

# Algorithms and Distributed Control and Safety Instrumented Systems for the Automation of the Processes in the Pilot Plant of the UNAB.

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**Abstract**— The present work involves the research and development of a new methodology for design of prototypes based on stem cell patterns and artificial cloning, applied to the processes in the pilot plant of the UNAB, . the methodology of artificial cloning arises as an alternative for the development of measurement and advanced control equipment, that allow a correct response to the modern industry requirement through functional replicas of sensors, controllers and actuators based on artificial intelligence techniques, apply them methods and procedures of artificial cloning and evolutionary computing. The methodology of patterns based design of stem cell and artificial cloning, let to replicate functions through an imitation reproduced for generations of “chromosomes” - configurations of initial population – information about equipment development functions, installation process, ordered according to multiobjective functions, with genetic operators – tools that let to modify the composition of the new chromosome generated by the fathers (initial population), during the reproduction and includes: mutation (generation of new information on a system), crossing (exchange of information between two systems), inversion (exchange of information inside a system) among others. with the model of genetic algorithm for artificial cloning is possible to have the basic structures for design based on patterns of stem cell for detection and diagnosis of failure, as solution for the implementation of evolving nature systems, like observers, adaptive controllers based on advanced techniques of industrial data processing: real time and distributed and safety systems.

**Keywords**— mechatronics mother’s cell patterns and artificial cloning, genetic algorithm, functional advanced control.

## I. INTRODUCTION

The technology of artificial cloning of industrial sensors, as presented here, consists of a group of means and procedures based on tools of artificial intelligence these are then applied in the reproduction of high fidelity of real devices used in automation and control of industrial processes. This is based on the integration of neural networks techniques and genetic algorithms. A method, a procedure and utilities form this technology (Muñoz, 2003). The method consists of the application and interpretation of the genetic mapping that it contains; the codes of the functional structure of the sensor. The mapping is a group of bars of codes that describe the functional operative units of the sensor; each operative unit is formed by unitary elements that represent a part of the operation of the sensor such as deviation of the angle of incidence, variation of the intensity of the sheaf of light, etc. A code is a series of digits that represent a part of the operation of the sensor where each digit represents a position

inside the functional structure (see Figure. 2). The procedure consists of the application of a group of guidelines directed to the structural connections of the neural networks which facilitates the flow of information for the learning of the cloned sensor. The utilities are criteria likenesses (Aguilar J., 1999), that apply measured a dimensional and they include parametrical characteristics of the real devices to clone that allow a sensor to reach a cloned version.

## II. CLONING PROCESS

### II.I Cloning Process

Five stages (Muñoz, 2002) compose the process of cloning artificial sensors.

Stage 1: in this stage the devices are selected to clone. The population is divided according to the number of objectives given in functional operative units; the group of operative units is called “objective function”. For example, for an I number of N devices that constitute the population and an I number of n operative units, the population is divided in an agreement populations part with the units whose size is N/n. Then, you re-iterate with a genetic algorithm each subpopulation with a strongest different objective function with the purpose of selecting the individuals; that is, to assure that each objective function is evaluated. Then, priority is assigned (hierarchical classification) (Muñoz, 2001), to the functions objective depending the problem be solved. Finally, each function is selected according to its priority and it is evaluated on each subpopulation. This is carried out until evaluation of all the functions objective. Is achieved to assure the diversity, the weakest individuals are replaced in each subpopulation.

Stage 2: Are obtained the partial solutions S1, S2, S3,..., Sn for each operative unit. The union of these solutions will allow to conform a new global population, to randomly which is applied an objective function that has been selected. This process is repeated until a certain number of iterations (fixed as convergence criteria) to assure that each function objective was evaluated inside the total population with a high reliability.

Stage 3: in this stage, in each subpopulation one selects the individuals that have the minimum value of the objective function that is evaluated. The number of individuals that are selected (for each sub population) it is taken as information to define the coefficient that will ponder each one of the components of the multiple objectives function (the group of different operative units). Finally, the total population is generated as the union of all

subpopulations and is evaluated using the multiple objectives function considered according to certain previous values.

Stage 4: in this stage the objective function is selected to evaluate, among the operative units that compose. One should make sure that all the functions are evaluated a defined minimum number of times.

Stage 5: in this stage a process of optimization is carried out with values and spaces characteristic of the partial solutions obtained in the stage 3 using the multiple objectives function resulting in stage 4. Then, the number of individuals is determined that give a minimum solution; that is to say satisfying the coefficient of consideration of the functions objectives with regard to the multiple objectives function. This represents the cloned device.

### II.2 Example of Application

Let us consider, a Pilot Plant of the UNAB ( see Figure 1) and let us consider that this prepares, among other, of the DELTA V platform on-line and the whole instrumentation associated to the monitoring of the process that are centralized in a team that serves as operation interface .



Fig. 1. Pilot Plant of the UNAB

For this example, the real analyzer is replaced a cloned intelligent sensor (Muñoz, 2003), starting from the real device due to frequent flaws presented in the system. The sensor determines the index of concentration . For this, it calculates the refraction index starting from a sheaf of monochrome light and then processes that information through a linear relationship with the index of viscosity. This information constitutes the primary element for later prosecution on the part of the monitoring system, which registers and permanently deploys the obtained information of the cloned sensor.

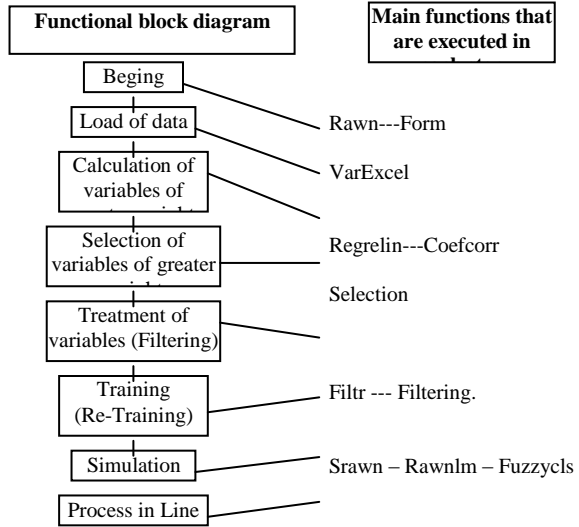


Fig. 2. Engge bloks

### III. THE ANALYZER'S DESCRIPTION

The analyzer (see Figure 3) it determines the refraction index through the solution S that is refracted measuring the critical angle of refraction. For it, the light coming from the light source L goes against the interface among a prism P and the solution. The rays of light meet with this surface to different angles. The reflected rays form an image ACB, where C is the position of the ray of the critical angle. The rays in to are reflected totally in the interface and the rays in B are partially reflected and partially refracted inside S. This way the optic image it is divided into illuminated area to and a dark area B. The position of the limit C among the areas to and B shows the value of the critical angle and therefore of the refractive index of the solution of the process. The refractive index is usually increased whilst increasing the concentration.

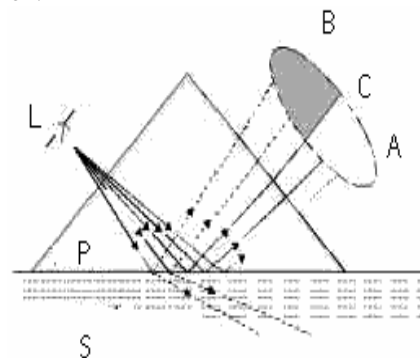


Fig. 3. Analyzer of the concentration of fenol

### III.1. Results for models

One can obtain an excellent genetic mapping with neural networks in advance with only a layer of non linear neurons taking the activation random values, continued by a training of the values of having left by ordinary Minimum Square. Static and dynamic examples show the feasibility of this approach. As in any non linear identification, care should be taken to make sure that the excitement entrance used for identification be in the same range of frequency and width like in the application. Later improvements they can be obtained for regularization of the values activation.

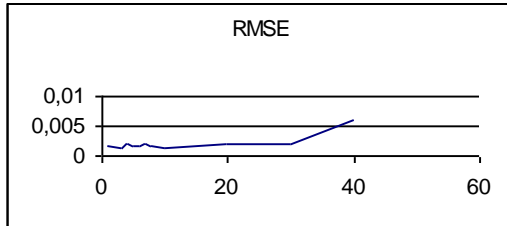


Fig. 4. RMSE

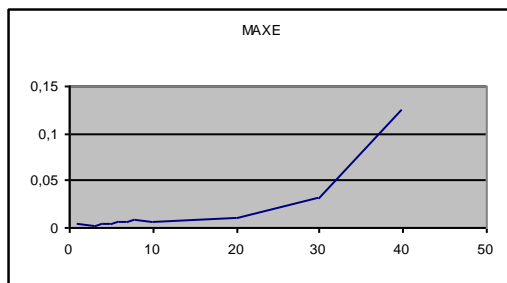


Fig. 5. MAXE

In a alone artificial neural networks entrance exit data are needed so that the net recognizes a pattern wrapped in the mapping from the entrance variables to the answer of the exit. It is true that the neural networks have been described as a black box to solve problems, but the ability of the neural networks to give quick and precise values for the case of the process engineers makes them a very useful tool. Its ability to execute the inverse problem easily of exchanging the entrance vectors and the exit of the neural networks is also constituted in another advantage for the analysis and diagnosis of a given system.

TABLE I  
EXPERIMENT RESULTS FOR MODELS

# NEUR	RMSE	MAXE
3	0.0010291	0.0027133
<b>5</b>	<b>0.0011054</b>	<b>0.0024877</b>
10	0.003029	0.012585
12	0.00096497	0.012741
15	0.0036674	0.0073696
20	0.00072544	0.0071936

The Methodology of Artificial Cloning process functions through an imitation reproduced by generations of “chromosomes”- representations of configurations of the initials - information on functions of performance of the equipment and/or installation, ordered according to an multiobjective function, with “genetic operators” - tools that allow altering the composition of the new chromosomes generated by the parents (initials), during the reproduction and include: Mutation (generation of new information in a system), Crossing (exchange of information between two systems), Investment (interchange information in a same system); in this form with the model of genetic algorithms for the artificial cloning process, can be had the basic structures for the design of a mechatronic cell mother, like solution for the implementation of the evolutionary circuits, where the commutation by mutation is replaced, as resulting from the change in the logical configuration block circuit by mutables logical blocks.

TABLE II.1  
EXPERIMENT RESULTS FOR MODELS

# N	RMSE	MAXE
5	0.0019238	0.003634
10	0.0017794	0.0037834
<b>12</b>	<b>0.0016122</b>	<b>0.0035634</b>
15	0.0021772	0.0071826
20	0.0035932	0.020569

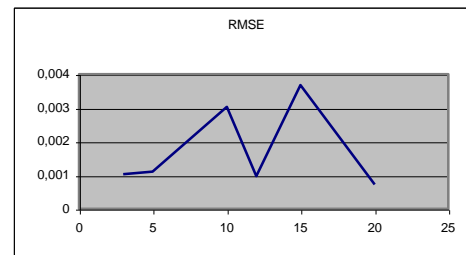


Fig. 6. RMSE

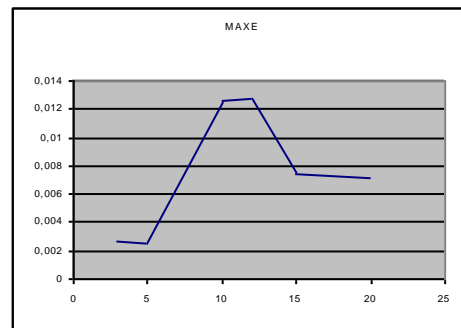


Fig. 7. MAXE

Fig. 8. RMSE for Expert Model

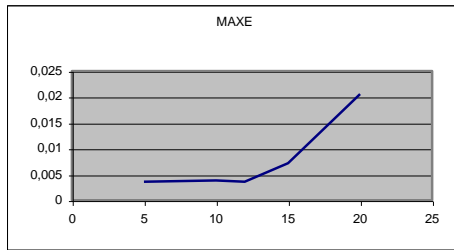


Fig. 9. MAXE for Expert Model

The technology of artificial cloning of industrial sensors, as presented here, consists of a group of means and procedures based on tools of artificial intelligence these are then applied in the reproduction of high fidelity of real devices used in automation and control of industrial processes. This is based on the integration of neural networks techniques and genetic algorithms. A method, a procedure and utilities form this technology. The method consists of the application and interpretation of the genetic mapping that it contains; the codes of the functional structure of the sensor. The mapping is a group of bars of codes that describe the functional operative units of the sensor, each operative unit is formed by unitary elements that represent a part of the operation of the sensor such as deviation of the angle of incidence, variation of the intensity of the sheaf of light, etc. A code is a series of digits that represent a part of the operation of the sensor where each digit represents a position inside the functional structure. The procedure consists of the application of a group of guidelines directed to the structural connections of the neural networks which facilitates the flow of information for the learning of the cloned sensor. The utilities are criteria likeness, that apply measured a dimensional and they include parametrical characteristics of the real devices to clone that allow a sensor to reach a cloned version.

This work shows a technology of artificial cloning for industrial sensors by means of the use of neural networks and genetic mapping. The neural networks allow develop to the intelligent structure of the sensors. For it, the method of activation of random values is used to train the sensors and to carry out the learning starting from real devices. The genetic mapping allows the generation of codes for the cloning procedure. For it, the mutation processes, crossing, reproduction and investment are used. Also, an example of a cloned sensor that determines the index of viscosity of lubricant oils with fenol for a monitoring system is briefly explained.

TABLE III  
DIFFERENT MODELS FOR OPTIMIZATION

MODEL	#N	RMSE	MAXE
CORRELATIO N-DISPERSION	5	0.0010612	0.0034794

TABLE IV.1  
EXPERIMENT RESULTS

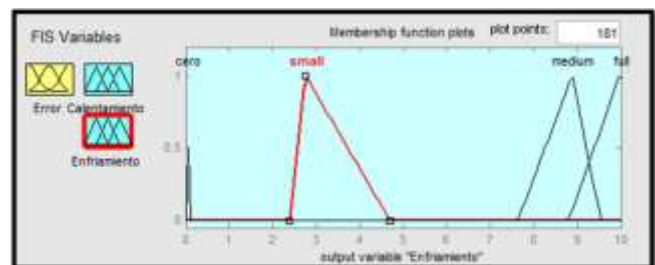
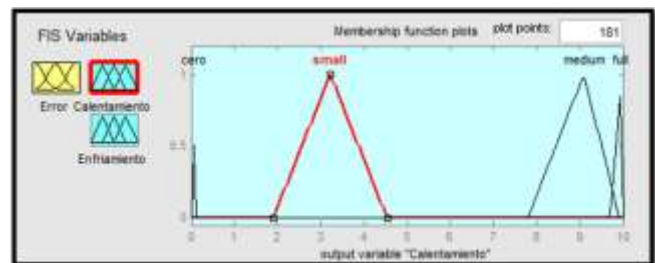
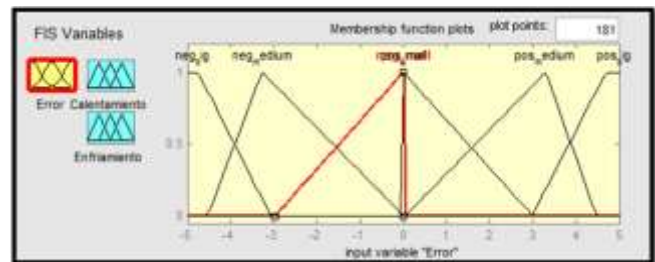
W1	V6	V7	V10	V14	V15
N#1	-0	6	4	3	4
N#2	11	-6	-4	1	6
N#3	9	-7	6	-1	0
N#4	4	-6	1	3	5
N#5	9	-1	-2	2	-5

TABLE IV.2  
EXPERIMENT RESULTS

W1	V17	V18	V32	V44	V63
N#1	12	-10	342	63	-1071
N#2	-6	-14	-457	-58	312
N#3	-6	11	-65	12	1017
N#4	9	-8	-923	-126	117
N#5	6	-6	1036	-51	549

TABLA V  
WEIGHTS

W2	0.0330	-0.0532	0.0284	0.0168	0.0039
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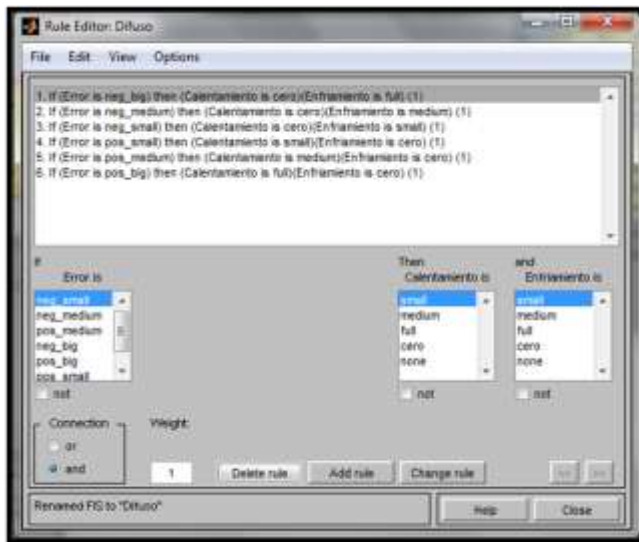


Fig. 10. Behavior of the Cloned Sensor of some parameters

#### IV. CONCLUSIONS

The use of the genetic mapping allows the design of quicker teams for the sequencing and with computer development the creation of the databases is possible to transmit, to store, to analyze and clone this information.

The artificial neural networks are able to manage complex and not linear problems, they can process information very quickly and they reduce the required computers effort in the development intensive computer of model, finding functional forms for empiric models as shown by that of our case with the cloned sensor.

As a result, the software tool (Golberg, 1983) elaborated for such an end, can be used in the training of any system (entrance-exit) that seeks to be solved applying neural networks of this type. It has all the intermediate steps required as the attendance in the selection of variables for statistical methods that use the mathematical one required for the treatment of this class of stochastic processes (Fonseca, 1998), prove of possible linear, sign treatment to filter noise eliminate false data, training-validation and tests for simulation off line and on-line with the real process. The measurement of the RMS error is used and the Maximum opposing error, mainly in the validation phase to be used as the comparison parameter that allows for the evaluation of the acting of the obtained pattern.

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