Final examination

Artificial Intelligence - AI

Intelligent Systems – INTSYS

30 October 2019

Maximum marks: 100

Duration: 24 hour take home examination

Instructions

- This paper contains 4 sections and 7 questions. Answer all questions.
- You may consult any reference materials (paper or online), but you MAY NOT discuss the problem with any individuals, especially classmates.
- Submit a single zip file via VULA containing your answers in a single PDF document and your Netica/code files where required before **11:00 on 31 October 2019.**
- Format your document as 12pt Serif (Times Roman), 2.54cm margins, single-spacing.
- You **MUST** also submit a **printed copy of your answers to the Computer Science secretary by 12:00 on 31 October 2019**.
- **No late submissions will be accepted.**

Section A - Bayesian models (39 marks)

Question 1 [5 marks]

Suppose that people attending a particular clinic have a long-term chance of 2 in 100 of having heart disease. Suppose also that the initial screening test used at the clinic has a true positive rate of 0.85 and that it has a true negative rate of 0.9. Now suppose that a patient tested positive on the screening test. Determine the probability that the person has heart disease. (5)

Question 2 [10 marks]

Over a number of years physicians at a local clinic noted a number of long term trends in tuberculosis (TB) patients that were defaulting on treatment in the community. The most likely defaulters were young males (under 30 years). They noted that 6% of the defaulters were young males, while only 4% were older males (30 and over). Females appeared to be slightly better at adherence in the community. 97% of young female patients were adherent while this decreased marginally for older female patients to 98%. There are 10% more male TB patients than females and there is an even distribution between young and old TB patients.

2.1. Construct an appropriate Bayesian network in Netica (6)

2.2. Enter the conditional probability table for each variable. (4)
Include a screen shot as part of your answer and submit your network as a Netica file called `defaulters.dne`.

Question 3 [24 marks]

Suppose that you are tasked with implementing a control system to maintain a high humidity environment in a tropical greenhouse located in Cape Town. The greenhouse has a sensor that detects when the humidity level is low and a simple humidifier that, when it is switched on, releases a fixed amount of mist (water vapour) into the greenhouse for 9 minutes and then switches off. The system must work as follows. The sensor reports whether there is a low level of humidity in the greenhouse. If the humidity level is low then the humidifier is switched on. This process repeats every 10 minutes. If the humidity is low and the humidifier is switched on, there is a 30% chance that the level will remain low. If the level is normal and the humidifier is switched on there is only a 1% chance that it will become low in the next 10 minutes. If it is low and the humidifier is not switched on it will always remain low. If it is normal and the humidifier is not switched on then there is a 10% chance that it would become low in the next 10 minutes. The humidity sensor is not always accurate when it detects low humidity levels. Its true positive rate is 0.97 and the false negative rate is 0.02. On average the humidifier is switched on once every 200 minutes.

3.1. Design a *dynamic Bayesian network* (DBN) in Netica to determine the actual humidity level at a given time and the change in the humidity level in the next 10 minutes if the humidifier is switched on. Include a screen shot as part of your answer and submit your network as a Netica file called `humidity_control.dne`. You should populate the CPTs with appropriate values, given the information above. You should show a two slice network with nodes at t_0 and t_1. Append chance node names in slices t_0 and t_1 with `_t0` and `_t1` respectively. (12)

3.2. Assume that the current humidity sensor reading is low and the humidifier is switched on at the current and each of the subsequent time steps to increase the humidity level, write code in python that does probablistic projection to determine the likelihood of a low humidity level in future time steps. The algorithm should terminate when P(low humidity) converges, i.e. does not change by more than a threshold of 0.0005 in the next time step. Your code should output the time step (t) and P(low humidity) at that time step. Give your code and the output. Submit your code in a file called `prob_proj.py`. (7)

3.3. Give the duration in minutes it will take before the P(low humidity) < 15% (2)

3.4. Discuss the consequence of adding an arc in a Dynamic Bayesian Network that crosses two time steps. (3)

Section B – Machine learning (21 marks)

Question 4 [21 marks]

Suppose that you want to predict house prices in Cape Town. You have access to a data set consisting of 10 000 entries. A sample of the data set (3 entries) is shown in the table below.

Suburb	**no of bedrooms**	**area of house (m^2)**	**price (R)**
Observatory	2	95	750000
Mowbray	1.5	80	1200000
Claremont	3	160	3000000

You may assume that there are 80 unique suburbs in Cape Town.

4.1. Describe a 10-fold cross validation approach for training and testing a machine learning model on this data. Clearly show how the final loss/error will be calculated for a given model using this approach. (4)

4.2. Design a three-layered multi-layered perceptron for the above problem with a single hidden layer with four nodes in the hidden layer. Clearly label the nodes, the links between the nodes and the weights. (7)

4.3. Describe the dimensions of the weight space for the above problem (2)

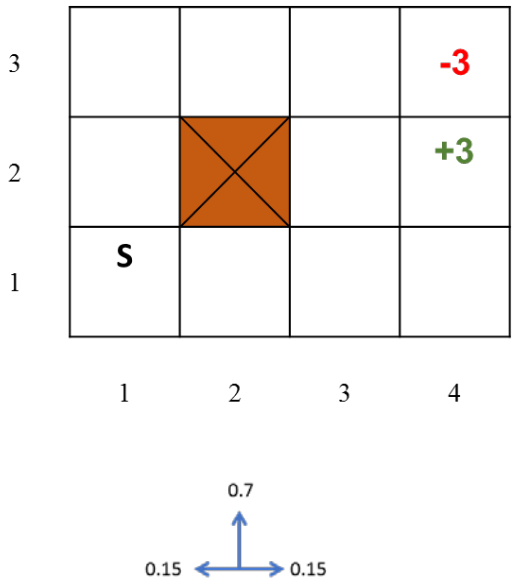
4.4. Describe how gradient descent can be used in the weight space to find the optimal hypothesis (3)

4.5. Suppose that you partition the data and use the backpropagation algorithm to train the neural network on the data. Is the resultant model the best model that can be found, i.e. is it possible to find another set of weight values for the same data partitions that may produce a better model than this model. Explain your answer. (5)

Section C – Reinforcement Learning [15 marks]

Question 5 [10 marks]

Consider the grid-world shown below. The states are grid squares, identified by their row and column number (row first). The agent always starts in state (1,1), marked with the letter S. There are two terminal goal states, **(2,4) with reward +3** and **(3,4) with reward -3**. The transition function is such that the intended agent movement actually occurs only 70% of the time. The agent may end up left or right of its intended position 15% of the time respectively. If a collision with a boundary occurs, the agent stays in the same state. Give the first two rounds of value iteration updates for each state, with a discount of 0.9. (Assume V_0=0 for all squares and give V_1 and V_2). (10)



Question 6 [5 marks]

In Q-learning one can follow an epsilon greedy strategy, by selecting some value for ε. Explain why this is important and provide some guidance on how one would determine the value of ε for different learning environments. (5)

Section D – Agents and general (25 marks)

Question 7

An intelligent agent is usually situated in some real-world environment. Using the table below, compare and contrast the five different AI techniques for their support to deal with the different types of environments.

Environment/AI technique	Fully vs partially observable	Episodic vs sequential	Discrete vs. continuous	Deterministic vs. stochastic	Static vs. dynamic	Known vs unknown
Bayesian Decision networks						
Dynamic Decision Networks						
Reinforcement Learning						
Machine learning including Neural networks						
Logic						