Principles of AI Planning

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Exercise Sheet 9

Due: Friday, January 13th, 2017

Exercise 9.1 (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 lead to the same successor node and carry the same weight. It is *canonical* if for each node, the minimal outgoing edge weight is zero.

(a) Let $c_1 = xy + y$ for variables x, y with $\mathcal{D}_x = \mathcal{D}_y = \{0, 1\}$. Draw the canonical reduced ordered EVMDDs for c_1 for both possible variable orders (x, y and y, x). Compare their sizes.

(b) Let $c_2 = x \cdot (2 + y + z) - u^2 + 7$ for variables x, y, z, u with $\mathcal{D}_x = \mathcal{D}_y = \mathcal{D}_z = \{0, 1\}$ and $\mathcal{D}_u = \{0, 1, 2\}$. Draw the canonical reduced ordered EVMDD for c_2 and variable order x, y, z, u.

Exercise 9.2 (EVMDD sizes and variable orders, 2 points)

Let $v_0, \dots, v_{2n-1}$ be variables with domains $\mathcal{D}_{v_i} = \{0, \dots, k-1\}$ for all $i = 0, \dots, 2n-1$, let $\pi : \{0, \dots, 2n-1\} \to \{0, \dots, 2n-1\}$ be a permutation of the variables, let $\kappa_j \in \mathbb{N}$, $j = 0, \dots, n-1$, 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 $v_0, \dots, v_{2n-1}$. 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 $v_0, \dots, v_{2n-1}$ 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 $n \cdot k^2$.

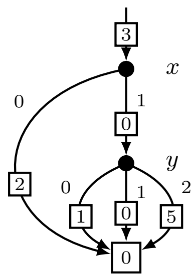
Hint: Consider the example $c = 2v_0v_3 + 6v_1v_5 + 4v_2v_4$. How should the variables be ordered to minimize the size of the EVMDD?

Exercise 9.3 (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 $s(x) = 1$ and $s(y) = 2$. To which value does the EVMDD evaluate for state s?

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



Exercise 9.4 (EVMDD-based action compilation, 2+2 points)

Consider again the EVMDD from Exercise 9.3. Assume it encodes the cost c_{o_1} of operator $o_1 = \langle z = 1 \wedge u = 1, x := 0 \rangle$.

(a) Give the EVMDD-based action compilation of o_1 using this EVMDD.

(b) Let $\Pi = \langle V, I, O, \gamma, (c_o)_{o \in O} \rangle$ with $V = \{x, y, z, u\}$, $\mathcal{D}_x = \mathcal{D}_z = \mathcal{D}_u = \{0, 1\}$ and $\mathcal{D}_y = \{0, 1, 2\}$, initial state I with $I(x) = I(y) = I(z) = I(u) = 1$, operators $O = \{o_1, o_2\}$ with o_1 as above and $o_2 = \langle x = 0, z := 0 \rangle$ with cost function $c_{o_2} = 1$ and goal formula $\gamma = (z = 0)$. 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.