Exercise #2
CSC/LIN 205, “Computational Linguistics”
Department of Computer Science
Grinnell College
November 9, 2016

The goal of this exercise is to develop a library representing hidden Markov models as a Scheme record type and implementing some basic algorithms involving those models.

0. The formal definition of hidden Markov models at the beginning of section 9.2.2 of the text suggests that a record type for representing such models needs five fields: the set of states of the model, the set of output symbols (“observables”) that it can produce, the initialization vector giving the initial probability of each state, the stochastic transition matrix, and a data structure of some sort giving the symbol emission probabilities.

Ideally, the definition of this type should be flexible enough to allow the implementation to represent, as special cases, (a) visible Markov models; (b) Markov models with single designated initial states, rather than initialization vectors; and (c) both arc-emission and state-emission hidden Markov models.

Write a Scheme record-type definition for hidden Markov models.

1. Place this record-type definition in a (computational-linguistics HMM) library. Add to this library definitions for specialized constructors for the various kinds of Markov models listed above, predicates to make sure that objects purporting to be HMMs really satisfy all of the constraints (e.g., the transition probabilities from a given state must sum to 1), and specialized selectors that might be useful as low-level operations on such records. Export the procedures you define (but not the helper procedures, unless they are useful in their own right outside the library).

2. Define and test a Scheme procedure that takes as arguments a hidden Markov model and a non-empty list of observations from the output alphabet for that model and returns the natural (base-e) logarithm of the probability that the model will generate the observations in that list, in the specified order.

(This procedure addresses the first of the three “fundamental questions for HMMs” formulated in section 9.3 of the textbook.)

This exercise will be due at the beginning of class on Monday, November 14. In that class, we’ll address the implementation of the Viterbi algorithm addressing the second of the “fundamental questions,” so it will be useful to have your library ready by then.

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