

Supplementary Information

Efficient Consistency Check Based on Perceived Initial Deviation

Liwen Zhang ^{1,2}, Fanglue Wang ^{3*}, Zhihuan Song ², Kaifeng Huang ¹, Yanli Hu ¹ and
Guiying Zhuo ¹

¹ School of Mechanical and Electrical Engineering, Huainan Normal University, Huainan, 232038, China.

² State Key Laboratory of Industrial Control Technology, School of Control Science and Engineering, Zhejiang University, Hangzhou, 310027, China

³ School of Biological Engineering, Huainan Normal University, Huainan, 232038, China.

* Correspondence: author: Fanglue Wang (wangfanglue66@163.com)

The working principle of perceptible algorithm is described in figure S1. The non-optimality of alignment can be determined based on the initial deviation location when the initial deviation occurs in the perceptible region.

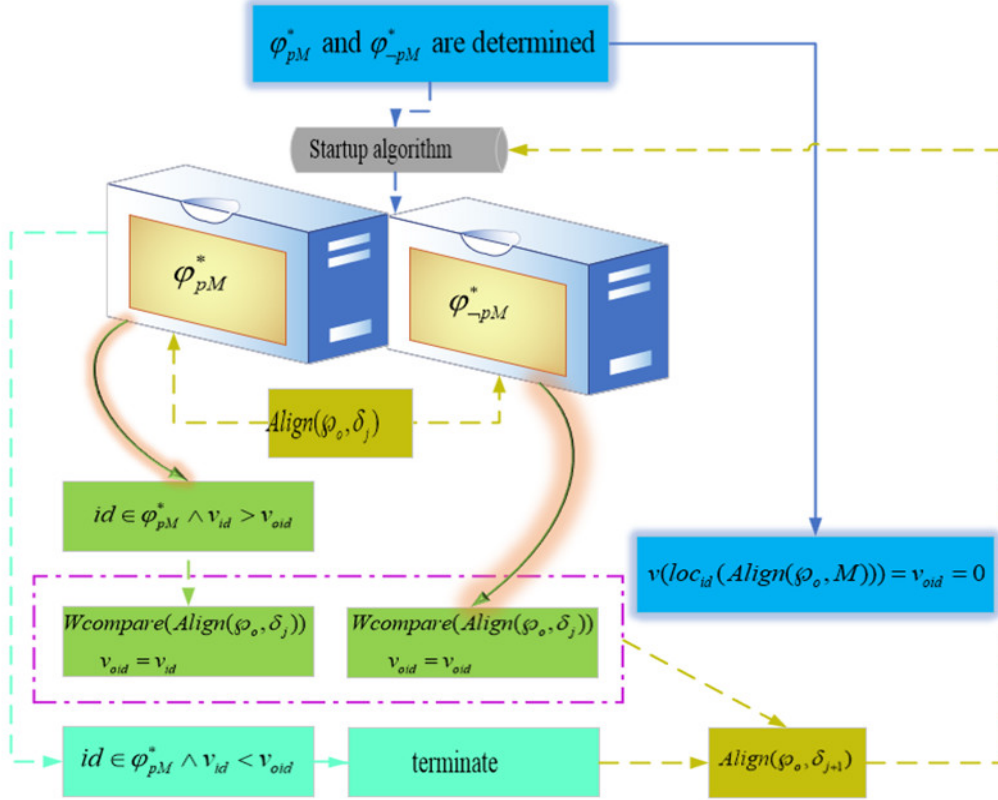


Figure S1. The working principle of perceptible algorithm. Note: $Wcompare$ is the function of complete comparison, id is the initial deviation, v_{oid} is the default location of initial deviation, and v_{id} is the location of initial deviation.

The perceptible search (PS) is divided into the following four steps:

- (I) $Ide(v(loc_{id}(Align(\varphi_o, \delta_j))) \in \varphi_{pM}^*)$ (Ide is the identified function)
- (II) $v(loc_{id}(Align(\varphi_o, \delta_j))) \geq v(loc_{id}(Align(\varphi_o, M))) \rightarrow v(loc_{id}(Align(\varphi_o, M))) = v(loc_{id}(Align(\varphi_o, \delta_j)))$
- (III) $v(loc_{id}(Align(\varphi_o, \delta_j))) < v(loc_{id}(Align(\varphi_o, M))) \rightarrow v(loc_{id}(Align(\varphi_o, M))) = v(loc_{id}(Align(\varphi_o, M)))$
- (IV) $v(loc_{id}(Align(\varphi_o, \delta_j))) < v(loc_{id}(Align(\varphi_o, M))) \rightarrow Align(\varphi_o, \delta_j) \neq Align_{op}(\varphi_o, M)$

Theorem 1 The optimal alignment is reasonably determined according to the perceptible condition in the perceptible region.

Proof: The initial deviation is produced by the inconsistent behavior between the event log and the process model. The substructure of initial deviation in the process model can be determined, denoted as $N_{\supset id}$. The last unit movement of $N_{\supset id}$ in any alignment is regarded as the perceptible end point, denoted as p_f . According to the definition 4, the sub-alignment is $Align_{(p_f)}(\wp_o, \delta_j)$ in the range from initial movement of an alignment to p_f . The first movement after p_f to the last movement of alignment is $Align_{(p_f)}(\wp_o, \delta_j)$. For example, table S1 records the alignments $\xi_1 = Align(\wp_o, \delta_1)$ and $\xi_2 = Align(\wp_o, \delta_2)$ between a trace $\wp_o = (ABCEG)$ and the firing sequences δ_1 and δ_2 . The substructure of initial deviation on the process model is produced by the conflict substructure of hidden transition τ and activity B , denoted as $N_{\supset id} = N_{(\tau, B) \times}$. Both ξ_1 and ξ_2 satisfy C_p before the p_f , since $N_{(\tau, B) \times}$ belongs to the perceptible region $\wp_{pM}^*$, i.e: $v(loc_{id}(\xi_1)) > v(loc_{id}(\xi_2)) \rightarrow cost(\xi_{1(p_f)}) < cost(\xi_{2(p_f)})$. From table S1, the red represents the initial deviation, the sub-alignments involved are marked with green background, the perceptible end point p_f is marked by blue, and gray backgrounds are automatically skipped without practical significance.

Table S1. The alignments δ_1 and δ_2 satisfy condition C_1 .

ξ_1	A	B	C	→	E	→	G
	A	B	→	D	→	F	G
ξ_2	A	B	C		E		G
	A	→	→		E		G

If $cost(Align_{(p_f)}(\wp_o, \delta_j) \cup Align_{(p_f)}(\wp_o, \delta_j)) > cost(Align_{(p_f)}(\wp_o, \delta'_j) \cup Align_{(p_f)}(\wp_o, \delta'_j))$ and $v(loc_{id}(Align(\wp_o, \delta'_j))) < v(loc_{id}(Align(\wp_o, \delta_j))) \rightarrow cost(Align_{(p_f)}(\wp_o, \delta'_j)) < cost(Align_{(p_f)}(\wp_o, \delta_j))$ in the perceptible range, $cost(Align_{(p_f)}(\wp_o, \delta_j)) > cost(Align_{(p_f)}(\wp_o, \delta'_j))$. In this case, the process model contains a selective substructure after the perceptible end point of p_f .

Therefore, $\text{cost}(\text{Align}_{(p_f)}(\wp_o, \delta_j) \cup \text{Align}_{(p_f)'}(\wp_o, \delta_j')) < \text{cost}(\text{Align}_{(p_f)}(\wp_o, \delta_j') \cup \text{Align}_{(p_f)'}(\wp_o, \delta_j))$ can be satisfied. $\text{Align}(\wp_o, \delta_j')$ is not the optimal alignment between $\wp_o$ and M . The process model M described in figure S2 can be inferred from the alignments recorded in table S1. The blue activities are located after p_f . As shown in figure S2, the substructure of initial deviation is located in the perceptible region.

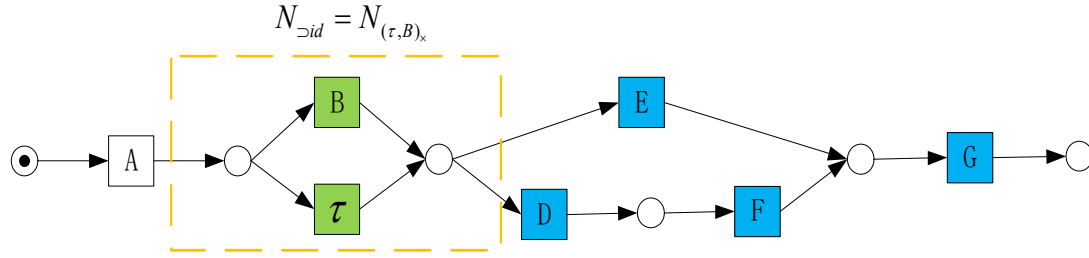


Figure S2. An instance of the substructure that produces initial deviation.

Table S2 records the other alignments ξ_3 and ξ_4 between $\wp_o = (ABCEG)$ and M . $\xi_{1 \star (p_f)}$ and $\xi_{2 \star (p_f)'}^*$ are merged to form ξ_3 , which can realize $\text{cost}(\xi_3) = 1 < \text{cost}(\xi_2) = 2$. In conclusion, ξ_2 can be directly determined to be the non-optimal alignment of $\wp_o$ when $v(\text{loc}_{id}(\xi_2)) < v(\text{loc}_{id}(\xi_1))$.

Table S2. The alignments δ_3 and δ_4 satisfy condition C_1 .

ξ_1'	A	B	C		E		G
	A	B	→		E		G
ξ_2'	A	B	C	→	E	→	G
	A	→	→	D	→	F	G