HYBRID SYSTEM TO IMPROVEMENT OF THE POWER SUPPLY CONTINUITY INDEXES

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ABSTRACT

This paper proposes a methodology to improvement of the power supply continuity indexes. This methodology consists in the fast fault location through hybrid system based on artificial intelligence. The proposed hybrid system combine a fault location algorithm (Ratan Das) and a classification technique (Support Vectorial Machine, Finite Mixture and LAMDA technique), these techniques combined with the fault location algorithm allow to identify the type and location of the faults.

INTRODUCTION

In Colombia there are two indexes to measure the power supply continuity: DES and FES. DES stands for equivalent duration of the interruptions, *i.e*. total time without power supply; meanwhile, FES stands for equivalent frequency of the interruptions, *i.e.* the total number of interruptions in a given time frame.

Due to nonfulfillment in the continuity indexes, DES and FES, in the first three trimesters of 2002, the electric distribution utilities made economic compensations by more 4000 million Colombian pesos (COP) approximately (1.3 million euros) to the Colombian customers. Taking into account the financial situation of the Colombian electric distribution utilities, we can conclude that some of them could go to bankruptcy. Given this situation, the assurance of power quality supply is a priority into the power transmission and electric distribution utilities. One important need in the Colombian system is the development of intelligent systems offering the capability to determine the location of the faults in the electric system [1].

DESCRIPTION OF THE METHODOLOGY

The methodology consists in a steps to determine the location and the type of the fault. This estimation is possible using the voltage and current signals measured at substation by the protection devices. Figure 1 shows the hybrid methodology [1].

Network parameters – Block 1: It contains the topology information and parameters of the network (distances, sequence impedances, loads and others).

Voltage and current signals – Block 2: Three phase signals registered during the fault.

Signal proccesing – Block 3: The RMS values of voltage and current signals are calculated. This calculation is realized by means of sliding window with 128 samples. This window is updated to each sample.

Extraction of descriptors – Block 4: The descriptors that represent the processed signals by the block 3 are obtained. These descrptors are strongly related with the distance and geographical location. These descriptors are described in [1].

Pre-fault, fault and post-fault magnitudes – Block 5: The pre-fault, fault and post-fault magnitudes of the voltage and current phasors are obtained.

Classification technique based on artificial intelligence – Block 6: With aid of the artificial intelligence techniques is determined the zone where is probably the fault. The techniques used in this research work are:

Support Vectorial Machine – SVM: They are performed as a binary classification technique resulting from the development of neural network and its combination with the optimization and genaralization theories [2,3].

Finite Mixture – FM: Statistic modelling tecnique allows to obtain a estimation of probability density function of random data, this funtion is given how a finite adding of multivariable density components [4,5].

Learning Algorithm Multivarible Data Analysis – LAMDA: It is a multivariable classification algorithm that combine the geralization capacity of fuzzy logic and interpolation capacity of neural networks [6,7,8].

Fault location algorithm – Block 7: The location or possible locations of fault are estimated. The Ratan Das method was selected after comparing more 10 fault location algorithms. This method considers an adequate line model to electric distribution systems [9].

Finally, in the block 8, the type and all possible locations of the fault are obtained. Later, these possible locations with the zone of fault are correlationed (block 8). The location zone is given by the artificial intelligence technique (block 6). It allows to reduce the multiple estimation of the fault location algorithm (Ratan Das).

HYBRID SYSTEM: DEVELOPED TESTS

The results obtained with the three hybrid systems (SVM, FM, LAMDA) will be show. A 25 kV power distribution system from Saskpower, Canada proposed in [9] is was used to test the fault location approach. The system was modeled using Alternative Transients Program – ATP and Power system Blockset – PSB of MatLab ®.

Hybrid system: SVM-Ratan Das

In the table 2 the fault location results are presented. The number of hits is high in the estimation of the location (around 90%).

The multiple estimation is almost annulled. It is obtained multiple estimation in the 2% of the tests. This by two motives: the first, when by mathematic reason the fault location algorithm did not converge, and the second, when there is not intersection between the estimations of the algorithm and the SVM zone of fault. In the table 3 is presented a comparison of results between SVM-Ratan Das hybrid system and the Ratan Das algorithm.

	P-G	PP	PP-G	PPP
Multiple estimation [%]	2,7	0,0	0,6	2,1
Mistake [%]	11,8	8,6	10,8	9,2
Hit [%]	85,1	91,4	88,6	87,9

Table 2. Fault location results. SVM-Ratan Das.

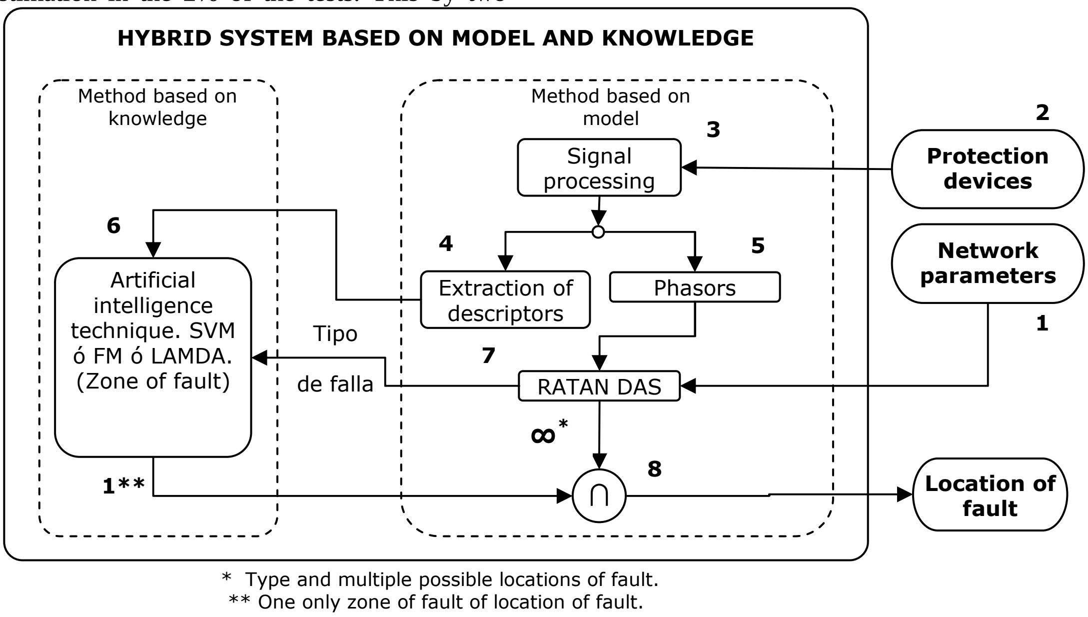

Figure 1. Hybrid methodology

It is can see in the table 3, that the precision in the estimation of fault location is increase and the multiple estimation is reduce. The results shown that the hybrid system reduce the multiple estimation of the fault location algorithm. It is due to hybrid system complements to each model, SVM and Ratan Das [9].

Hybrid system: FM-Ratan Das

The test results will be analyzed with the followings four exits type: *a) Exit 1*: Complete intersection. All possible locations of the fault given by the Ratan Das are inside of the zone of fault given by the artificial intelligence technique. b) *Exit 2*: Average intersection. Someone possible locations of fault are inside of the zone of fault. *c) Exit 3*: Empty intersection. All possible locations of fault are outside of zone of fault. *d) Exit 4*: Fault location algorithm does not converge. The only exit is the zone of fault given by the artificial intelligence technique.

Estimation	Ratan Das algorithm method				SVM-Ratan Das hybrid system			
	PG	PP	PPG	PPP	PG	PP	PPG	PPP
Fault type [%]	100	100	76.9	100	100	100	100	100
Fault section estimation [%]	52.7	60.6	58.9	64.2	85.1	91.4	88.6	87.9
Multiple estimation [%]	39.8	30.8	31.9	25.8	2.7	0.0	2.6	2.1

Table 3. Comparison between Ratan Das algorithm and SVM-Ratan Das hybrid system

The figure 2 shows the results of FM-Ratan Das hybrid system according to each exit type (vertically).

The presence of exits type 4 (single phase and three phase faults) is due to Ratan Das did not converge. The majority of the exits are type 1, it is a good performance of hybrid system, because as possible locations as zone of fault are intercepted completely. The representative presences of exits type 2 allow to reduce the amount estimations given by Ratan Das algorithm. Finally, the exits type 3 give uncertain, because there is not intersection between the possible locations and zone of fault.

In the table 4 is showed the proportion of each exit with respect to the total number of simulations (1551). The two first exits show the effectively of FM-Ratan Das hybrid system (90,97%).

Tipo de salida			
1	**2**	**3**	**4**
60,41%	30,56%	8,12%	0,903%

Table 4. Proportion of each exit. FM-Ratan Das

The mistake proportion of model is associated to the exits type 3 and 4, which correspond to 9,03% of all data. The differences between the proportions of the exits are successfully, due to goal is that the hybrid system allows to improve the result given by the two models. The proportion of exit type 2 (30,56%) guarantee that the multiple estimation is reduced.

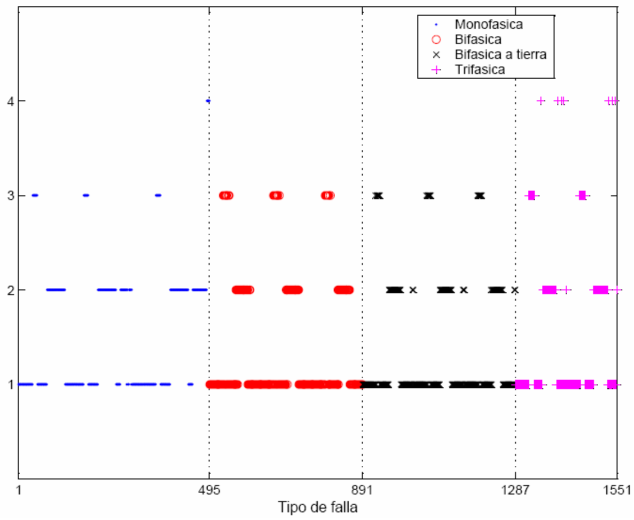

Figure 2. Fault location results by fault type. FM-Ratan Das.

Hybrid system: LAMDA-Ratan Das

The test results will be analyzed with the exits described in the previous section (vertically).

The figure 3 shows the results of LAMDA-Ratan Das hybrid system according to each exit type.

The behavior of the distribution of exits in the figure 3, is similar to behavior in the figure 2, by the following two reasons: (1) there are a representative amount of exits type 1, (2) the majority of exits are type 1 and 2. The previous reasons allow to guarantee that the multiple estimation will be reduced.

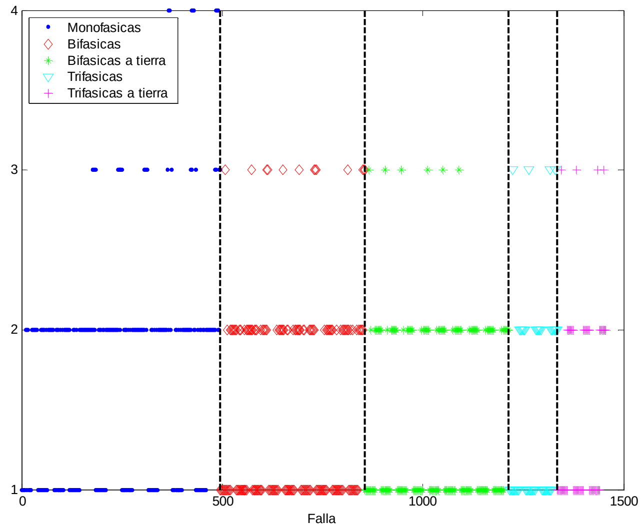

Figure 3. Fault location results by fault type. LAMDA-Ratan Das.

In the table 4 is showed the proportion of each exit with respect to the total number of simulations.

Tipo de salida			
1	**2**	**3**	**4**
50.45%	43.85%	4.7%	1%

Table 5. Proportion of each exit. LAMDA-Ratan Das

The effectively of LAMDA-Ratan Das hybrid system is 94,3%, while mistake proportion is 5,7%. This behavior confirm that hybrid system has inherited the qualities as LAMDA technique as Ratan Das algorithm [10].

COMPARISON OF THE HYBRID SYSTEM BASED ON SVM, FM AND LAMDA

With aim of choose the hybrid system with the better behavior in the estimation of fault location, it is realized a global comparison of three techniques. In table 6 is presented this comparison [11,12,13,14].

The three hybrid systems have a similar proportion in the estimation of fault location (90% approximately). This result is good with respect to the proportion obtained with the Ratan Das algorithm (71,57%). In the third column of the table 6 appear the proportion of test in which is reduced the number estimations in one or more estimations. The Support Vectorial Machine – SVM reduced the number of estimations in 49,37% of total number test (423). Finite Mixture and LAMDA technique reduced the number of estimations in 31% (420) and 44% (534) approximately.

Finally, it is can say and without generalize, that hybrid system based on Support Vectorial Machine allows to determine (studied circuit) the fault location with better precision that the hybrid system based on Finite Mixture and LAMDA technique.

CONCLUSIONS

In this paper has been proposed a methodology based on hybrid system conformed by a fault location algorithm and artificial intelligence technique (SVM, FM, LAMDA). This methodology allows the electric energy facilities improve the power supply continuity indexes, because its results allow to reduce the identification and displacement time to the geographical location of the faults.

The proposed methodology in an electric distribution circuit was implemented. It is showed the advantages of implement a hybrid system in a distribution circuit. The hybrid system allowed to reduce the multiple estimation of the fault location algorithm, meanwhile in the technique based on knowledge allowed to improve its precision in the estimation of fault location.

MODEL	Hit [%]	Reduction of the multiple estimation [%]	Number of simulations	Data of validation
SVM –RDAS	88,08	49,37	1410 ATP/EMTP	423
FM – RDAS	90,97	30,56	1551 ATP/EMTP	420
LAMDA- RDAS	94,30	43,85	1455 MATLAB	534
RDAS	71.57	No apply	2417 MATLAB	No apply

Table 6. Comparison of the hybrid system based on SVM, FM AND LAMDA

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