Complete and hand in *one of the following* exercises before 31st of January, 2003 to the course assistant (Room C311 in the computer science building). The exercise will affect your grade on the course. In all exercises, provide the program code and a sufficient amount of working examples for demonstration.

1 Hidden Markov Model

Make your own implementation of the Hidden Markov model. Introduce the data structures you use in the model; preferably make it possible to use arbitrary emission probability densities. At the least, Gaussian emission probability densities and multinomial probability distributions should be implemented.

Implement the filtering (forward) and smoothing (backward) algorithms for inference separately, also enabling missing data. Next, implement the learning algorithms for the transition probablities, prior probabilities, and the emission probability models. In the Gaussian case, implement the use of tied covariance matrices. In the learning of transition matrices, implement the use of Dirichlet priors. Sampling from the HMM should also be implemented.

2 Contrastive divergence mean-field learning

Implement the contrastive divergence mean-field learning in Boltzmann machines as presented in (Welling and Hinton, 2002). Keep your model within reasonable complexity in order to avoid some problems. Create your own data set for a small-scale pattern completion task and test how the Boltzmann machine is able to solve it. Additionally, you may implement some other learning technique used in Boltzmann machines in which case you should compare the approaches.

3 Constructing the junction tree

Construct a program to create a junction tree from the Bayesian network. Start with a directed acyclic graph (DAG) and the transform it a moral graph. See what heuristic algorithms are available for triangulating a moral graph. Implement and compare some of the approaches. If you want, you can implement your own heuristics and state the properties in light of some examples. You can ask for some starting points in the literature from the lecturer.