Lehr- und Forschungsgebiet Informatik 5
RWTH Aachen University

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Introduction to Artificial Intelligence (Winter 2018)

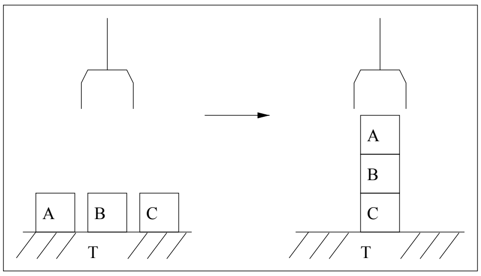
Assignment 5

Submit your solution electronically via the L2P until 09.01.2019.

Homework assignments are optional but strongly recommended.

Exercise 5.1 (30 points)

Consider the following simplified variant of the well-known Blocks World. There are three blocks A, B, and C, each of which is initially located on the table T. The goal is to have A on B and B ontop of C. The robot can perform the following two actions:



- Move(x, y, z): move block x from y onto block z. This requires that x is on y and both x and z are clear.
- MoveToTable(x, y): move block x from y onto the table. This requires that x is on y and x is clear.

(a) Present STRIPS operators for the two actions together with the initial state (Start) and the goal (Finish). Use the predicates On(x, y) to denote that block x is on (block or table) y and Clear(x) to say that there is no block on top of block x.

(b) Draw the partial plan that results from first introducing Move$(\mathsf{B}, y_1, \mathsf{C})$ and then Move$(\mathsf{A}, y_2, \mathsf{B})$, each satisfying one precondition of Finish. Satisfy the remaining open preconditions by means of Start using appropriate variable assignments where necessary. Use solid lines for causal links and dashed lines for ordering constraints. Since a causal link always implies an ordering, you do not have to draw both arrows in these cases but only the one for the causal link.

(c) Indicate where the plan contains a conflict by circling the precondition/effect pair that causes this threat. Resolve the conflict by either promotion or demotion and draw the resulting plan. Is the plan now consistent? Is it complete?

Exercise 5.2 **(20 points)**

Given the full joint distribution shown below, calculate the following:

(a) $P(toothache)$

(b) $\mathbf{P}(Cavity)$

(c) $\mathbf{P}(Toothache \mid cavity)$

(d) $\mathbf{P}(Cavity \mid toothache \vee catch)$

	$toothache$		$\neg toothache$	
	$catch$	$\neg catch$	$catch$	$\neg catch$
$cavity$	0.108	0.012	0.072	0.008
$\neg cavity$	0.016	0.064	0.144	0.576

Exercise 5.3 **(25 points)**

Prove what is called **marginalization** or the **Law of Total Probability** (the latter especially if $n = 2$ and $B_2 = \neg B_1$), namely that

$$P(A) = P(A \mid B_1) \cdot P(B_1) + \cdots + P(A \mid B_n) \cdot P(B_n)$$

if $P(B_1 \vee \cdots \vee B_n) = 1$ and $P(B_i \wedge B_j) = 0$ for $i \neq j$.

You an make use of the following probability laws:

- If $P(B) = 0$ then $P(A \wedge B) = 0$ and $P(A \vee B) = P(A)$.
- If $P(B) = 1$ then $P(A \vee B) = 1$ and $P(A \wedge B) = P(A)$.

Exercise 5.4 **(25 points)**

In an exam a professor asks a student three questions. If the student is well-prepared she can give the right answer to any of these questions with a probability of 95 %. Otherwise she will have a 30 % chance to answer the first question correctly, a 50 % chance to answer the second question correctly, and only a 10 % chance to answer the third question correctly. If the student is (or is not) well-prepared, answering some questions correctly or not neither increases nor decreases the chance for answering another question correctly. Normally, 4 out of 5 students are well-prepared.

Let Q_i stand for answering question i correctly, and W for being well-prepared.

(a) Which (unconditional or conditional) probabilities are *directly* given in the above text with what values? [Hint: There are exactly seven.]

(b) Compute: $P(W \mid Q_1)$, $P(Q_1, Q_2 \mid \neg W)$, $P(Q_3 \mid Q_1, Q_2, W)$.

(c) If the student answers the first and second question correctly but gives a wrong answer to the third question: How probable is it that the student is well-prepared? In other words:

Compute $P(W \mid Q_1, Q_2, \neg Q_3)$.

(d) Compute $P(W \mid Q_1, \neg Q_2, \neg Q_3)$.[1]

(e) Why is it important that correct or incorrect answers to some questions do not influence the chance for answering another question correctly?

[1] Are you surprised by this value compared to part (c)) because of the 50 % chance of the second question? If you like you can compute $P(W \mid (\neg)Q_1, (\neg)Q_2, (\neg)Q_3)$ for all the other combinations of the Q_i and $\neg Q_i$.