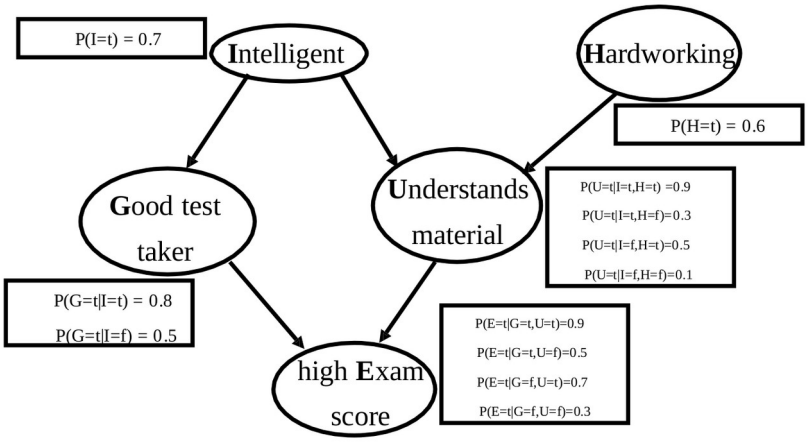
Assigned: **28 Nov 2024** **Due:** **15 Dec 2024**	**KRR Homework Assignment 1** **Bayesian Networks**

Problem 1 (4p)

An instructor wants to determine whether a student has understood the material, based on the exam score, as the Bayes net in figure bellow. Whether the student scores high on the exam is influenced both by whether he/she is a good test taker, and whether he/she understood the material. Both of those, in turn, are influenced by whether he/she is intelligent; whether he/she understood the material is also influenced by whether the student is a hard worker. All the random variables are Boolean.



a) Manually derive the the probability that a student who did well on the test is intelligent, that is, compute P (I=t| E=t). It is mandatory to express the probability algebraically, before filling in the numbers.

b) Verify your manually derived answer against a computed one. Model the given Bayesian Network using the Junction Tree implementation you implemented in the lab sessions. Retrieve the answer for the query and check it against your manual computation.

c) For the above Bayesian network, label the following statements about conditional independence as true or false. Explain each of your answers.
◦ G and U are independent.
◦ G and U are conditionally independent given I, E, and H.
◦ G and U are conditionally independent given I and H.
◦ E and H are conditionally independent given U.
◦ E and H are conditionally independent given U, I, and G.

Problem 2 (3p)

A patient goes to the doctor for a medical condition, the doctor suspects three diseases as the cause of the condition. The three diseases are D1, D2, D3, which are marginally independent from each other. There are four symptoms S1, S2, S3, S4 which the doctor wants to check for presence in order to find the most probable cause of the condition. The symptoms are conditionally dependent to the three diseases as follows: S1 depends only on D1, S2 depends on D1 and D2. S3 is depends

on D1 and D3, whereas S4 depends only on D3. Assume all random variables are Boolean, they are either ‘true’ or ‘false’.

a) Draw the Bayesian network for this problem.
b) What is the number of independent parameters that is required to describe this joint distribution? Explain your answer.

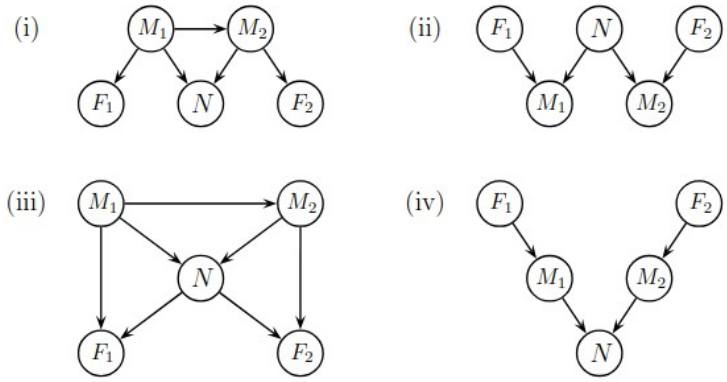
c) Assume there is no conditional independence between the variables, how many independent parameters would be required then? Explain your answer.
d) What is the Markov Blanket of variable S2?

(Remember that the Markov blanket for a node is the set of nodes composed of the node’s parents, its children, and its children other parents. The Markov blanket of a node contains all the variables that shield the node from the rest of the network).

Problem 3 (3p)

Two astronomers in two different parts of the world, make measurements M1 and M2 of the number of stars N in some small regions of the sky, using their telescopes. Normally, there is a small possibility of error by up to one star in each direction. Each telescope can be, with a much smaller probability, badly out of focus (events F1 and F2). In such a case the scientist will undercount by three or more stars or, if N is less than three, fail to detect any stars at all.

Consider the four Bayesian Networks shown below:



a) Which of them correctly, but not necessarily efficiently, represents the above information? (Multiple answers may be possible). Justify your answer.

b) Which is the best network? Justify your answer.