NTNU
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Department of Computer and Information Science

Examination paper for TDT 4171 Artificial Intelligence Methods

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Examination date: May 24th 2016
Examination time (from-to): 09.00 – 13.00
Permitted examination support material: No printed or hand-written support material is allowed. A specific basic calculator is allowed.

Other information: In case of uncertainty or any amigiuties, the English version of the exam will be used as the reference.

Language: English
Number of pages (front page excluded): 3
Number of pages enclosed:

Informasjon om trykking av eksamensoppgave
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Date Signature

Task 1: Reasoning with Uncertainty (20p)

a) **Independence (4p):** Explain independence and conditional independence using your own words and mathematical formulas.

b) **Complexity (4p):** Explain why independence and conditional independence is useful when reasoning with uncertainty.

c) **Inference (4p):** Given the full joint probability distribution (table 1), calculate P(Heart Disease | Chest Pain), first with and then without normalization.

Table 1: Heart disease.

	Chest Pain		¬Chest Pain	
	High Blood Pressure	¬High Blood Pressure	High Blood Pressure	¬High Blood Pressure
Heart Disease	0.09	0.05	0.07	0.01
¬Heart Disease	0.02	0.08	0.03	0.65

d) **Bayesian Network (8p):** Draw a Bayesian Network and set up conditional probability tables based on the following information.

The captain of the space ship the *Centurion Sparrow* starts evasive maneuvers once the alarm goes off with a probability of 0.7, while the probability that the gunner starts shooting is 0.75. The alarm goes off when the Centurion Sparrow flies into an asteroid field with a probability of 0.9. The alarm also goes off when enemy space ships are close by, but only with a probability of 0.8. If an enemy space ship appears when the Centurion Sparrow is in an asteroid field, the alarm goes off with a probability of 0.95. Sometimes, the alarm goes off when no enemy ships are close and the space ship is in open space. This happens with a probability of 0.07. The captain gets excited when flying in asteroid fields, and she does it as often as she can. Thus, the probability of the ship being in an asteroid field is 0.3. Enemy spaceships appear with a probability of 0.05.
Now, calculate the probability that the gunner starts shooting, when ~~no~~[1] *the* alarm sounds, the space ship is in open space, the captain does nothing and an enemy ship appears.

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[1] The exam said *when no alarm sounds*, but this is not possible to compute. This was noted during the exam and changed to *when the alarm sounds*.

Task 2: Probabilistic Reasoning over Time (20p)

a) **Markov assumptions (4p):** What is a *transition model* and a *sensor model*? Explain the *Markov assumption for a second-order Markov model* and the *sensor Markov assumption* in your own words. Write the definitions of these two assumptions as formulas.

b) **Temporal Inference (8p):** Give an overview of the four basic inference tasks for temporal models.

c) **Filtering (8p):** We cannot measure temperatures from the past, so we have to do it indirectly. We assume that there is a correlation between tree growth rings and temperature. Figure 1 illustrates this tree growth world.

If it was a hot temperature (H) the probability of a large (L) tree growth ring was 0.8 and the probability of a large tree growth ring was 0.3 if the temperature was cold (C).

The probability that a hot year is followed by a hot year is 0.7 and the probability that a cold year was followed by a cold year is 0.6.[2]

Assume a prior of $\mathbf{P}(t_0)$ = <H = 0.6, C = 0.4>.

Compute $P(H_2 \mid l_1, l_2)$. That is: Compute the probability of the weather being hot at time step 2, given that the tree ring sizes were large for time step 1 and 2.

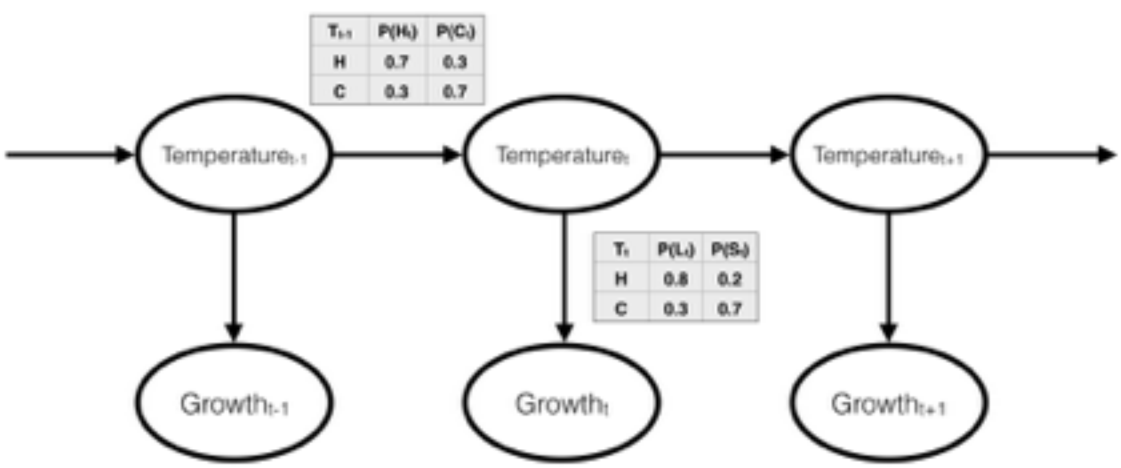

Figure 1: Bayesian network structure and conditional distributions describing the tree growth world.

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[2] This text differs from the figure. This was noted during the exam and the students were asked to choose one of them (and specify which they chose).

Task 3: Case-Based Reasoning (20p)

a) **CBR cycle (5p):** Illustrate the CBR cycle and explain its different components.

b) **Case (3p):** A case is a central concept in CBR, and cases typically have two parts. Which parts are they?

c) **Similarity (4p):** Similarity is important in CBR. Explain what a similarity measure is and provide one or more examples.

d) **CBR System (8p):** We are going to build a CBR system for diagnosing car faults given the following information.

   We have two observations:
   Car A was a 2009 model of make VW Golf where the state of the lights were OK, the state of the light switch was OK, and the problem was that the front light did not work. The mechanic had to replace the front light fuse because it was defect.

   Car B was a 2010 model of make VW Passat with surface damage on the lights, the light switch was OK, but the front light did not work. The mechanic had to replace the front lights and the bulb as it was broken.

   Now, the mechanic gets a new observation, car C.
   Car C is a 2008 model of make Volvo where the state of the lights are OK, the state of the light switch is OK, but the front light is not working.

   Design a CBR system capable of diagnosing car C. Explain a possible diagnosis using the CBR cycle.

Task 4: Various

a) **Data sets (4p):** Explain the difference between training set, validation set and test set.

b) **Cross validation (4p):** Explain the difference between hold out cross-validation, k-fold cross-validation and leave-one-out cross-validation.

c) **Chinese room (4p):** Explain the Chinese room thought experiment and what it is meant to illustrate. Please do not use more than two pages.

d) **Value iteration (8p):** Explain the value iteration algorithm and write pseudo code for it.