Information

Flag question

Bayesian Networks and Distributions

Which of the following statements about Bayesian Networks are correct?

Question 1

Correct

Mark 1.00 out of 1.00

Flag question

In a Bayesian network, any variable must have at least one parent

- True
- False ✓

The correct answer is 'False'.

Question 2

Correct

Mark 1.00 out of 1.00

Flag question

The Chain Rule for Bayesian Networks is only valid when there are conditional independencies in the network

- True
- False ✓

The correct answer is 'False'.

Question 3

Incorrect

Mark 0.00 out of 1.00

Flag question

If a variable A in a network is independent of some other variable B, then B is also independent of A

- True
- False ✗

The correct answer is 'True'.

Question 4

Correct

Mark 1.00 out of 1.00

Flag question

A variable that is not connected to any other variables in a network does not contribute to the probability of an atomic event

- True
- False ✓

The correct answer is 'False'.

Question 5

Incorrect

Mark 0.00 out of 1.00

Flag question

A fully connected Bayesian network (i.e., a network without any independencies) defined over N Boolean variables must have exactly $2^N - 1$ non-redundant parameters

- True
- False ✗

The correct answer is 'True'.

Question 6

Correct

Mark 1.00 out of 1.00

Flag question

For any full joint distribution defined over a set of variables $\mathcal{X}$ there is exactly one Bayesian network over $\mathcal{X}$ that represents this joint distribution

- True
- False ✓

Question 7
Incorrect
Mark 0.00 out of 1.00
Flag question

A variable that is not connected to any other variables in a network is not part of the full joint distribution

- True ✗
- False

The correct answer is 'False'.

Information
Flag question

Consider a world defined by the following set $\mathcal{X}$ of random variables:

- $Sun(S) = \{\text{yes}, \text{no}\}$
- $Day(D) = \{\text{mo}, \text{tue}, \text{wed}, \text{thu}, \text{fr}, \text{sat}, \text{sun}\}$
- $Work(W) = \{\text{home}, \text{office}, \text{none}\}$
- $Mood(M) = \{\text{low}, \text{med}, \text{high}\}$

Information
Flag question

Think of the following distributions (or sets of distributions) as multi-dimensional tables. For each of the following items, say how many dimensions (axes) the corresponding table has, and how many entries (numbers) this table will contain (ignore redundancies):

Question 8
Correct
Mark 1.00 out of 1.00
Flag question

$P(W \mid S)$

Dimensions: 2 ✓
Entries: 6 ✓

Question 9
Correct
Mark 1.00 out of 1.00

$P(D \mid M = low, W = office)$

Dimensions: 1 ✓

Question 10
Correct
Mark 1.00 out of 1.00
Flag question

$P(D, W, M \mid S)$

Dimensions: 4 ✓
Entries: 126 ✓

Question 11
Correct
Mark 1.00 out of 1.00
Flag question

$P(D, W \mid S, M)$

Dimensions: 4 ✓
Entries: 126 ✓

Question 12
Incorrect
Mark 0.00 out of 1.00
Flag question

If we know that $(S, W, M \perp D)$ (that is, $(Sun, Work, Mood)$ and Day are independent), then how many **non-redundant** parameters do we need at most to represent the full joint distribution?

Answer: 17 ✗

The correct answer is: 23

Question 13
Incorrect
Mark 0.00 out of 1.00
Flag question

How many **non-redundant** parameters would need to be specified for the following simple Bayesian Network:

$D \longrightarrow S \longrightarrow W \longrightarrow M$

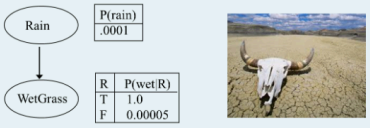
Answer: 22 ✗

The correct answer is: 23

Information
Flag question

Inference in BNs

Consider our simple Death Valley model from the lecture:



P(rain)
.0001

R	P(wet|R)
T	1.0
F	0.00005

Information
Flag question

Calculate the following entry(ies) from the joint distribution $P(R, W)$:

Question 14
Correct
Mark 1.00 out of 1.00
Flag question

$P(r, w) =$

- $.0001 * 1.0 + .9999 * .00005$
- $.0001 * .0001/1.0$
- $.0001 * 1$ ✓
- $.0001 + 1.0$

Your answer is correct.
The correct answer is: $.0001 * 1$

Question 15
Incorrect
Mark 0.00 out of 1.00
Flag question

$P(\neg r, \neg w) =$

- $.9999 * 0.0$
- $.9999 + .00005$
- $.9999 * .00005$ ✗
- $.9999 * .99995$

Your answer is incorrect.
The correct answer is: $.9999 * .99995$

Question 16
Incorrect
Mark 0.00 out of 1.00
Flag question

If we randomly draw $10,000$ samples from this network via Forward Sampling, what is the expected number of samples with $R = true$?

Answer: 0 ✗

The correct answer is: 1

Question 17
Correct
Mark 1.00 out of 1.00
Flag question

If we estimate $P(r \mid \neg w)$ via Rejection Sampling, we will always get a division by zero.

- True
- False ✓

The correct answer is 'False'.

Information
Flag question

Assume our algorithm for drawing samples from the network is defective in the sense that it *always* draws the value from a distribution that has the highest probability, and assume we use that algorithm to draw a sample of size 100 from t
model. What would be the estimates, from this sample set, that we get by Rejection Sampling for the following queries (**enter -1** in case the calculation includes a **division by zero**):

Question 18
Incorrect
Mark 0.00 out of 1.00
Flag question

$P(r, w)$

Answer: 0.0001 ✗

The correct answer is: 0

Question 19
Correct
Mark 1.00 out of 1.00
Flag question

$P(\neg r | \neg w)$

Answer: 1 ✓

The correct answer is: 1

Question 20
Correct
Mark 1.00 out of 1.00
Flag question

$P(\neg r, w)$

Answer: 0 ✓

Question 21
Correct
Mark 1.00 out of 1.00
Flag question

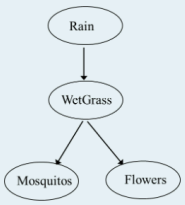
$P(w | \neg r)$

Answer: 0 ✓

The correct answer is: 0

Information
Flag question

Now consider a slightly extended Death Valley model with the following structure, with *Mosquitos* and *Flowers* being Boolean variables, and let us abbreviate the variable names by their initial letters *R, W, M, F*.



Consider the query $P(Rain \mid m)$:

Question 22
Incorrect
Mark 0.00 out of 1.00
Flag question

How many edges (arrows) does the Mutilated Network for this query have?

- 4
- 1 ✗
- 3
- 2
- 0
- 5

Your answer is incorrect.
The correct answer is: 2

Information
Flag question

Which of the four variables will have their distribution tables modified in the Mutilated Network (compared to the original network)? Choose true in case the distribution table changes for the respective variable.

Question 23
Incorrect
Mark 0.00 out of 1.00
Flag question

F

- True ✗
- False

Question 24
Correct
Mark 1.00 out of 1.00
Flag question

M

- True ✓
- False

The correct answer is 'True'.

Question 25
Correct
Mark 1.00 out of 1.00
Flag question

R

- True
- False ✓

The correct answer is 'False'.

Question 26
Correct
Mark 1.00 out of 1.00
Flag question

W

- True
- False ✓

Question 27
Correct
Mark 1.00 out of 1.00
Flag question

$P(M)$

- True
- False ✓

The correct answer is 'False'.

Question 28
Correct
Mark 1.00 out of 1.00
Flag question

$1/Z \times P(M)P(F)P(W)P(R)$

- True
- False ✓

The correct answer is 'False'.

Question 29
Correct
Mark 1.00 out of 1.00
Flag question

$1/Z \times P(M|W,F,R)$

- True ✓
- False

The correct answer is 'True'.

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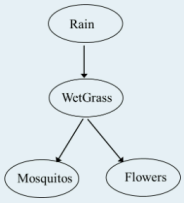
Information
Flag question

Parameter Learning

Assume we have four Boolean random variables *Rain, Wet, Mosquitos, Flowers* (R, W, M, F) that describe the state of a particular place in Death Valley, and assume we have a training set $\mathcal{D}$ consisting of 1000 samples (atomic events) from this world. Also, assume we are given the following graph structure for a potential model:



Information
Flag question

Maximum Likelihood Parameter Learning:

Question 30
Correct
Mark 1.00 out of 1.00
Flag question

How many non-redundant parameters do we have to learn for this network?

- 12
- 4
- 8
- 7 ✓
- 16
- 3
- 15

Question 31
Correct
Mark 1.00 out of 1.00
Flag question

If in $\mathcal{D}$, the values of M and F are completely correlated (in each sample, the value for M (t or f) is equal to the value of F), the distribution tables learned for M and F by Maximum Likelihood are identical.

- (•) True ✓
- ( ) False

The correct answer is 'True'.

Question 32
Incorrect
Mark 0.00 out of 1.00
Flag question

Suppose that all examples in $\mathcal{D}$ have w (i.e., $W = true$), and 500 samples in $\mathcal{D}$ have f (i.e., $F = true$). Which of the following (if any) is the estimate for $P(F|w)$ that Laplace Smoothing with $\alpha = 1$ will return (where we always first write the value for true, then for false):

- (•) $[.5 + 1, .5 + 2]$ ✗
- ( ) $[.5, .5]$
- ( ) $[.501, .501]$
- ( ) $[.409, .501]$
- ( ) $[.501, .499]$

Your answer is incorrect.
The correct answer is: $[.5, .5]$

Information
Flag question

Bayesian Parameter Learning:
Suppose we have a dataset $\mathcal{D}$ of size 1000, 500 of these have $R = true$ and 500 have $R = false$. Consider the task of learning the parameter $\theta = P(R = \text{true})$ by Bayesian Parameter Estimation. Which of the following statements are true:

Question 33
Correct
Mark 1.00 out of 1.00
Flag question

If we use a uniform (flat) prior distribution, the posterior will be equal to the prior

- ( ) True
- (•) False ✓

The correct answer is 'False'.

Question 34
Incorrect
Mark 0.00 out of 1.00
Flag question

If we use a uniform (flat) prior distribution, the MAP estimate for θ will be 0.5

- ( ) True
- (•) False ✗

The correct answer is 'True'.

Question 35
Incorrect
Mark 0.00 out of 1.00
Flag question

If we use a uniform (flat) prior distribution, the Posterior Mean estimate for θ will be 0.5

- ( ) True
- (•) False ✗

The correct answer is 'True'.

Question 36
Correct
Mark 1.00 out of 1.00
Flag question

If we use a uniform (flat) prior distribution, the ML estimate for θ will be 0.5

- (•) True ✓
- ( ) False

The correct answer is 'True'.

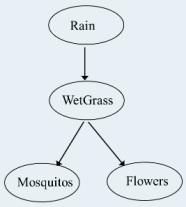
Retake Exam WS2023/24

Information
Flag question

Model Fitting and Structure Learning

Assume we have four Boolean random variables $Rain, Wet, Mosquitos, Flowers(R, W, M, F)$ that describe the state of a particular place in Death Valley, and assume we have a training set $\mathcal{D}$ consisting of 1000 samples (atomic events) from this world.

Further, assume a structure learning algorithm is currently considering the following graph structure, given a training set $\mathcal{D}$ consisting of 1000 and using the BIC Score for structure evaluation:



In which of the following cases will the **regularisation term** in the BIC score change:

Question 37
Incorrect
Mark 0.00 out of 1.00
Flag question

if we multiply the log likelihood term in the BIC with a constant > 1

- (•) True ✗
- ( ) False

The correct answer is 'False'.

Question 38
Correct
Mark 1.00 out of 1.00
Flag question

if we remove an edge from the above model structure

- (•) True ✓
- ( ) False

The correct answer is 'True'.

Question 39
Incorrect
Mark 0.00 out of 1.00
Flag question

if we add an additional edge to the above model structure

- ( ) True
- (•) False ✗

The correct answer is 'True'.

Question 40
Incorrect
Mark 0.00 out of 1.00
Flag question

if we increase the number of values that variable F can take

- ( ) True
- (•) False ✗

The correct answer is 'True'.

Question 41
Incorrect
Mark 0.00 out of 1.00
Flag question

if we duplicate all examples in training set $\mathcal{D}$

- ( ) True
- (•) False ✗

The correct answer is 'True'.

Information
Flag question

HMMs

Assume you have inherited the favorite cat of the late physicist Erwin Schroedinger, along with the box she lives in:

Before closing the box with the cat inside, you equip the cat with a little measurement device that measures, once a second, whether the cat is alive, and sends a corresponding boolean signal to you. You close the box and then eagerly watch the signals coming out of the box to infer the (hidden) state of your beloved cat.

Let us model this story with two Boolean variables $CatState(S) = \{alive, dead\}$ and $SignalObs(O) = \{alive, dead\}$, and make the following assumptions:

- The moment after you close the box (which we call $t = 0$), the cat will definitely be alive.
- If the cat is alive now, there is a 90% probability she is also going to be alive the next second. When she's dead, she will remain dead, unfortunately.
- The measurement device is highly reliable: when the cat is dead, the device will always send "dead"; when she is alive, there is a 1% chance that the device will erroneously report "dead"; otherwise, it will report "alive".

Information
Flag question

Fill in the parameters for a HMM that models this scenario:

Question 42
Incorrect
Mark 0.00 out of 2.00
Flag question

$\Pi = \ldots$:

$\Pi(\text{alive}) =$ 2 ✗

$\Pi(\text{dead}) =$ 1 ✗

Question 43
Partially correct
Mark 2.00 out of 4.00
Flag question

$\mathbf{A} = \ldots$

$P(\text{alive} \mid \text{alive}) =$ 1 ✗

$P(\text{dead} \mid \text{alive}) =$ 0 ✗

$P(\text{alive} \mid \text{dead}) =$ 0 ✓

$P(\text{dead} \mid \text{dead}) =$ 1 ✓

Question 44
Partially correct
Mark 2.00 out of 4.00
Flag question

$\mathbf{B} = \ldots$

$P(\text{alive} \mid \text{alive}) =$ 1 ✗

$P(\text{dead} \mid \text{alive}) =$ 0 ✗

$P(\text{alive} \mid \text{dead}) =$ 0 ✓

$P(\text{dead} \mid \text{dead}) =$ 1 ✓

Information
Flag question

Which of the following statements about this model are correct:

Question 45
Incorrect
Mark 0.00 out of 1.00
Flag question

Regardless of the observations, the probability that the cat is alive diminishes with every time step

- True
- False ✗

Question 46
Incorrect
Mark 0.00 out of 1.00
Flag question

It is possible that there exists a sequence of signal observations so that the Viterbi algorithm will return a state sequence with at least one transition from "dead" to "alive"

- True ✗
- False

The correct answer is 'False'.

Question 47
Correct
Mark 1.00 out of 1.00
Flag question

Given a probability distribution over the current state of the cat, the model permits us to make predictions over future signal observations.

- True ✓
- False

The correct answer is 'True'.

Question 48
Correct
Mark 1.00 out of 1.00
Flag question

The pointwise product of forward and backward message sums to 1.0

- True
- False ✓

The correct answer is 'False'.

Question 49
Correct
Mark 1.00 out of 1.00
Flag question

The state distribution of the cat at a given time point t is independent of future signal observations (i.e., observations that happen after t)

- True
- False ✓

The correct answer is 'False'.

Question 50
Incorrect
Mark 0.00 out of 1.00
Flag question

For any t, if $O^{(t)} = dead$, the probability that the cat is alive is 1%

- True ✗
- False

The correct answer is 'False'.

Question 51
Incorrect
Mark 0.00 out of 1.00
Flag question

The development of the cat's true state over time is a Markov process

- True
- False ✗

The correct answer is 'True'.

Information

Flag question

Linear Gaussian Models

Consider the simple "Consumer Confidence Index" model from the lecture slides, with (real-valued) random variables X (consumer confidence) and Z (survey outcome).

Information

Flag question

Which of the following distributions (if any) does the Kalman Filtering Algorithm calculate?

Question 52

Correct

Mark 1.00 out of 1.00

Flag question

$\mathcal{N}(x^{(t-1)}, \epsilon_x)$

- True
- False ✓

The correct answer is 'False'.

Question 53

Correct

Mark 1.00 out of 1.00

Flag question

$\mathcal{N}(x^{(t)} + z^{(t)}, \epsilon_z)$

- True
- False ✓

The correct answer is 'False'.

Question 54

Correct

Mark 1.00 out of 1.00

Flag question

$P(Z^{(t)} \mid x^{(t)})$

- True
- False ✓

The correct answer is 'False'.

Question 55

Correct

Mark 1.00 out of 1.00

Flag question

$P(Z^{(t)} \mid \mathbf{x}^{(1:t)})$

- True
- False ✓

The correct answer is 'False'.

Information

Flag question

Which of the following assumptions about consumer confidence and surveys are encoded in the specific transition and observation model that we specified in the lecture slides:

Question 56

Incorrect

Mark 0.00 out of 1.00

Flag question

that, if the σ_x^2 is positive, X can only grow over time (or stay the same)

- True ✗
- False

The correct answer is 'False'.

Question 57
Correct
Mark 1.00 out of 1.00
Flag question

that the current consumer confidence $x^{(t)}$ completely determines the value of the survey $z^{(t)}$

- True
- False ✓

The correct answer is 'False'.

Question 58
Incorrect
Mark 0.00 out of 1.00
Flag question

that consumer confidence and survey outcomes are measured on the same scale

- True
- False ✗

The correct answer is 'True'.

Question 59
Correct
Mark 1.00 out of 1.00
Flag question

that the expected value (mean) of $X^{(t+1)}$ is the previous value $x^{(t)}$

- True ✓
- False

The correct answer is 'True'.

Question 60
Correct
Mark 1.00 out of 1.00
Flag question

that $Z^{(t+1)}$ and $Z^{(t)}$ are independent

- True
- False ✓

The correct answer is 'False'.