use the following command line:

  Trains the model, tests it on a given test file, save the predictions and reports the accurracy, with and without smoothing
  `./tagger -smoothing [yes|no] -train-set [path] -test-set [path] -test-set-predicted [path]`
- The test corpus tagged by your tagger (with and without smoothing).
- The accuracy of your tagger on the test corpus (with and without smoothing).
- Final report for all steps (see separate instructions on Blackboard).