Habib University - City Campus
Course Title: CS452 – Probabilistic Graphical Models
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Class ID: 1117
Examination: Midterm Exam – Fall 2024   Exam Date: Oct 10, 2024
Total Marks: 25 points   Time: 70 mins

Instructions for students:
- The question paper must be returned at the end of exam along with the answer script.
- All answers must be given on answer script.

Q1 **[06 points]** A few weeks after planting a crop, there are three tests available to detect if the crop is infected with a certain pest. The first is a leaf inspection test, which has a false positive rate of 5% and a false negative rate of 15%. The second is a soil test, which can detect pest larvae with a false positive rate of 12% and a false negative rate of 25%. The third is a plant sap test that also detects pests larvae, with a false positive rate of 8% and a false negative rate of 18%. The probability of detecting pest larvae in the soil is 85% if the crop is infected and 5% if the crop is not infected. The probability that the crop is infected by the pest after planting is 80%.

Construct a Bayesian network for this scenario. Specify all prior and conditional probabilities as given in the scenario.
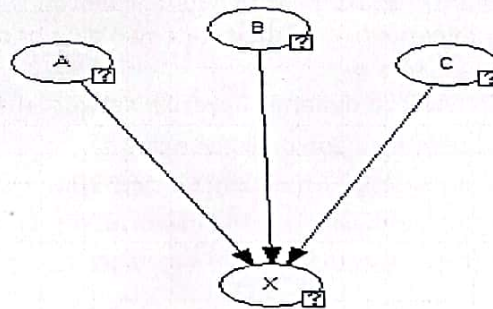
Note:
- False Positive is Predicting negative as positive.
- False Negative is Predicting positive as negative.

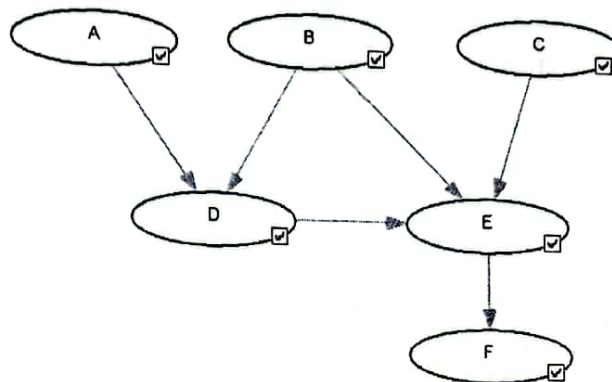**Q2** **[06 points]** Considering the influence net below and its corresponding influences,

P(A) = 0.8	
P(B) = 0.6	
P(C) = 0.1	
$(h_A, g_A) = (-0.9, -0.1)$	
$(h_B, g_B) = (0.6, -0.3))$	
$(h_C, g_C) = (-0.7, 0.4)$	
Baseline = 0.2	

Find the following probabilities:

a) $P(X|A{\sim}BC)$

b) $P(X|{\sim}AB{\sim}C)$

Q3 **[05 points]** Consider the Bayesian network below,

Answer the following questions:

   a) Given that there is no evidence on the network, identify all pair of nodes that are independent.

   Note: If A ⊥ B then this is understood that B ⊥ A. You do not have to repeat.

   b) Identify the node that, if instantiated, will make all nodes in the network dependent on each other.

Q4 **[08 points]** A public health agency is tracking the spread of a virus within a small population over five consecutive days. Each person in the population can either be infected or healthy. The probability of infection is influenced by two factors: the individual's level of social interaction and their physical health. The agency conducts daily swab tests to detect infections, but the tests are not entirely accurate, exhibiting both false positives and false negatives. The infection state of an individual on any given day depends significantly on their state from the previous day and also has a smaller dependence on their state two days prior.

   a) Construct a **dynamic** Bayesian network that models this scenario to infer the true infection state of a person on a given day.

   b) Is this Bayesian network **stationary**? Why or why not?

   c) Is this Bayesian network **Markovian**? Why or why not?

   d) Is there a way to incorporate **memory** in Bayesian networks?