CS 5313/7313: Advanced AI

Probabilistic Reasoning over time

The problems in this set will require you to implement algorithms, collect test/training data, and report analysis of experimental results[1]. Submit code, data, and reports with detailed analysis and supporting documentation including graphs and tables as necessary.

Hidden Markov Models (HMMs): Solve Exercise 15 to develop an HMM and do calculations for at least t=1 and 2 for Exercise 17 (available here) to develop a clear understanding of the problem. Then implement the following algorithms:

- exact HMM smoothing algorithm using constant space, the forward-backward *Country-Dance algorithm* (use the process described in pages 474–475 of the textbook), and
- the *online* fixed-lag smoothing algorithm in Figure 14.6,
- the most likely sequence of states, using the *Viterbi algorithm* (refer to the algorithm on page 5 of the MarkovModels.pdf document).

You will use these algorithms to compute the state estimation, smoothing, and fixed-lag smoothing (report results from lag values over the range [2,5]) probabilities for the scenarios in Exercise 17 above, but for all $t \in \{1 \dots 25\}$.

Dynamic Bayesian Networks (DBN): For the domain presented in Figure 14.7, consider the DBN formulation where each state consists of a $\langle location, heading \rangle$ pair which results in a state space size of $42 \times 4 = 168$. Use the environment simulator provided to obtain the sequence of observations.

Implement the *particle filtering* algorithm (Figure 14.17) for approximate inference in DBNs and compute the filtering probabilities of the posterior distribution of the robot state from observations received for each time step $t = [1, \dots, 100]$. For each time step, report the most likely state(s) (multiple states if they all have the same highest probability) and the corresponding probability.

[1] Numbered exercises and figures the Russell & Norvig AIMA textbook (4th Edition).