# An erratum for the paper "Completeness and Optimality Preserving Reduction for Planning" in Proc. IJCAI, 2009

In Page 2, change **Definition 1** from

An action $o$ is associated with a DTG $G_i$ (denoted as $o \vdash G_i$) if $o$ is associated with any edges in $G_i$.

to

An action $o$ is associated with a DTG $G_i$ (denoted as $o \vdash G_i$) if $eff(o)$ includes a partial assignment of $x_i$.

# An erratum for the paper "Stratified Planning" in Proc. IJCAI, 2009

In Page 2, change the last line of **Definition 1** from

$x \in trans(o)$ and $x' \in dep(o)$, or, $x \in \mathit{aff}(o)$ and $x' \in trans(o)$

to

$x \in \mathit{aff}(o)$ and $x' \in dep(o)$, or, $x \in \mathit{aff}(o)$ and $x' \in \mathit{aff}(o)$.

# Memo on the flaws in "Stratified Planning" and "Completeness and Optimality Preserving Reduction for Planning"

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Stratified Planning uses a notion called "transition" to define the layers for domain variables and actions. For a SAS+ planning task and an action $o$, if a domain variable $x$ appears in both $dep(o)$ and $aff(o)$[1], then we say $o$ contains a transition for domain variable $o$.

However, it is possible for actions to have no transitions. During stratification, actions without transitions are stratified to a special layer: $\infty$. When that happens, SP cannot guarantee the commutability of actions during the search. In other words, Lemma 1 of the SP paper may not be correct when there are actions without transitions.

In fact, we can build the stratification solely based on $pre(o)$ and $aff(o)$. We just need to change $trans(o)$ to $aff(o)$. It is safe to assume that for any action $o$, $aff(o)$ is non-empty. Otherwise, we can remove the action from the planning task without affecting the solvability of the problem. With that, we modify the Definition 1 of the SP paper slightly to the following one.

**Definition 1.** *Given a SAS+ planning task* $\Pi$ *with state variable set* $X$*, its causal graph (CG) is a directed graph* $CG(\Pi) = (X, E)$ *with* $X$ *as the vertex set. There is an edge* $(x, x) \in E$ *if and only if* $x \neq x'$ *and there exists an action* $o$ *such that* $x \in aff(o)$ *and* $x \in dep(o)$*, or,* $x \in aff(o)$ *and* $x \in aff(o)$*.*

Now layer $\mathcal{L}$ of for an action $o$ is defined as the layer of the domain variables in $aff(o)$. We can establish the following results.

**Theorem 1.** *For a SAS+ planning task* $\Pi$ *and its causal graph and the stratification, the layer number for actions* $o \in \Pi$ *is well-defined for all actions that have non-empty* $aff(o)$

[1] Note on notations: $dep(o)$ and $aff(o)$ are sets of domain variables, $pre(o)$ and $eff(o)$ are sets of partial assignments.

**Proof:** For every action $o \in \Pi$, since *aff*($o$) is non-empty, $o$ at least gets assigned to a layer. We only need to proof that the layer number is well-defined ($o$ does not get to assigned to more than one different layer numbers).

If $o$ has two different layer numbers $l_1$ and $l_2$, we know that *aff*($o$) contains at least two domain variables $x$ and $y$ in two different layers. Let us assume that $x$ is in layer $l_1$ and $y$ is in layer $l_2$, and $l_1 \neq l_2$. In this case, according to Definition 1, there is an arrow from $x$ to $y$ in the causal graph, and vice versa. Hence, $x$ and $y$ must be in the same strongly connected component when stratification is done. It implies that $l_1 = l_2$, which contradicts with our assumption that $l_1 \neq l_2$. Therefore, $o$ can only get a finite, unique layer number. ■

This proof of the following theorem is the same to the proof appeared in the SP paper. It is correct even for actions without transitions.

**Theorem 2.** *(Lemma 1 in the SP paper) For a SAS+ task* $\Pi$*, a stratication* $str(\Pi) = (U, L)$ *and a state* $s_0$ *, for any valid path* $p = (a_1, \cdots, a_n)$*, if there exists* $2 \leq i \leq n$*, such that* $L(a_i) < L(a_{i-1})$ *and that* $a_i$ *is not a follow-up action of* $a_{i-1}$*, then* $p = (a_1, \cdots, a_{i-2}, a_i, a_{i-1}, a_{i+1}, \cdots, a_n)$ *is also a valid path and leads to the same state from* $s_0$ *as* $p$ *does.*

**Proof:** Note that in the SP paper, the claim that *"since* $\mathcal{L}(a_i) < \mathcal{L}(a_{i-1})$*, the SCC in* $CCG(\Pi)$ *that contains* $ai - 1$ *has no dependencies on the SCC that contains* $a_i$ *. Therefore, eff*($a_i$) *contains no assignment in* $pre(a_{i-1})$*"* is not true when $\mathcal{L}(a_i) = \infty$.

However, under the new definition, since $\mathcal{L}(a_i) < \mathcal{L}(a_{i-1})$, there is no edge from the domain variables appear in *aff*($a_i$) to domain variables in either *dep*($a_{i-1}$) or *aff*($a_{i-1}$), we show that *eff*($a_i$) must not contain any assignment in $pre(a_{i-1})$. Otherwise, if there is a variable assignment shared by *eff*($a_i$) and $pre(a_{i-1})$, say $x$, we have $\mathcal{L}(a_i) = \mathcal{L}(x)$ since $x$ is the variable that is in *aff*($a_i$). However, we know that there must be an arrow from a variable in *eff*($a_{i-1}$) to *dep*($a_{i-1}$), that is to say, $\mathcal{L}(a_{i-1}) \leq \mathcal{L}(x) = \mathcal{L}(a_i)$. This contradicts with our assumption that $\mathcal{L}(a_i) < \mathcal{L}(a_{i-1})$.

The rest of the proof is identical to the one in the SP paper. ■

We have explained that $trans(o)$ should really be replaced by *eff*($o$) because $trans(o)$ can be empty in Stratified Planning. The same adjustment should also be applied to the Expansion Core algorithm because it also relies on the $trans(o)$ notion to associate actions to DTGs.

The EC paper claimed that if the goal path length is 1 and if $s_i^0$ is not a goal in its DTG, $a \vdash G_i$. With the definition of "association" in the paper, if an one step solution has action $a$ that does not have any transitions, $a$ would not be able to associate with $G_i$. Under the new definition, since $a$ leads to a different variable value for $x_i$ in $G_i$, $a$ is associated with $G_i$ by definition. The rest of the proof in the paper is still valid, and the statements following the theorem still hold.