**Principles of AI Planning**

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# Exercise Sheet 8

**Due: Friday, December 14th, 2018**

Send your solution to `drexlerd@tf.uni-freiburg.de` or submit a hardcopy before the lecture.

**Exercise 8.1** (Abstraction heuristics, 2+4 points)

A state of a 15-puzzle planning task is given as a permutation $\langle b, t_1, \dots, t_{15} \rangle$ of $\{1, \dots, 16\}$, where $b$ denotes the empty tile (blank) and all other components denote the positions of the tiles.
Let $T^1 = \{t^1_1, \dots, t^1_n\}, T^2 = \{t^2_1, \dots, t^2_m\}$ with $1 \leq n, m \leq 14$ be a partitioning of $\{t_1, \dots, t_{15}\}$ (i.e., $T^1 \cup T^2 = \{t_1, \dots, t_{15}\}$ and $T^1 \cap T^2 = \emptyset$). Consider the following abstractions:

- $\alpha_1(\langle b, t_1, \dots, t_{15} \rangle) = \langle b, t^1_1, \dots, t^1_m \rangle$
- $\alpha_2(\langle b, t_1, \dots, t_{15} \rangle) = \langle b, t^2_1, \dots, t^2_n \rangle$
- $\alpha_3(\langle b, t_1, \dots, t_{15} \rangle) = \langle t^1_1, \dots, t^1_m \rangle$
- $\alpha_4(\langle b, t_1, \dots, t_{15} \rangle) = \langle t^2_1, \dots, t^2_n \rangle$

For $1 \leq i \leq 4$, the heuristic estimates of $h_i$ are equal to lengths of optimal plans in the respective abstractions (e.g., $h_i(s) = h^*(\alpha_i(s))$). Show that:

(a) $h_1 + h_2$ is not admissible.

(b) $h_3 + h_4$ is admissible.

*Hint:* A heuristic is admissible if it is goal-aware and consistent.

**Exercise 8.2** (Affecting labels vs. orthogonality, 4 points)

Recall: For a transition system $\mathcal{A}$ and a label $\ell$ of $\mathcal{A}$, we say that $\ell$ *affects* $\mathcal{A}$ if $\mathcal{A}$ has a transition $\langle s, \ell, t \rangle$ with $s \neq t$.
Prove the following: Let $\mathcal{A}_i$ be an abstraction of some transition system $\mathcal{T}$ with abstraction mapping $\alpha_i$ for $i \in \{1, 2\}$. If no label of $\mathcal{T}$ affects both $\mathcal{A}_1$ and $\mathcal{A}_2$, then $\alpha_1$ and $\alpha_2$ are orthogonal.

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