Calculators may be used in this examination provided they are not capable of being used to store alphabetical information other than hexadecimal numbers

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Artificial Intelligence 2

Main Summer Examinations 2024

Time allowed: 2 hours

[Answer all questions]

Turn Over

Note

Answer ALL questions. Each question will be marked out of 20. The paper will be marked out of 60, which will be rescaled to a mark out of 100.

Question 1

(a) Explain the following concepts in logistic regression:

(i) Dependent (response) variable **[3 marks]**

(ii) Odds **[3 marks]**

(b) Sudden arrhythmic death syndrome, or SADS, is when someone dies suddenly following a cardiac arrest with no obvious cause. Several potential risk factors, such as age, blood pressure and cigarette smoking are used as independent variables for investigation. The dependent variable (response) is 2-year incidence of SADS in females without prior coronary heart disease. We use the data to fit a logistic regression and the model coefficients are shown in Table 1, with the model interception of -15.3 (not shown in the Table)

θ_i	Risk Factor	Model Coefficient θ
θ_1	Blood Pressure (mm Hg)	0.0019
θ_2	Weight (% of study mean)	-0.0060
θ_3	Cholesterol (mg/100 mL)	0.0056
θ_4	Glucose (mg/100 mL)	0.0066
θ_5	Smoking (cigarettes/day)	0.0069
θ_6	Hematocrit (%)	0.111
θ_7	Vital capacity (centiliters)	-0.0098
θ_8	Age (years)	0.0686

Table 1: Logistic Regression model coefficients

(i) Based on the values in Table 1, give brief interpretations of how age (θ_8) and vital capacity (θ_7) affect the estimated risk of women SADS, respectively. **[6 marks]**

(ii) Using logistic regression, predict the probability of SADS for a 50 year old woman with systolic blood pressure of 120 mmHg, a relative weight of 100% a cholesterol level of 250 mg/100mL, a glucose level of 100 mg/100mL, a hematocrit of 40%, and a vital capacity of 450 centiliters who smokes 10 cigarettes per day. **[8 marks]**

Question 2

You are a General Practitioner (GP) who specialised in three ailments, Flu , Cold and Allergy, denoted as F, C and A, respectively. Denote possible symptoms as V (fever), H (cough), R (runny nose) and I (itchy eyes). Each ailment has the following symptoms:

- Flu: V, H and R
- Cold: H and R
- Allergy: H, R and I

We assume all the ailments and symptoms are binary random variables.

(a) Draw a Bayesian network to diagnose these three ailments based on patients' symptoms. **[6 marks]**

(b) Write down the joint probability distribution represented by this Bayesian network. **[4 marks]**

(c) How many parameters are required to describe this joint probability distribution? Show your working. **[4 marks]**

(d) Suppose a patient complains that he/she has two symptoms, cough ($H = 1$) and runny nose ($R = 1$). What diagnosis can you make just based on this information? What new physiological and background information you could collect for a more accurate diagnosis? Explain why the new information can help. **[6 marks]**

Question 3 Constraint Satisfaction Problems (CSPs)

(a) Please briefly explain the reason of not using breadth first search (BFS) to solve CSPs. **[6 marks]**

(b) Suppose we have 3 professors who need to deliver 6 modules (M_1-M_6) in computer science. Each module needs to be delivered during $9:00-10:00$ in the morning of one or several days.

- M_1: Artificial Intelligence needs to be delivered on both Monday and Thursday;
- M_2: JAVA needs to be delivered on three days, Tuesday, Wednesday and Thursday;
- M_3: Evolutionary Computation needs to be delivered on Wednesday;
- M_4: Data Structure needs to be delivered on both Wednesday and Friday;
- M_5: Software Engineering needs to be delivered on both Tuesday and Friday;
- M_6: Network needs to be delivered on Thursday.

Note each professor can deliver some modules. Here are the details

- Professor A can deliver M_1, M_2, M_3, M_4;
- Professor B can deliver all the modules (i.e., $M_1, M_2, M_3, M_4, M_5, M_6$);
- Professor C can deliver M_2, M_5, M_6.

Note that a professor can only deliver at most one module in one day (e.g, Professor A cannot deliver both M_1 and M_2 since both modules need to be delivered on Thursday). Each module can only be delivered by a professor. Your task is to assign professors to modules so that each module can be successfully delivered.

(i) Formulate this problem as a CSP problem. Specifically, you need to give variables, domains and constraints. We use variable M_i to represent the ith module ($i \in \{1, \ldots, 6\}$) and Professor A delivering M_i can be expressed as $M_i = A$. Domain of each variable (denoted by $d(M_i)$) is a subset of $\{A, B, C\}$. Constraints should be specified formally (i.e., using the form of $M_i \neq M_j$). **[6 marks]**

(ii) Draw the constraint graph associated with your CSP. **[3 marks]**

(iii) Use **backtracking search with forward checking and ordering** to find a solution of this problem. Let us assume that tie of variables is broken numerically (i.e., in the order of $M_1, M_2, \ldots, M_6$). The value of a variable should be considered alphabetically (i.e., in the order of A, B, C). Give the order of states to be visited. **[5 marks]**

End of Paper

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Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or Tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.