Symbolic Machine Learning - Sample Exam

Filip Železný and Jiří Kléma

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Learning an s-DNF (15 points) Design an on-line learning agent that learns an s-DNF (i.e., a disjunction of conjunctive terms, where each terms has at most s literals) on n propositional variables from only *negative observations* (i.e, truth-assignments for which the DNF is not satisfied). Describe the initial hypothesized DNF (what terms will be in it?) and describe how the DNF is updated with each negative example.

Provide the best possible bound on the maximum number of errors the agents makes, without any assumption on the set of observations received. Is the bound polynomial or exponential in (i) s, (ii) n ?

Assume propositional variables a,b (i.e $n = 2$) and $s = 2$. Demonstrate the sequence of hypothesized DNF's,for the successive observations $o_1 = (a = 1, b = 0)$, $o_2 = (a = 0, b = 1)$.

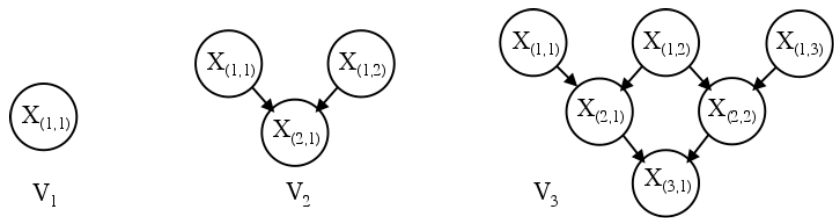
Version space (5 points) Consider a version-space agent whose version space is the space of monotone (i.e., containing no negations) conjunctions on 3 propositional variables. How large will the initial (i.e., before seeing any observation) version space be? What is the maximal possible size of it after making the first wrong class decision?

Least general generalization (10 points) Determine the least general generalization of the following two assertions

1. *Superman is mortal or he is not a human.*
2. *Every human who smokes is mortal.*

by representing them as first-order logic clauses and computing their least general generalization with respect to the θ-subsumption order.

Very Big V Structures (10 points). Let V_n be a Bayes net with nodes $X_{(i,j)}$ for all $i + j \leq n + 1$, where both $i \geq 1$ and $j \geq 1$, and where the parents of $X_{(i,j)}$ are $X_{(i-1,j)}$ and $X_{(i-1,j+1)}$. Nodes $X_{(1,j)}$ have no parents. V_1, V_2 and V_3 are shown below.

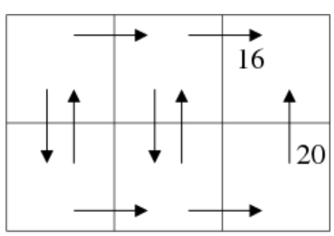


a) (4 points) For any V_n, give general conditions in terms of i, j, k, and l that make $X_{(i,j)}$ independent of $X_{(k,l)}$ (i.e., $X_{(i,j)} \perp\!\!\!\perp X_{(k,l)}$), assuming $k > i$.

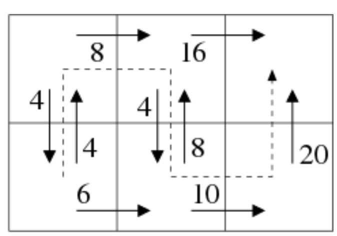
b) (4 points) For any V_n, give conditions in terms of i, j, k, and l that make $X_{(1,i)} \perp\!\!\!\perp X_{(1,j)} | X_{(k,l)}$ for $j > i$.

c) (2 points) When computing $P(X_{(3,1)})$ with variable elimination, what factor is created by first eliminating $X_{(1,2)}$ from V_3?

Q learning (10 points). Consider the deterministic world below (part (a)). Allowable moves are shown by arrows, and the numbers indicate the reward for performing each action. If there is no number, the reward is zero. Given the Q values in (b), show the changes in the Q estimates when the agent takes the path shown by the dotted line (the agent starts in the lower left cell) when $\gamma = 0.5$ and $\alpha = 0.5$. Show all of your work including intermediate steps.



(a)



(b)