OPTIMIZING THE DECISION FUNCTION OF THE RESIDUES SELECTION

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Abstract: To optimize the decision functions, we will start setting parameters of decision functions, and then define some criteria that allow them to assess them performance. Two methods for construction of decision functions are proposed to meet the best criteria of performance: one is based on an algorithm derived from the formulation of the problem, the other is based on an optimization by a genetic algorithm.

Keywords: Networks of neurons, generator residue, model dynamic, diagnosis, machine

1. INTRODUCTION

Each decision function is defined by two ensemble disjunctive residue spotted by their indices: $I_0 \subset \{1 \ldots n_r\}$, $I_1 \subset \{1 \ldots n_r\}$. Relation (1) defines the decision function D (I_0, I_1) by I_0 and I_1 parameters:

$$D(I_0, I_1) = \left(\underset{i \in I_0}{\wedge} \overline{T}_1 \right) \wedge \left(\underset{i \in I_0}{\wedge} T_1 \right) \text{ cu } I_0 \cap I_1 = \emptyset \quad (1)$$

Assemblies residue defining the decision D_j used to locate the defect f_j are noted with I_0 and I_1:

$$D_j = D\left(I_0^j, I_1^j\right) \qquad (2)$$

I_0^j (*respectively* $I_{1,}^j$) corresponds to a part of residues which are little or unaffected (respectively affected) as opposed with $f_j \cdot I_{0,\max}^j$ to identifying all residues associated with '0' respectively '1' in the boolean symbol of f_j. We therefore have:

$$I_{0,\max}^j = \{i / \alpha_{ij} = ' \succ\succ ' \}, I_{1,\max}^j = \{i / \alpha_{ij} \neq ' \succ\succ ' \} \qquad (3)$$

A usual construction of D_j from a table of boolean decision is therefore gave by $D_j = \left(I_{0,\max}^j, I_{1,\max}^j\right)$, which is equivalent to relation (2).

Relation (1) defines a decision function from the lines residues T_i. The same relation (1) therefore indicates how the decision line is calculated. We seek now to answer the following question: what information about the amplitudes of faults can be inferred from the calculation of the line D (I_0, I_1). This T_1 is replaced by an interpretation exceeded threshold. In the expression of D (I_0, I_1), to simplify the logic equations, D (I_0, I_1) is first recast (5) taking into account the hypothesis of simple defect[1]: S_f = 1 (Sf_k corresponding to occurrence of possible defect f_{12}).

Simple defect hypothesis: Sf = 1

$$Sf = \underset{k=1 \ldots nf}{\vee} Sf = 1 \quad \text{for } Sf_k = \underset{k \neq l}{\wedge}\left(f_l = 0\right) \qquad (4)$$

The expression of D (I_0, I_1) taking in account Sf = 1

$$\begin{aligned} D(I_0, I_1) &= D(I_0, I_1) \wedge Sf = \\ &= \underset{k}{\vee}\left[\left(\underset{i \in I_0}{\wedge} \left(\overline{T}_i \wedge Sf_k \right) \right) \wedge \left(\underset{i \in I_1}{\wedge} \left(T_i \wedge Sf_k \right) \right) \right] \end{aligned} \qquad (5)$$

T substitution interpretation, in terms of faults knowledge:

$$D(I_0, I_1) = \underset{k}{\vee}\left(\breve{f}_k(I_1) \prec |f_k| \leq \hat{f}_k(I_0) \right) \qquad (6)$$

$$\breve{f}_k(I_1) = \max_{i \in I_1}(\alpha_{ik}), \hat{f}_k(I_0) = \max_{i \in I_0}(\alpha_{ik})$$

In relation (6), the $\left[\breve{f}_k(I_1); \hat{f}_k(I_0)\right)$ interval is associated with each f_K defect. More precisely, (6) establishes a link between the value of a certain decision function, D (I_0, I_1) and knowledge about the amplitudes of faults, this knowledge is expressed in the form of intervals whose edges depend on I_0, and I_1 of the sensitivity residue defects. Application (1) and (6) with $I_0 = I_{0,\max}^1 = \{1\}$ and $I_1 = I_{1,\max}^1 = 2{,}3$.

$$\begin{aligned} D(I_0, I_1) &= D = \overline{T}_1 \wedge T_2 \wedge T_3 = \\ &= \left(30\% \prec |f_1| \leq ' \prec\prec ' \right) \vee \left(20\% \prec |f_2| \leq 40\%\right) \end{aligned} \qquad (7)$$

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[1] The simple defect hypothesis is to assume that it can produce one defect.

The symbol ' « ' in (7) can be considered as arbitrarily large. Relation (7.) indicates us that D_1 become true when | f_1 | > 30% or | f_2 | is between 20% and 40%. If the decided aim of D_1 is to locate f_1, D_1's sensitivity to f_2 can lead to a false decision.

Starting from the interpretation of D (I_0, I_1) to know the faults, remains to define performance criteria designed to assess whether a function of decision is "good" or "bad". A "good" D_j decision function allows to locate f_j to other defects, which are as sensitive as the f_j.

2. LOCALIZATION, ANALYSIS AND CRITERIA FOR SENSITIVITY

In the example given by (7.) appears that D_1 would allow to locate f_1 (D_1 otherwise said, would be sensitive to the f_j and only f_i) if the interval of associated f_2 is null. Validating (6), this observation is generalized to obtain a criterion for i_0 and i_1^j because D_j = $D\left(I_0^j, I_1^j\right)$ to locate the f_j. Criterion's location of f_j, f_j, $J_{LOC(j)}$ is verified if and only if, for any defect other than the f_i, the amplitudes leading D_i to take the "true" value is null:

$$J_{LOC(j)} = 1 \quad \text{for } \forall k \neq j, \breve{f}_k\left(I_1^j\right) \succ \widehat{f}_k\left(I_0^j\right)$$

$$\left(\Leftrightarrow \max_{i \in I_1^j}\left(\alpha_{ik}\right) \succ \min_{i \in I_0^j}\left(\alpha_{ik}\right)\right) \tag{8}$$

$$J_{LOC(j)} = 0$$

To cancel the associated faults $f_{k \neq j}$ corresponds to disengage from $D_j = D\left(I_0^j, I_1^j\right)$ defects, other than f_i (6.). Diagnosing appears above all as a matter of decoupling problem, latter can be achieved equally well with both numerical (generation of waste) and logical (decision) models.

Location criterion refers to D_j's (non-) sensitivity to defects, other than f_j. The criteria related to the sensitivity of D_j with f_j defect are now established. This sensitivity is even greater as the associated interval to the f_j in D_j $\left[\breve{f}, \left(I_1^j\right), \widehat{f}_j\left(I_0^j\right)\right]$ is bigger. Lower limit must be minimized to ensure good sensitivity to small defects (SSD), the upper limit should be possible maximized to ensure proper sensitivity to major defects (large) (SMD). Criteria $J_{SSD\ (j)}$ and $J_{SMD\ (j)}$ are defined taking into account the normalization between 0 and 1 of i, j coefficients. They must be maximized during decision synthesis D_j function.

$$J_{SSD(j)} = 1 - \breve{f}_j\left(I_1^j\right) = 1 - \max_{i \in I_1^j}\left(\alpha_{ij}\right) \tag{9}$$

$$J_{SMD(j)} = 1 - \widehat{f}_j\left(I_0^j\right) = \mathrm{mIN}_{i \in I_0^j}\left(\alpha_{ij}\right) \tag{10}$$

Limiting us to a particular form for the decision, a summary of features for decision D_j = $D\left(I_0^1, I_1^0\right)$ for f_j defect is reduced, so the crowds to find I_0^j and I_1^j residues that maximizes simultaneously: a criterion for localization of f_j (8), a sensitivity criterion to small defects f_j (9) and a sensitivity criterion to major f_j defects (10). First, an analysis is treated for problem of optimization, being developed in three points.

A simple solution is to throughout systematically the space solutions. How each residue can be in I_0^j, or either in I_1^j, or in $I_0^j \cup I_1^j$'s behavior, or a browse of all solutions would lead to the calculation criteria 3^{nr} times. In sensitivities of MCC, 18 residues were generated: $3^{18} \approx 3{,}9 \cdot 10^8$. A systematic way of space solutions is therefore removed.

Considering that an upper limit of sensitivity of D_j to f_j must be dispensed with, maximization of sensitivity criterion to large defects requires that $I_0^j \subset I_{0,\max}^j$ ((10) and (3)). Under these conditions, to choose I_0^j = $I_{0,\max}^j$ is optimal choice to meet the locating criterion (8), although is not necessarily the only possible choice.

Indeed, similarly, such $\max_{i \in I_{1,\max}^j}\left(\alpha_{ik}\right) \geq \max_{i \in I_1^j \subset I_{1,\max}^j}\left(\alpha_{ik}\right)$, to choose $I_1^j = I_{1,\max}^j$ is optimal to meet the localization criterion (8) even if is not a necessarily possible choice. However, this choice leads to the worst sensitivity to small f_j defects (9). It is interesting to note that they found a compromise between sensitivity and robustness: sensitivity to f_j defect (9) and robustness location. As we see on the MCC application, when $I_1^j = I_{1\max}^j$ D_j's sensitivity to f_j defect can make D_j almost unusable in practice, we look to restore the compromise between sensitivity and robustness with the advantage of f_j's sensitivity.

3. THE CONSTRUCTION ALGORITHM OF DECISION FUNCTIONS, APPLICATIONS

If we analyze the problem fixed by optimizing the decision functions, leads us to propose algorithm in Table 1.

Table 1: The algorithm to build the D_j decision function, the most possible sensitive to f_j satisfying the locating criterion and using a minimal number of residues.

Algorithm	Observations
$I_o^j = I_{0,max}^j$	Initializing I_o^j (see review 2)
Because $J_{LOC(j)}$=0 and $I_o^j \neq I_{1,max}^j$	Initializing a boot to an iterative building of I_1^j
$I_1^j = I_1^j \cup \left\{ i \text{ sothat } \alpha_{ij} = \min_{i \in I_{1,max}^j - I_1^j} \alpha_{ij} \right\}$	As long as the location criterion (8) is not satisfied and remain in $I_{1,max}^j$ selection residues

End because
If $J_{LOC(j)}$=0 then
Return to residues generation
Sensitivity study => new α
Algorithm resumption
Unless
For i=1…n_r
If $i \in I_o^j \cup I_1^j$ and if i is out from I_o^j or from I_1^j does not lead then $J_{LOC(j)}$, $J_{SPD(j)}$, and $J_{SGD(j)}$ variations, then
We get i from I_o^j if $i \in I_o^j$
We get i from I_1^j if $i \in I_1^j$
End if
nd for
End if
$D_j = D(I_o^j, I_1^j)$
	The residues selection from $I_{1,max}^j$ and more sensitive to f_j and not before.
	If f_j (8) localization have not been able to achieve
	Must be generate other residues
	If are not removed unnecessarily selected residues (decision with a minimum number of residues)
	For each residue
	
	Construction of decision function D_j with I_o^j and I_1^j

a) The corresponding continuous current machine application (MCC)

Table 2. The decision functions sensitivity which causes interference to all residues

Defect	Sensitivity
$f_1=f_\beta$	f_β>41,9%
$f_2=f_1$	f_I>73,5%
$f_3=f_\Omega$	f_Ω>25,1 %
$f_4=f_U$	f_U>32,1%

Table 3. The application of algorithm to build decision functions

Defect	Decision function	Sensitivity
$f_1=f_\beta$	$D_1=T_4$	f_β>1,3%
$f_2=f_1$	$D_2 = \overline{T}_{13} \wedge \overline{T}_{15} \wedge T_1$	f_I>13,6%
$f_3=f_\Omega$	$D_3 = \overline{T}_{16} \wedge T_{17}$	f_Ω>0,3 %
$f_4=f_U$	$D_4 = T_{13} \wedge \overline{T}_{14}$	f_U>15,9%

The corresponding MCC is based on the sensitivity study and from this, its decision functions to interfere all residues ($D_j = D(I_{0max}^{j'}, I_{1,max}^{j'})$, satisfying location criteria, but their sensitivity to defect test is rather bad (Table 2).

Poor sensitivity of residues react directly on the results of Table 2: indeed, the sensitivity of decision making to intervene all residue is the residue of the least sensitive. The algorithm leads to a decision function whose sensitivity to defects is correct (Table 3), while the criterion is satisfied and location.

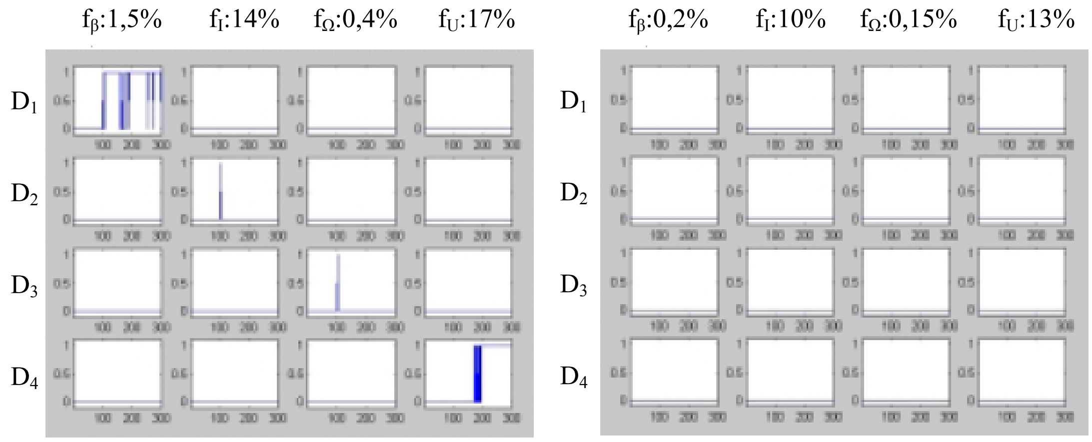
It may be noted that residues from 13 to 17 are retained to calculate logical functions from D_2 to D_4. These residues are common in the observations with unknown input (OUI), or through a frequencies proxy (FP). These methods of generating residue indeed cause several degrees of freedom to adjust the sensitivities of residues than residues Global Synthesis (RG) or local (RL).

Sensitivity function varies with the f_β decision is the residue most sensitive to f_β. A similar situation can be found to be for f_I and f_Ω. However, D_4's sensitivity is f_U>15,9% when the most sensitive residue to f_U is r_{18} with f_U > 3,8%.

Contrary to other defects, more iteration in loop and the algorithm (Table 1), are required to meet before the location criterion. The most sensitive residue to f_u to be included in I_1^4 to satisfy (1.) is r_{13}. Consequently, D_4's sensitivity to f_u is that of r_{13} (f_u > 15.9%).

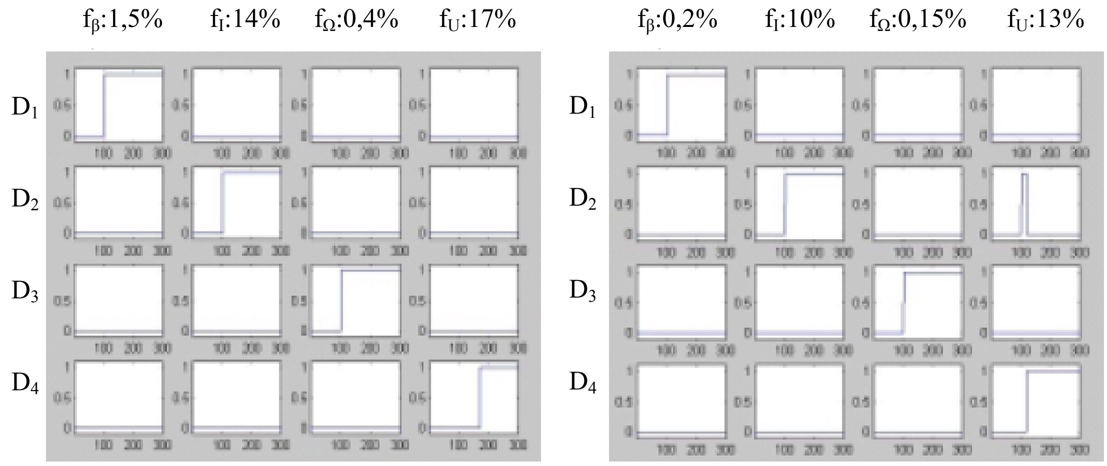
Decision functions simulation (Figure 1.a and Figure 1.b) confirms the limits of sensitivity in Table 3. Instability decisions D_1 and D_4 in Figure 1. are related to noise measurement, a simulation without noise allowed us to verify that the transient non null values of D_2 and D_3 are not related to the presence of noise in the measurements. The fact that D_2 and D_3 take real value for a short period of time is explained by overcoming the threshold, not necessarily short, as the residue limit of sensitivity and having a transitional behavior (Figure 2). A solution to pall (hide for a short time) this problem is to store the threshold exceedances (Figure 1.c.). Even if the threshold exceedances are stored, as temporal aspects are not taken into account, the order of threshold overruns to be the origin of false decisions (Figure 1.d).

To verify this interpretation, the results of the threshold exceedance are shown in Figure 3. Can verified the fact that the threshold overruns perfect match expected results taking into account the sensitivity study. Figure 3. leads to the conclusion that the origin of false decisions in Figure 1.d comes from the delay of r_{13} that exceeds its threshold compared to r_{16}, in response to f_u.



(a) amplitudes upper limit of defect sensitivity of decision function (without storing threshold exceedances)

(b) amplitudes of faults below the limit of sensitivity decision functions (without storing threshold exceedances)



(c) amplitudes upper limit of defect sensitivity decision function (by storing threshold exceedances)

(d) amplitudes of faults below the limit of sensitivity decision functions (by storing threshold exceedances)

Figure 1: Simulation of obtained decision functions.

Transient residue and his threshold (sensitivity limit)

Test's result to overcome the threshold.
Without memory.

Test's result to overcome the threshold.
With memory.

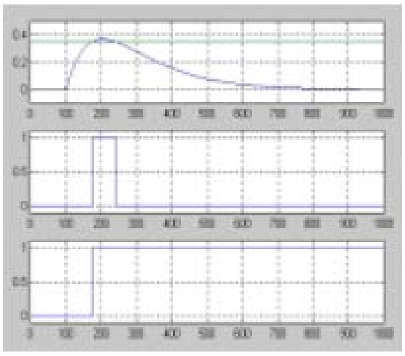


Figure 2. Overcoming tests of threshold with and without memory.

f_β :50% f_I :50% f_Ω :50% f_U :50%

T_4
T_{13}
T_{14}
T_{15}
T_{16}
T_{17}

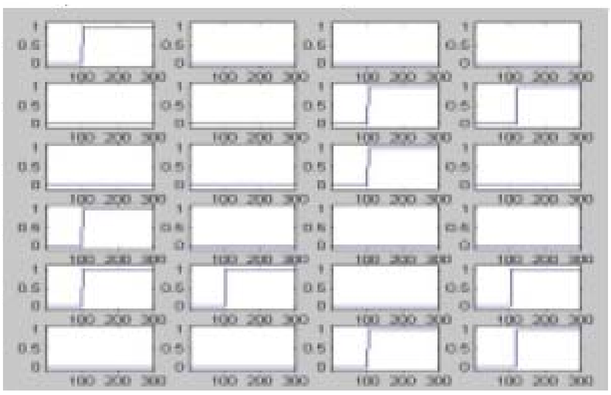


Figure 3. Overcoming tests of memory threshold with 50% defects

Storing exceedances threshold corresponds in fact to a dynamic decision and not a purely static decision.

The proposed decision presents some limitations related to consideration of temporal aspects. To note that the information provided by the study of sensitivity achieved is not sufficient for such a decision into account. Another limit comes from assuming the shape of defects (in step), and more generally in how they are taken into account uncertainties related to the interpretation of exceedances threshold.

4. CONCLUSIONS

For this, one solution is to progressively build I_1^j on choosing $I_{1,\max}^j$ residues from the most sensitive f_j defect to the most sensitive one, and to stop building I_1^j once it is satisfied the location criterion (8.).

Location is especially strong in the different uncertainty sources and as $\breve{f}_k\left(I_i^j\right)$is higher than $\hat{f}_k\left(I_0^j\right) f_k \; i_0^j$ in (8.).

If localization criterion (8.) is not satisfied when $I_0^j = I_{0,\max}^j$ and where $I_1^j = I_{1,\max}^j$, than none any decision function based on relation (1.) does not allow to locate the meaning criterion f_j (8.). In this case, two approaches are considered: re-generation of residues, to modify existing or raise residues to create new ones, is an alternative. A second alternative would be to broaden the range of possible decision functions (eg generalize (1.) by using typical or logical operators). Any approach that was developed for evaluating the decision function should be resumed and accordingly adapted.

To reduce to five the number of residues involved in decision functions in Table 3, it is possible to choose $D_I = T_{15}$. The sensitivity of D_1 and f_β is $f_\beta > 6\%$.

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