Artificial Intelligence DD2380, HT 2009
Homework 3

Due: See BILDA (around October 5)
Where: BILDA.
Scope: This homework covers chapters 11-17 and 22-23.

Instructions

In the spirit of the goal oriented grading system this homework starts with some general questions (part A) for receiving a passing grade. You are to solve Part A of the homework individually and hand it in (upload to BILDA) individually and the answers must be in your own words. Upload the answers as a single **pdf**-file.

The second part of the homework (Part B) requires you to make an implementation to solve a problem. You are encouraged to solve this part of the homework in pairs. You have to use a programming language that is freely available and commonly known (Matlab, Python, C/C++, Java) and you have to provide the source code as well for testing. The results of Part B should be uploaded to BILDA separately from Part A. Each upload should be **a SINGLE zip-file**. See BILDA for more instructions.

The third part (Part C) cannot be started until after you have handed in Part A and B. If you want to do Part C but not Part B, please follow instructions on BILDA for Part B (to let us know your preferred language).

We expect you to follow the code of honor (http://www.csc.kth.se/utbildning/hederskodex/).

Grading

The max number of points on parts A-C is 70p. The grade is given by

A	≥ 58
B	≥ 47
C	≥ 36
D	≥ 24
E	≥ 12

Language

The homework should be written in English.

Part A

Exercise 1, 16p

Each of the below questions is worth max 2p.

1. Explain the difference between regression and progression planners and give example of cases where we prefer one before the other.
2. Write Bayes' theorem and annotate different terms. Explain the difference between ML and MAP estimators and how they relate to the Bayes theorem.
3. Why do we prefer to use graphical models such as Bayesian networks when dealing with probabilities? Give an example of a Bayesian network.
4. What is a first order Markov process? What is meant by 'hidden' in hidden Markov models?
5. What is a usual notation for a hidden Markov model? What are the three problems usually considered in the scope of hidden Markov Models?
6. Explain the concept of belief state in the context of POMPDs. Given an example to illustrate (not from the book).
7. Which model is likely to generate strings that are closer to humanlike, a unigram model or a bigram model and why?
8. Explain the difference between a plan and a policy

Exercise 2, 6p

Parse the string "The winter is cold and I hate the cold" using the simple grammar for ϵ_0 described in the book. Do parsing using

1. bottom-down parsing (**3p**)
2. top-down parsing (**3p**)

Explain your steps.

Exercise 3, 4p

Imagine that you want to set up a business for selling used things. Discuss a strategy for how to handle the bidding process assuming that the bids will be called in by phone and can therefore be considered rather costly. Back up your motivation with references to the literature.

Exercise 4, 12p

Your housekeeping robot operates on a battery. You can monitor the state of the battery by looking into BatteryLevel display consisting of four bars: when all four are lightened, the battery should be full. However, sensing battery level is rather noisy: if the robot bumps into something, the display may be indicating an empty battery (1 bar lightened) even if the battery is full. The Hidden Markov Model for the problem is given below with state transition and observation matrices.

	1/4 FULL	1/2 FULL	3/4 FULL	FULL
1/4 FULL	0.8	0.1	0.02	0.08
1/2 FULL	0.3	0.6	0.01	0.09
3/4 FULL	0.1	0.17	0.65	0.08
FULL	0.1	0.2	0.3	0.4

	BAR-I	BAR-II	BAR-III	BAR-IV
1/4 FULL	0.9	0.05	0.04	0.01
1/2 FULL	0.12	0.7	0.1	0.08
3/4 FULL	0.1	0.15	0.7	0.05
FULL	0.1	0.05	0.2	0.65

1. Start by drawing a model of the system with hidden and observable states annotated. Do not forget to draw all the connections in between the hidden states, as well as between states and observations. (**4p**)

2. Assuming that the initial state of the battery is *FULL* and that there you observed the display three times as O = $\{o_1 = BAR - IV, o_2 = BAR - I, o_3 = BAR - II\}$, fill in the tables below using forward and backward estimation methods, (**4p**):

FORWARD	π	t_1	t_2	t_3
1/4 FULL				
1/2 FULL				
3/4 FULL				
FULL				

BACKWARD	π	t_1	t_2	t_3
1/4 FULL				
1/2 FULL				
3/4 FULL				
FULL				

3. What can you tell about the battery status in each point of time and what is the prediction of battery state in next time instance? (**4p**)

You can choose to do estimations either by implementing the code for forward and backward procedures or to do the estimations by hand. In the case of former, you need to supply the code. In the case of later, you need to provide all the steps in the calculation and not just the final results.

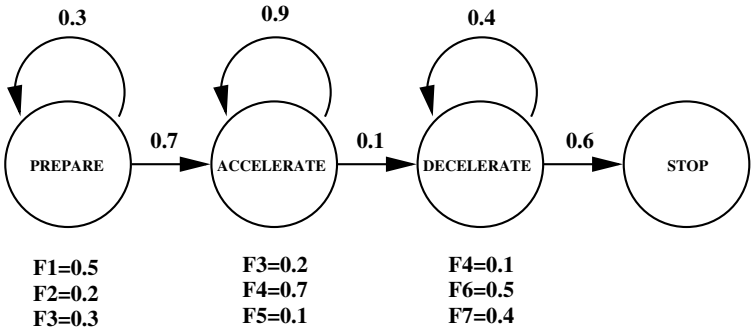
Part B

Exercise 5, 22p

You have developed an automatic video annotation system for annotating recorded running sequences of Usain Bolt. The system takes as an input images from a video stream of a running sequence, extract some visual data and annotates each image as:

- Usain is preparing for running
- Usain runs/accelerates
- Usain decelerates

You have built the following model for the system:



Here, $F1 \dots F7$ represent seven ways of classifying each video frame and their probabilities of being observed in each state. The states are annotated by x_t and observations in each time step are represented by o_t.
Thus, the system divides a video sequence in several video frames and each of them is classified to one of the $F1 \dots F7$. You use the system to estimate the following:

a What is $P(x_2 = ACCELERATE)$? (**2p**)

b What is $P(o_2 = F2)$? (**3p**)

c What is $P(x_2 = ACCELERATE | o_2 = F2)$? (**3p**)

d Describe shortly if the suggested model is realistic regarding i) the type of the HMM, ii) number of states, etc. Also, describe what procedures should be used for estimating the model and how training data would be generated. (**4p**)

e If we assume $o_1 = F1$, $o_2 = F2$, $o_3 = F3$, $o_4 = F4$, $o_5 = F4$, $o_6 = F6$, $o_7 = F7$. What is the most likely (in HMM sense) sequence of states? (**5p**)

f If we assume $o_1 = F1$, $o_2 = F3$, $o_3 = F4$, $o_4 = F5$, $o_5 = F6$. What is the most likely (in HMM sense) o_6? (**5p**)

You can choose to do subtasks (a)-(c) in code or by hand. In the case of former, you need to supply the code. In the case of later, you need to provide all the steps in the calculation and not just the final results.

Subtasks (e) and (f) should be solved by implementing the Viterbi algorithm. Do not forget to attach the code.

Part C

Exercise 5, 10p

After submission of Part A and B, you will be assigned somebody elses homework for a review. You will need to upload the review to BILDA. See BILDA for more info.