Student ID: ....

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

VUW VICTORIA UNIVERSITY OF WELLINGTON

TEST – 2021

TRIMESTER ONE

COMP 307 / AIML 420

INTRODUCTION TO ARTIFICIAL INTELLIGENCE

Time Allowed: 60 MINUTES

CLOSED BOOK

Permitted materials: Only silent non-programmable calculators or silent programmable calculators with their memories cleared are permitted in this test.
Non-electronic foreign language translation dictionaries may be used.

Instructions: There are a total of 60 marks on this test.
Attempt all questions.

Questions

1. Reasoning under Uncertainty [10]
2. Bayesian Networks [20]
3. Planning and Scheduling [20]
4. Other Topics [10]

Question 1. Reasoning under Uncertainty [10 marks]

[Note: You should show your *working* of the calculation in the form like $P(X=0|Y=1) = \frac{P(X=0,Y=1)}{P(Y=1)}$. It does not matter whether you compute the final numbers here – you can write your final answers in expression form like $\frac{0.55+0.08}{0.89}$.]

(a) [5 marks] The table below shows a questionnaire result about favourite movie genre.

	action	**comedy**	**drama**	**sci-fi**	**animation**	**Total**
male	18	7	2	21	2	50
female	5	16	14	5	10	50
non-binary	2	7	5	3	3	20
Total	25	30	21	29	15	120

Calculate (i) $P(drama, female)$, (ii) $P(comedy, male)$, (iii) $P(action)$, (iv) $P(non\text{-}binary|comedy)$ and (v) $P(amination|female)$. **Show your working.**

(b) [5 marks] Consider three *Binary* variables X, Y, Z, we know that X and Z are conditionally independent given Y. We also know that $P(X=1) = 0.2$, $P(Y=1|X=1) = 0.3$, $P(Y=1|X=0) = 0.6$, $P(Z=1|Y=1) = 0.7$ and $P(Z=1|Y=0) = 0.2$. Calculate (i) $P(X=0, Y=0, Z=1)$; (ii) $P(Z=1|X=1)$. **Show your working.**

Question 2. Bayesian Networks [20 marks]

(a) [5 marks] Given a test instance, i.e., a n-dimensional feature vector $(f_1, f_2, ..., f_n)$, the Naive Bayes Classifier predicts its class label by the following steps:

Step 1) for each class c, get the probabilities $P(f_1|c)$, ... $P(f_n|c)$ and $P(c)$ estimated from the training data.

Step 2) for each class c, calculate $P(f_1, f_2, ..., f_n|c) * P(c) = P(f_1|c) * ... * P(f_n|c) * P(c)$.

Step 3) predict the class with the largest $P(f_1, f_2, ..., f_n|c) * P(c)$.

(i) In Step 1), explain *how to deal with zero occurrence* to calculate the probabilities.

(ii) In Step 2), briefly state the assumption made for the equation.

(iii) In Step 3), we know that the class with largest $P(f_1, f_2, ..., f_n|c) * P(c)$ also has the largest $P(c|f_1, f_2, ..., f_n)$. Briefly explain the reason. **Show your working.**

(b) Given a Bayesian network with five Boolean variables (nodes), A, B, C, D, E (e.g., A can take values a and $\neg a$). The factorisation of the network is $P(A, B, C, D, E) = P(A) * P(B) * P(C|A, B) * P(D|C) * P(E|C)$.

(i) [3 marks] Draw the Bayesian network based on the factorisation.

(ii) [3 marks] List three conditional independence relationships in the network.

(iii) [9 marks] **Show the steps** to calculate $P(a|d, e)$. No number is needed, and it is enough to show the probabilities that can be read from the network's tables, e.g., $P(a)$ and $P(b|a)$.

Question 3. Planning and Scheduling [20 marks]

(a) [2 marks] Briefly describe a main difference between classical planning and scheduling.

(b) [2 marks] List two real-world applications of routing problems.

(c) Consider the planning problem of a robot that moves an object from one room to another. There are three rooms A, B and C, and the robot can move from any room to any other room. The object and robot are both **initially** in room A, and the **goal** is to use the robot to move the object to room C. The robot has the following **actions**: `Move` from one room to another; `Carry` the object from one room to another; `Pick` the object; `Drop` the object. `Move` can only be taken when the robot is not holding the object, and `Carry` can only be taken when the robot is holding the object. `Pick` can only be taken if the robot and object are in the same room, and the effect is that the object is `Held`. `Drop` can only be taken when the robot is holding the object, and the effect is that the object is in the room where it is dropped. The object is not in ANY room if it is held.

(i) [2 marks] Write the initial state in the Planning Domain Definition Language (PDDL).

(ii) [2 marks] Write the goal state in PDDL.

(iii) [6 marks] Write the `Move`, `Carry`, `Pick` and `Drop` actions in PDDL.

(iv) [2 marks] Write a plan (a sequence of actions) from the initial state to the goal state.

(d) [4 marks] Dispatching rule can be used to solve dynamic scheduling problems. It selects the next action through a 2-step selection process. Given a state with the following four candidate actions $a1 = Process(o1, m1, 30)$ (i.e., start processing the operation $o1$ by machine $m1$ at time 30), $a2 = Process(o2, m1, 30)$, $a3 = Process(o3, m2, 30)$, $a4 = Process(o4, m2, 50)$, and we have the priority value $prior(a1) = 40$, $prior(a2) = 60$, $prior(a3) = 20$, $prior(a4) = 100$, state (i) the actions selected after the first step of selection; (ii) the final selected action.

Question 4. Other Topics [10 marks]

(a) [1 mark] List two real-world applications of natural language processing.

(b) [3 marks] State **3Vs** of *big data* with brief descriptions.

(c) [2 marks] Briefly describe how to use Support Vector Machine (SVM) to classify non-linearly separable data.

(d) [2 marks] List two **neural network**-based deep learning methods, and state whether each of them is supervised or unsupervised.

(e) [2 marks] List two **non-neural network**-based deep learning methods, and state whether each of them is supervised or unsupervised.

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