

## **OxWasp Project: Comparing methods of inference for hidden Markov models.**

### **Project aims.**

The aim of this project is to compare different methods to infer the parameters of hidden Markov models. Several methods are used in the literature, namely:

1. Calculate the likelihood using the forward algorithm and optimize the parameters.
2. Expectation-Maximisation via the Baum-Welch algorithm.
3. Heuristic fitting using Viterbi training.
4. Bayesian inference using a Monte-Carlo Markov Chain in which the likelihood is calculated using the forward algorithm and the parameters are updated using Metropolis-Hastings moves.
5. Bayesian inference using a Monte-Carlo Markov Chain in which the parameters and hidden states are updated using Gibbs moves.

### **Tasks.**

Start by implementing the maximum likelihood methods (1, 2, 3) and run them on the earthquake dataset we used in the lectures which is available at <http://bit.ly/2EXIScZ> for a Poisson-HMM with three states. One aspect of the comparison is speed of the methods. Another is accuracy of the inference, and you should use simulated data to assess this. A third aspect is the risk of each method to get stuck in a local maxima of the likelihood. Your comparison should be as thorough and fair as possible, fully exploring the conditions in which one method works better than another.

If time allows, implement the two Bayesian methods (4, 5) and compare them in a similar way, at least to each other, and perhaps also (when you think it makes sense) to the maximum likelihood methods (1, 2, 3).

### **References.**

Rabiner LR. A tutorial on hidden Markov models and selected applications in speech recognition. Proc IEEE. 1989;77: 257–286. doi:10.1109/5.18626

Visser I, Speekenbrink M. depmixS4: An R Package for Hidden Markov Models. J Stat Softw. 2010;36: 1–21. doi:10.18637/jss.v036.i07