Principles of AI Planning

Prof. Dr. B. Nebel, Dr. R. Mattmüller
D. Speck
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University of Freiburg
Department of Computer Science

Exercise Sheet 7

Due: Friday, December 11th, 2015

Exercise 7.1 (EVMDDs, 1+1 points)

An EVMDD is called *reduced* if it contains no two isomorphic subgraphs and if it contains no nodes where all outgoing edges carry the same weight. It is *canonical* if for each node, the minimal outgoing edge weight is zero.

(a) Let $c_1 = AB + B$ for variables A, B with $\mathcal{D}_A = \mathcal{D}_B = \{0, 1\}$. Draw the canonical reduced ordered EVMDDs for c_1 for both possible variable orders (A, B and B, A). Compare their sizes.

(b) Let $c_2 = A \cdot (2 + B + C) - D^2 + 7$ for variables A, B, C, D with $\mathcal{D}_A = \mathcal{D}_B = \mathcal{D}_C = \{0, 1\}$ and $\mathcal{D}_D = \{0, 1, 2\}$. Draw the canonical reduced ordered EVMDD for c_2 and variable order A, B, C, D.

Exercise 7.2 (EVMDD sizes and variable orders, 2 points)

Let $v_0, \ldots, v_{2n-1}$ be variables with domains $\mathcal{D}_{v_i} = \{0, \ldots, k-1\}$ for all $i = 0, \ldots, 2n-1$, let $\pi : \{0, \ldots, 2n-1\} \to \{0, \ldots, 2n-1\}$ be a permutation of the variables, let $\kappa_j \in \mathbb{N}$, $j = 0, \ldots, n-1$, be natural numbers, and let $c = \sum_{j=0}^{n-1} \kappa_j v_{\pi(2j)} v_{\pi(2j+1)}$ be an arithmetic function over $v_0, \ldots, v_{2n-1}$. Intuitively, c is a weighted sum of products of two variables each, such that no variable occurs in more than one product subterm. Show that there exists a variable order for $v_0, \ldots, v_{2n-1}$ such that there exists an EVMDD with that order that represents the function c and that has a size (number of edges) in the order of $n \cdot k^2$.

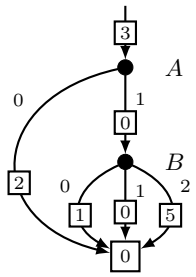
Hint: Consider the example $c = 2AD + 6BF + 4CE$. How should the variables be ordered to minimize the size of the EVMDD?

Exercise 7.3 (Evaluating relaxed states with EVMDDs, 1+1 points)

Consider a cost function represented by the EVMDD on the right.

(a) Let s be a state with $s(A) = 1$ and $s(B) = 2$. To which value does the EVMDD evaluate for state s?

(b) Let s^+ be a relaxed state containing the facts $(A, 0)$ and $(A, 1)$ for A and $(B, 0)$ and $(B, 2)$ for B. To which value does the EVMDD evaluate for s^+? Show how you computed your result by annotating the nodes of the EVMDD appropriately.



Exercise 7.4 (EVMDD-based action compilation, 2+2 points)

Consider again the EVMDD from Exercise 7.3. Assume it encodes the cost c_{o_1} of operator $o_1 = \langle C = 1 \wedge D = 1, A := 0 \rangle$.

(a) Give the EVMDD-based action compilation of o using this EVMDD.

(b) Let $\Pi = \langle V, I, O, \gamma, (c_o)_{o \in O} \rangle$ with $V = \{A, B, C, D\}$, $\mathcal{D}_A = \mathcal{D}_C = \mathcal{D}_D = \{0, 1\}$ and $\mathcal{D}_B = \{0, 1, 2\}$, initial state I with $I(A) = I(B) = I(C) = I(D) = 1$, operators $O = \{o_1, o_2\}$ with o_1 as above and $o_2 = \langle A = 0, C := 0 \rangle$ with cost function $c_{o_2} = 1$ and goal formula $\gamma = (C = 0)$. Give an optimal plan π for Π and an optimal plan π' for the EVMDD-based action compilation of Π and their respective costs. Discuss how the two plans are related.

You may and should solve the exercise sheets in groups of two. Please state both names on your solution.