

MiniProject 3

ECE/CS 4720-7720 Machine Learning and Pattern Recognition

Write a program to evaluate the Bayesian belief network for the **modified** fish example in the textbook using the following information regarding $P(a_i)$, $P(b_j)$, $P(x_l|a_i, b_j)$, $P(c_k|x_l)$, and $P(d_m|x_l)$ – i.e. refer to the dependencies/graph in Example 4, in Chapter 2, but use the tables provided here instead.

$P(a)$			
$P(a_1 = \textit{Winter})$	$P(a_2 = \textit{Spring})$	$P(a_3 = \textit{Summer})$	$P(a_4 = \textit{Autumn})$
0.25	0.25	0.25	0.25

$P(b)$		
$P(b_1 = \textit{NorthAtlantic})$	$P(b_2 = \textit{MidAtlantic})$	$P(b_3 = \textit{SouthAtlantic})$
0.4	0.2	0.4

$P(X/a, b)$			
	$P(X_1 = \textit{Salmon} a_i, b_j)$	$P(X_2 = \textit{Tuna} a_i, b_j)$	$P(X_3 = \textit{SeaBass} a_i, b_j)$
a_1, b_1	0.6	0.2	0.2
a_1, b_2	0.5	0.3	0.2
a_1, b_3	0.8	0.1	0.1
a_2, b_1	0.7	0.1	0.2
a_2, b_2	0.4	0.3	0.3
a_2, b_3	0.3	0.5	0.2
a_3, b_1	0.2	0.3	0.5
a_3, b_2	0.6	0.1	0.3
a_3, b_3	0.2	0.1	0.7
a_4, b_1	0.1	0.1	0.8
a_4, b_2	0.1	0.3	0.6
a_4, b_3	0.2	0.7	0.1

$P(c/X)$			
	$P(c_1 = \textit{light} X_l)$	$P(c_2 = \textit{medium} X_l)$	$P(c_3 = \textit{dark} X_l)$
X_1	0.3	0.3	0.4
X_2	0.5	0.3	0.2
X_3	0.4	0.2	0.4

$P(d/X)$			
	$P(d_1 = \textit{wide} X_l)$	$P(d_2 = \textit{average} X_l)$	$P(d_3 = \textit{thin} X_l)$
X_1	0.3	0.4	0.3
X_2	0.4	0.2	0.4
X_3	0.2	0.3	0.5

Test your program on the cases given below – **present the results in your report**, and state any assumptions you made. You should also try/report at least 3 other 'queries' of your own.

- (a) A light, thin fish is caught in the North Atlantic in the Summer. What is the probability it is a SeaBass? How about Tuna?
- (b) An average, light fish is caught in the North Atlantic. What is the probability it is winter? spring? summer? autumn?
- (c) A median, thin fish is caught in the Summer. What is the probability it came from the Mid Atlantic?

Hint: to solve this problem, you must remember what is $P(A, B \mid C)$ in terms of $P(A, B)$ and $P(C)$ – then, you must also remember how to find, say, for the same example, $P(A, B)$ from $P(A, B, C)$ and $P(C)$ also from $P(A, B, C)$.

HW3 Solution Key

THE MAIN FUNCTION CAN BE CALLED USING ANY COMBINATION OF 'a1', 'a2', ... 'd1', 'winter', 'summer', 'thin', 'ci', etc... (and in any order)

For example:

`pabxcd_cond_abxcd('winter');` $\Rightarrow P(a_1)$
`pabxcd_cond_abxcd('salmon', 'l', 'winter');` $\Rightarrow P(x_1, l, a_1)$
`pabxcd_cond_abxcd('salmon', 'l', 'thin', 'dark');` $\Rightarrow P(x_1, l, x_2, c_1)$

```
File: /home/gdesouza/Classes/ec7728/Code/pabxcd_cond_abxcd.m #1
function ret = pabxcd_cond_abxcd(varargin)
% This function calculates the probability of a sequence of linguistic terms
% given a set of parameters. The input is a vector of linguistic terms, and
% the output is a scalar representing the probability.
% The function is implemented using nested loops to calculate the
% probability of each term given the previous terms.
% The function is implemented using nested loops to calculate the
% probability of each term given the previous terms.
```

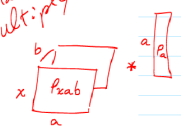
The last function is not really necessary. I used it only to scan the input and also

```
File: /home/gdesouza/Classes/ec7728/Code/scaninput.m #1
function [a,b,x,c,d,ca,cb,cc,cd] = scaninput(varargin)
% This function scans the input parameters and converts from
% 'winter' to 'a1', 'salmon' to 'x1', 'thin' to 'd2', etc...
% If the input parameters are already 'a1', 'x1', etc..., then it
% just keeps them as they are.
```

to find and to sort the possible linguistic terms (e.g. 'winter', 'a1', 'b1', 'thin', etc...).
 That is: 'thin', etc...
 The only purpose of this function is to allow the main function (istone) to be called w/ variable # of parameters and in any order

The second function is used to actually

```
File: /home/gdesouza/Classes/ec7728/Code/pabxcd.m #1
function ret = pabxcd(a,b,x,c,d)
% This function calculates the probability of a sequence of linguistic terms
% given a set of parameters. The input is a vector of linguistic terms, and
% the output is a scalar representing the probability.
% The function is implemented using nested loops to calculate the
% probability of each term given the previous terms.
% The function is implemented using nested loops to calculate the
% probability of each term given the previous terms.
```

calculate $P(a,b,x,c,d)$. Please, notice that nested loops are not required.
 This loop is because Matlab simply doesn't multiply 3D matrices:


This is just a few examples of the program being called.

```
File: /home/gdesouza/Classes/ec7728/Code/hw3.m #1
% Main program -- test
clear all
global pa pb pxab pcx pdx
pa=[0.25;0.25;0.25;0.25];
pb=[0.6;0.4];
pxab(:,:,1)=[0.5 0.6 0.4 0.2; 0.5 0.4 0.6 0.2];
pxab(:,:,2)=[0.7 0.8 0.1 0.3; 0.3 0.2 0.9 0.7];
pcx=[0.6 0.2; 0.2 0.3; 0.2 0.5];
pdx=[0.3 0.6; 0.7 0.4];

% Ex. on Page 59
pabxcd_cond_abxcd('summer', 'north', 'sea', 'dark', 'thin') % P(a3,b1,x2,c3,d2) = 0.038

% Ex. on Page 61
pabxcd_cond_abxcd('x1', 'b2', 'c1') % P(x1,c1,b2) = alpha*0.114
pabxcd_cond_abxcd('c1', 'b2', 'x2') % P(x2,c1,b2) = alpha*0.042

pabxcd_cond_abxcd('south', 'light') % P(c1,b2) = alpha = 0.156

pabxcd_cond_abxcd('x1','b2','c1') % P(x1,c1,b2) = P(x1,c1,b2)/P(c1,b2) = 0.73
pabxcd_cond_abxcd('x2','b2','c1') % P(x2,c1,b2) = P(x2,c1,b2)/P(c1,b2) = 0.27

% HW question 2 on Page 81 - Ex.9a
pabxcd_cond_abxcd('salmon','l','dark','thin','north','summer')
```

Figure 1: Solution for Question 2

Above is my **entire** solution for the original problem in the textbook. It is shown 'redacted' here just to give you an idea of how short and compact (number of lines) you should expect a solution for this problem to be. In other words, this problem is 90% inspiration and 10% perspiration.

I used Matlab, but as always, **you do NOT have to solve it in Matlab** and a solution in any other language+vector-library should be as compact.