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FAIL PROCESSES PREDICTABILITY IN SYSTEMS WITH S-DEPENDENT COMPONENTS

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Abstract: In assumption of the faulty processes independence, the distribution of working times of each component may be considerate invariant. If it will renounce at this assumption, the faulty processes dynamic is dependent on the instantaneous state of the system. This continue the studies from a couple of paper in which the identification of these dependencies is achieved by a model that can be train to generate distributions of times comparables with those from the real system . Based on simulations with this proposed model, it will show the possibility of prediction in faulty processes probability terms.

Keywords: predictive diagnose, Markow chains, s-dependent components.

1.INTRODUCTION

An identification method for the faulty processes dependence of a technic sistem components is proposed in [1]. It is based on the follow reason: there is the possibility to estimate the previous critical states of faults with intelligent estimators which include empirical observations and the processing results of some states of observed components. The estimated critical states are data input for a fuzzy estimator which try to reduce the error between the statistical parameters of model and those of the real system, thus asymptotic, the model will reproduce functioning times repartitions close to those of real system. The main part of model represents the vectors state generator, which produces series of faulty events corresponding to the dependencies identificated by the model.

2.STATISTICAL PARAMETERS OF EVENTS SERIES

Any prediction of a random process evolution is limited by the stochastically nature of process himself. On the other way, in case of faulty processes of system components, the behavior of these systems will become closer to a deterministic behavior.

2.1. Transition Matrics

Data base and/or state vectors generator supply successive sequences like these:

$$U^j = S^j_{i1}, S^j_{i2},\dots, S^j_{ik},\dots, S^j_{ip}, F_i,\dots \quad (1)$$

where S^j_{ik} represent state vectors of system of trajectory j, F_i is the faulty event of component $e_i, i=1:n$ [1]. Eliminating the state vectors, a list with the following form will obtain:

$$L = \{F_{i1}F_{i2},\dots,F_{ij},\dots,F_{iN}\}\Big|\begin{matrix} ij = 1:n \\ N - the\ list's\ components\ number\end{matrix} \quad (2)$$

The prediction must indicate which is the next most probable faulty event in the series describe above after the last registration F_{iN}

2.2.The first orderly prediction

We'll considerate that the L list represent a first orderly Markow chain with the following argument which rezult from [1]:

At the occurrence of an faulty event F_i^{n-1}, which is produce as result of the succession of the $S_{i1}^j, S_{i2}^j, ..., S_{ik}^j, ..., S_{ip}^j$ events, all elements of the last event remain unchanged, except that's corresponding to the faulty component, which take value 1, equivalent to a critical state and it affect most powerfully the evolution of e_i component. So, all the sequence $S_{i1}^j, S_{i2}^j, ..., S_{ik}^j, ..., S_{ip}^j$ determine (in continuance) the system evolution, that means the probability of F_{i1}^n state depends only on F_{i2}^{n-1}:

$$P(F_{i1}^n) = P(F_{i1}^n \mid F_{i2}^{n-1}) \qquad (3)$$

As a result of the hypothesis that the chain is first orderly, and the *S(0)* vector of initial state is known, it is determining the transition matrics P. We'll call this prediction, *first orderly prediction*, according to hypothesis that the chain is first orderly.

We'll calculate the conditioned probabilities for succession of events from (2) :

$$p_{kl} = P(F_k \mid F_l) = \frac{P(F_k F_l)}{P(F_l)} = \frac{N(F_k F_l)/(N-1)}{N(F_l)/N} \qquad (4)$$

where $N(F_k F_l)$ is the apparition number of the ordered couple $F_k F_l$.

2.3.The two- orderly prediction

In a same maner it is made the two- orderly multiple prediction, based on hypothesis that the chain is an two- orderly multiple. This hypothesis presume that the E^n state depends only on the E^{n-1} and E^{n-2} states.

$$P(F_{i1}^n) = P(F_{i1}^n \mid (F_{i2}^{n-1} \cap F_{i3}^{n-2})) \qquad (5)$$

that is caracteristic to the two- orderly Markow chain. We'll call this prediction, two- orderly prediction, according to hypothesis that the chain is two- orderly.

The conditioned probabilities will be calculated with the formula:

$$p_{klm} = P(F_m \mid F_k \cap F_l) = \frac{P(F_k \cap F_l \cap F_m)}{P(F_k \cap F_l)} = \frac{N(F_l \cap F_m)/(|L|-2)}{N(F_k \cap F_l)/(|L|-1)} \qquad (6)$$

where $F_k \cap F_l \cap F_m$ represent the succesion event, in the writer order of individual events F_k, F_l *and* F_m:

If the number of components (faulty events) is *n*, then the transitions matrics for the two-orderly Markow chain is:

$$P = \begin{bmatrix} P_{111} & P_{112} & .... & P_{11n} \\ P_{121} & P_{122} & .... & P_{12n} \\ .... & .... & .... & .... \\ P_{kl1} & P_{kl2} & . & P_{k\ln} \\ .... & ..... & & ..... \\ P_{nn1} & P_{nn2} & & P_{nnn} \end{bmatrix} \quad (7)$$

where P_{klj} is the probability of character j to follow the couple kl (renouncing to common symbol F).
The rank i of line that contain the probabilities associate to symbols kl is given by:

$$i = (k-1) \cdot n + l \quad (8)$$

Similar, it could be writen the transition matrices for upper order predictions. We'll accept that, the more the dependence of faulty processes of the system components is powerfully, the better the multiplicity order of prediction is more reduced [3].

4. NUMERICAL EXAMPLE

In [1] was modelated the evolution of the faulty processes of the hydraulic part of a MOP drive mechanisme of an HT bracker with the following main components: 1.Electric motor;
2. Supple mechanical couple; 3.The hydraulic pump; 4.The hydraulic resistance (detentor); 5.The oil.

The dependencies between components, estimated by the system described in the first paragraph , lead to the following list L, with $N=50$ faulty events, generated with the state vectors generator:

*U=2 5 4 2 3 5 1 4 2 5 4 2 3 5 4 1 2 5 4 4 2 3 5 1 4 2 5 4 2
5 1 4 2 5 4 3 2 5 1 4 2 5 4 2 3 5 1 4 2* ***5*** *4:*

(For simplicity, only the component's index are writed)
We consider as known the evolutions until the ***5*** marked symbol (the last recording: the fault of the component 5) and we are interested on which is the next most probable fail event.

4.1.First orderly Prediction

It is proceeding like in paragraph 2.1. Using (4), the transition matrices will result:

P =

0	0.1660	0	0.8340	0
0	0	0.3100	0	0.6900
0	0.2000	0	0	0.8000
0.0700	0.7200	0.0700	0.0700	0.0700
0.3800	0	0	0.6200	0

-The prediction is given by the expression S(*next(5))=S(5)*P*, where:

$$S(5) = [0 \quad 0 \quad 0 \quad 0 \quad 1]$$

The result is:

S(*next(5)*)=[0.3800 0 0 **0.6200** 0]

Therefore the most probable *event* is the aparition of the symbol *4*, *that just folow in the series U.*

4.2. The two- orderly prediction

The proceeding is like to 2.2 paragraph. Using (7), (8), the transition matrices with nonzeros lines will result:

	0	0	0	0	1.0000	P(1)
	0	1.0000	0	0	0	P(4)
	0	0	0	0	1.0000	P(8)
	0.2500	0	0	0.7500	0	P(10)
P=	0	0	0	0	1.0000	P(12)
	0.7500	0	0	0.2500	0	P(15)
	0	1.0000	0	0	0	P(16)
	0	0	0.4000	0	0.6000	P(17)
	0	1.0000	0	0	0	P(18)
	0	1.0000	0	0	0	P(19)
	0	0	0	1.0000	0	P(21)
	0.1429	0.5714	0.1429	0.1429	0	P(23)

The next event after the producing of event 5 is:

next(5) = S x P = [0.25 0 0 ***0.75*** *0]*

The result is the same like in the first orderly prediction case: the most probable event is the event 4, but making a comparation between the both values of prediction, it's observing that the value given by the two- orderly prediction is greater.

In conclusion, using the proposed model in [1], the presented prediction experiments prove that the components of a system are dependents, the prediction of some fail events become posible. Of course, because the prediction is expressed with the maxim value of a probability, establishing the needed prediction order it must to made after a statistical processing of the prediction results.

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