Window-based Diagnostic Algorithms for Discrete Event Systems and Verifying Precision of Diagnostic Algorithms

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Diagnosis of Discrete Event Systems (DES)

1. Diagnosis by computing belief states

2. Off-line computation: number of belief states makes it inapplicable for real-world problems

3. Symbolic and propositional logic using Binary Decision Diagram is subject to exponential blow-up in space.

4. Pre-computation of belief states takes exponential running time and has an exponential size in the number of states.

New Time-Windows Algorithms

1. Time windows only consider most recent observations
2. Motivations and benefits:
(1) flexibility: independent diagnosis analyses on separate time windows and skips irrelevant time windows
(2) reduce diagnosis complexity: more manageable and build a diagnoser of polynomial size
(3) precision loss? Precision is tested.
3. DES model: Figure 1 shows an Automaton
4. Diagnosis indicates whether system is in nominal mode or in faulty mode. Diagnoser assumes that system is not faulty unless proved otherwise.
5. Table 1 and 2 show two examples Window-based Diagnosis and demonstrate the importance to decide which algorithm to use and size of time window.

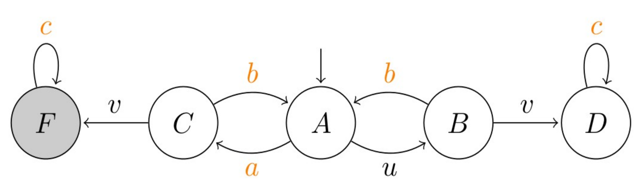

Figure 1. DES Model: *F* is a faulty state. Other states are nominal. a, b, c are observable events. u, v are unobservable.

Observation	Slice	Diagnosis	Output
a,b,b,b,b,c,c,c	(a,b,b,b)	N	N
	(b,c,c,c)	N	
a,b,b,b,a,c,c,c	(a,b,b,b)	N	F
	(a,c,c,c)	F	
b,a,b,a,c,c,c,c	(b,a,b,a)	N	N
	(c,c,c,c)	N	

Table 1: Algorithm 1 (Al_1) slices a sequence of observations every 4 observations.

Input	Slice	Diagnosis	Output
a,b,b,b,b,c,c,c	(a,b,b,b)	N	N
	(b,b,b,c)	N	
	(b,c,c,c)	N	
a,b,b,b,a,c,c,c	(a,b,b,b)	N	F
	(b,b,a,c)	F	
	(a,c,c,c)	F	
b,a,b,a,c,c,c,c	(b,a,b,a)	N	F
	(b,a,c,c)	F	
	(c,c,c,c)	N	

Table 2: Algorithm 2 (Al_2) slices a sequence of observations every 4 observations and time windows overlap. Al_1 has drawbacks of imprecise diagnosis as it could not diagnose fault in the third observation.

Verify precision of diagnosis algorithms using simulation

1. Measure precision of Time-Window Algorithms

2. Build simulation si (M, A) for model (M) and diagnostic algorithm (A). Figure 2 illustrates Al_1 simulation for DES model in Figure 1.

Experiments and results

1. Use Binary Decision Diagram to test diagnosability of model and precision of windows-based algorithms.
2. Example of factory operations: Figure 3 shows central model Mc dispatching a job (ai) to operation plants (Mi) and receiving feedback (ei). If Mc enters faulty scenario, only e1 will be observed from M1.
3. In Figure 4, results show that they are all diagnosable.

Future work

1. "Backbone" diagnosis: remember what we know for sure
2. How to find root cause of ambiguity?
3. Create a benchmark for experiments

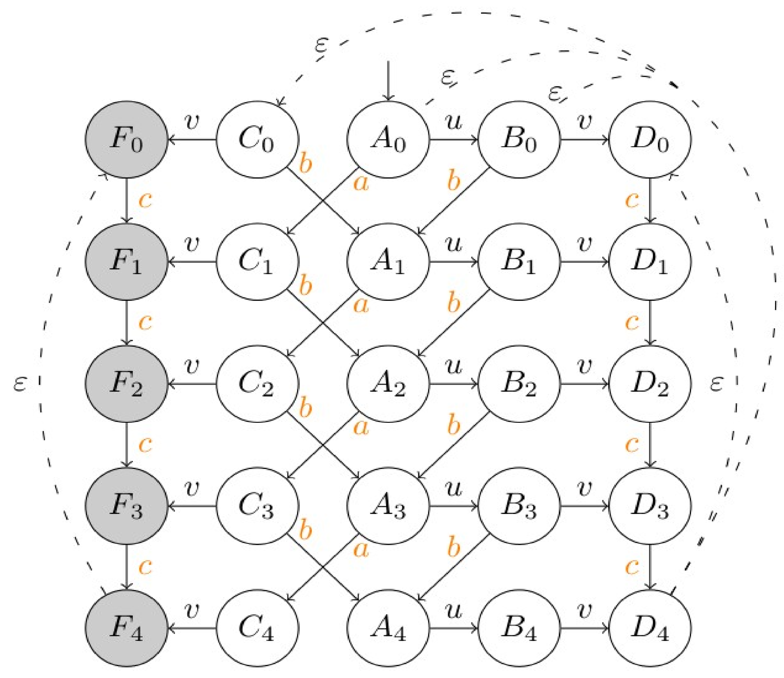

Figure 2. Part of Algorithm 1 simulation: Dotted lines also need to link A_4 to A_0, B_0, C_0 and D_0. Same applies to B_4 and C_4.

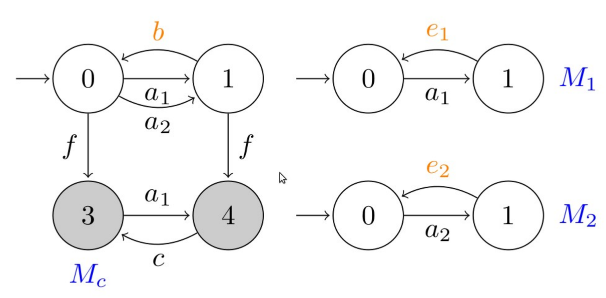

Figure 3. Example of factory operations

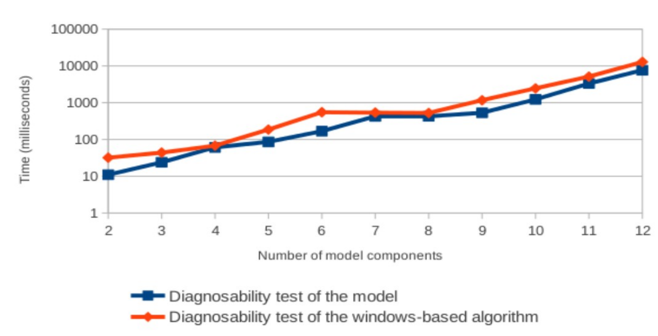

Figure 4. Running time of precision tests

From imagination to impact

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