International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

September 2015 Issue 24 Volume 7 Number 3 Pages 37-41

PRELIMINARY TESTS BASED ON FUZZY INTELLIGENCE ON A SYSTEM OF NON-DESTRUCTIVE EXAMINATION

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Abstract- In recent years the development of applications that covers many areas of knowing, different researchers have performed hardware implementations around paradigms such fuzzy systems, neural networks, or hybrid systems results in form of two earlier systems, known as neuro-fuzzy systems. Applications have been developed for different devices and/or platforms. Fuzzy systems are currently used in a wide range of industrial and scientific applications. Although design and process optimization especially can be very time consuming, it is convenient to use fuzzy logic-based algorithms to automatically optimize them. This paper made some preliminary testing of a system based on fuzzy intelligence on a system of nuclear non-destructive examination. Fuzzy Logic Controller (FLC) based system is designed for improving the performance of nuclear non-destructive examination.

Keywords: Nuclear Research, Fuzzy Logic Controller, Non-Destructive Examination.

I. INTRODUCTION

In recent years, the number and variety of applications of fuzzy logic have increased significantly. Fuzzy systems are currently used in a wide range of industrial and scientific applications. Since the design and optimization process especially fuzzy systems can be very time consuming, it is convenient to use for the construction of algorithms automatically optimize them.

The nuclear control system is a challenge because: 1) control is a task that many multi-objective manipulated variables are coordinated with the transition from the system; 2) nonlinear system; 3) more if parameters are determined as variables of time and the dynamic characteristics of the system are changed operating conditions [1]. For controller design, dynamic model is a usually simplified system. Therefore, discrepancies between the mathematical model and the real system are inevitable [2]. This asymmetry may come from unshaped dynamics of change in the system parameters and / or approximating complex behavior of a simple model.

To ensure that the resulting controller is able to produce satisfactory results in this unfavorable situation, a robust controller is essential to achieve a reliable and safe system automation [3].

II. OVERVIEW OF FUZZY LOGIC

A. Fuzzy Logic

Fuzzy logic is a mathematical logic that maps the input space with space data output using a truth value, to a degree between 0 and 1 [4]. It deals with inaccurate data reasoning fuzzy set that is produced by a clear set that helps in decision making. Clear sets are sets in which each element is either a member or not. Fuzzy sets are sets in which a member of that may be partially set. A member function involves a fuzzy set in a graphic manner. Fuzzy logic based control system can be used in place of any control system with a wide range of applications. Fuzzy logic was also used in fields such as artificial intelligence [5].

B. Fuzzy Interference System

Fuzzy logic consists of three stages. These steps are: fuzzyfication, interference and neural control system as shown in Figure 1 [6].

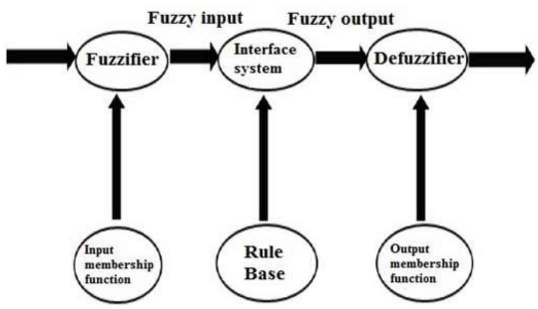

Figure 1. Fuzzy logic

Fuzzification is represented as a first stage in which a clear entry (a numeric value) is converted to a fuzzy input mapped as a function of the input member. A member function is a graphical representation of changes for a given variable fuzzy language. A clear entry may have more than one value fuzzy. This mapping is done for all values for a given input diffuse clear. If more than one entry is made clear when separate mapping to find that fuzzy entry.

Fuzzy interference system (FIS) is the next stage, the output of the fuzzy input is calculated according to the fuzzy rule base. A basic set of rules is a simple if-then conditions that depend on operator experience and data analysis. Rule base is represented in the form of a matrix in which all permutations and combinations of input membership functions must be handled properly and efficiently with member output function. FIS is usually met especially with Mamdani or Sugeno [7].

We consider a fuzzy system with a set of fuzzy rules like M_j:

M_j: if x_1 is μ_j^i and ... and x_n is μ_j^n then y is v_j

where $x_1, \ldots, x_2 \in R$ are inputs value , and $y \in R$ is the output value. $\mu_j^i: \; R \to [0,1]$ and $v_j: \; R \to [0,1]$ are fuzzy rules. Fuzzy sets are represented by membership functions parameterized as a triangular, trapezoidal or bell-shaped function [8]. A complete set of rules is evaluated max-min interface resulting in a fuzzy set output *v*:

$$v(y) = \max_{M_j} \left\{ \min \left\{ \mu_{j1}^1(x_1), \ldots, \mu_{jn}^n(x_n), v_j(y) \right\} \right\} \qquad (1)$$

This system presented above represents a good assessment procedure known Mamdani controllers. Sugeno rule is effectively used for complex mathematical analyzes [9, 10].

Defuzzification is the final step is to clear out the aggregate output fuzzy. This step shows numerical values. The five common methods for defuzzification which are represented in Figure 2 are: Centroid, Bisecter, Mean of maximum, Smallest of maximum and Largest of maximum. Centroid defuzzification method is the method more commonly used [11].

$$z_C = \frac{\int_Z \mu_A(z)\, z\, dz}{\int_Z \mu_A(z)\, dz} \qquad (2)$$

where z_C is the centroid function and μ_A represent the set of fuzzy rules.

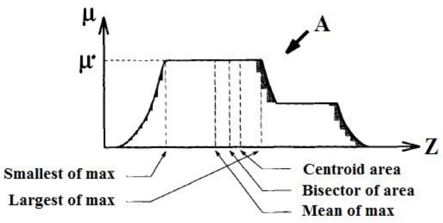

Figure 2. The five common methods for defuzzification

In this method, the weighted power output of each fuzzy membership functions is multiplied by their respective values and summed diffuse. This value is now divided by the sum of weighted power output member function. Result output is clear that the operator is profitable.

The contribution of fuzzy logic control components in some scientific fields was impressive. The fuzzy control demonstrated its effectiveness on other controllers, such as electronic PID controllers [12].

III. NON-DESTRUCTIVE EXAMINATION SYSTEM

The Non-Destructive Examination System (NDES) the Institute of Nuclear Research Pitesti is designed to examine both nuclear fuel and materials tested in different reactors or nuclear plants. NDES consists of a universal machine exam console controls. The machine is equipped with universal exam stepper motors for vertical movement and rotation of the fuel.

A. Stepper Motor

The stepper motor is an electromagnetic converter which performs conversion of a series of digital pulses in a motion proportional to its axis. It is supplied with current pulses result of tensions due to the application of "step" or combinations of several "steps". In this way the air gap magnetic field has a discrete repetitive. The transition from one position to another, which is step angle of the engine, is under the influence of the magnetic field change Repeat discrete, i.e. stepper motor converts impetus given as a step in discrete angular displacement.

The stepper motor is part of synchronous motors, the rotor speed as expressed by the number of steps taken per unit time, pulse frequency depends on supply. One characteristic of the stepper motor only is the total angular displacement being constructed of a certain number of steps, the number of control pulses applied to the motor phases [13].

Classification of stepping motors:

- Stepper motors with permanent magnets
- Stepper motors with variable reluctance
- Hybrid stepper motors

Hybrid engines are a combination of the first two. There are special stepper motors, such as linear stepper motors, electrohydraulic, piezoelectric. Permanent magnet motor shown in Figure 3 operates at relatively low speeds, developing low couples with large pitch angles of 45° or 90° [14].

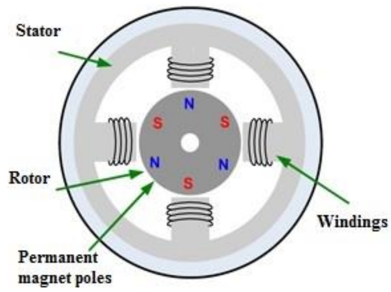

Figure 3. Stepper motor with permanent magnets

Variable reluctance motor shown in Figure 4 has the rotor iron with projections on the surface of outdoor. It presents a high torque. Variable reluctance motor of Figure 4 is composed of eight-pole stator with four phase, AA_1, BB_1, CC_1, DD_1. Activating a phase causes a magnetic attraction between the stator and rotor, leading to rotor teeth alignment by an angle of 45°. The process continues with the power phases CC_1, DD_1, A_1A, B_1B in clockwise [15].

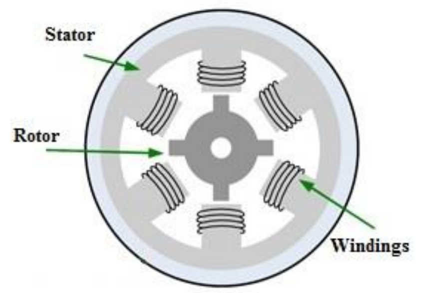

Figure 4. Stepper motor with variable reluctance

Hybrid engines shown in Figure 5 combines the best features of motors with permanent magnets and the magnetic reluctance of. They are built with stator poles and rotor teeth is permanent magnet. These motors are widely used in industrial applications as dynamic and static develops high torque.

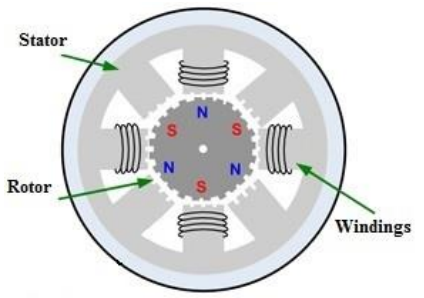

Figure 5. Hybrid stepper motor

Step angle of the stepper motor θ could be calculated with:

$$\theta = \frac{360^\circ}{m \times N_r} \tag{3}$$

where, m is the number of phases of the stator, and the number of rotor teeth is numeral [16]. Stepper motors used for NDES are among those with permanent magnets.

B. FLC and Stepper Motor in Matlab/Simulink

FLC provides an algorithm that transforms linguistic control, based on expertise in automatic control strategy. So fuzzy logic algorithm is much closer to human thought than traditional systems logic. The experiments were carried out on a system based on a stepper motor and a FLC shown in Figure 6.

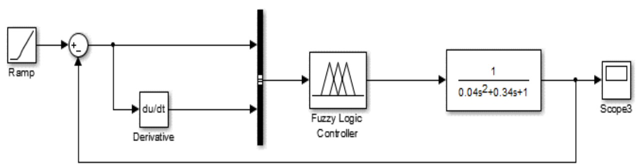

Figure 6. The FLC model and the stepper motor in Matlab/Simulink

In order to describe the process of fuzzification they were used triangular membership functions shown in Figures 7, 8 and 9. To establish the initial error, the simulation was used range [0 0.8]. To change the initial error, the simulation was used range [0 0.6].

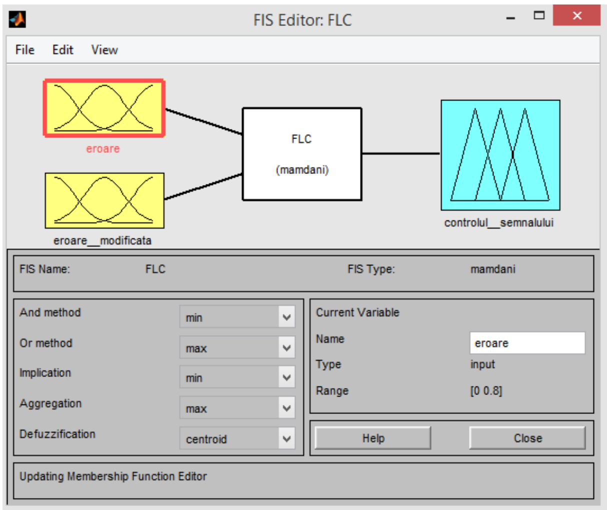

Figure 7. FIS Editor: FLC

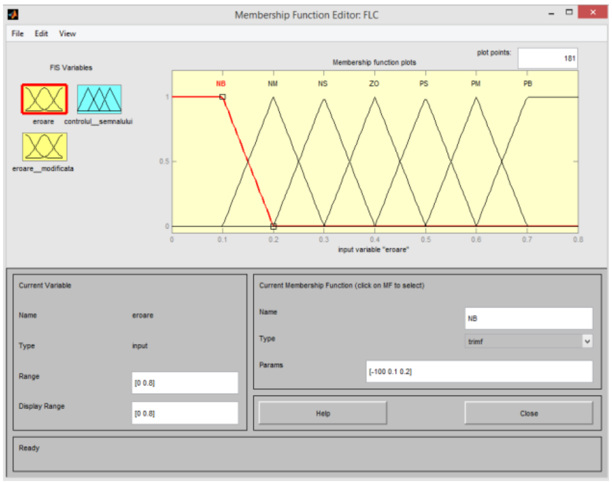

Figure 8. The membership function used in fuzzy set to establish initial error

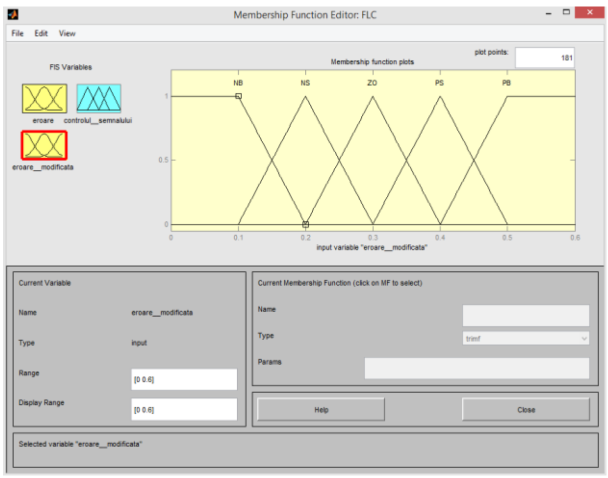

Figure 9. The membership function used in fuzzy set to change the initial error

For defuzzification was also used triangular membership function was used range [0 0.8] represented in Figure 10. The rule base used to set fuzzy rules were created using previous information of the dynamics of stepper motors, shown in Figure 11 and Table 1.

The initial error and change the initial error of the system have an important role in achieving the desired position stepper motor shaft.

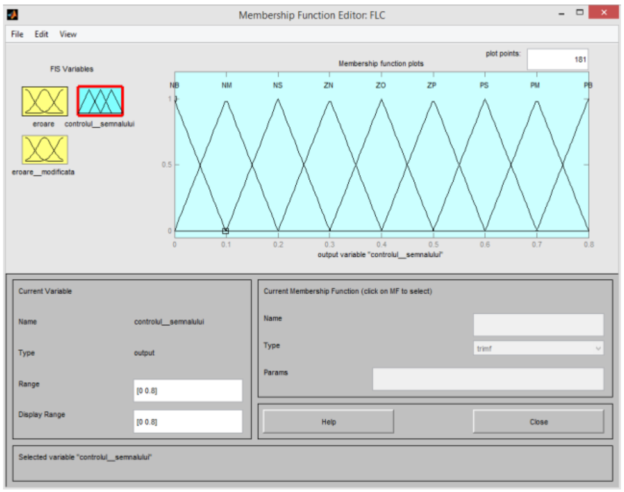

Figure 10. The membership function used in fuzzy set for the signal control

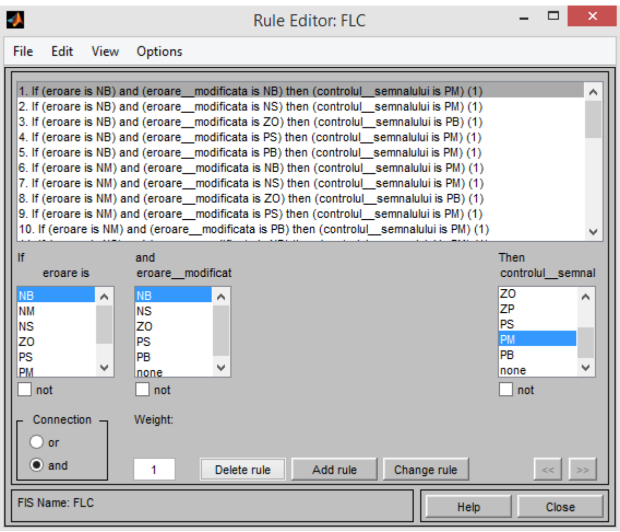

Figure 11. The rule base for FLC

Table 1. The rule base used for the control signal

	NB	NS	ZO	PS	PB
NB	PM	PM	PB	PM	PM
NM	PM	PM	PB	PM	PM
NS	PM	PM	PB	PB	PM
ZO	PM	PM	PB	PM	PM
PS	PM	PB	PB	PM	PM
PM	PM	PM	PB	PM	PM
PB	PM	PM	PB	PM	PM

NB = negative big, NM = negative medium, NS = negative small, ZN = negative zero, ZO = zero, ZP = pozitive zero, PS = pozitive small, PM = pozitive medium, PB = pozitive big.

It is noted in the final simulations obtaining the desired position of the stepper motor shaft. Final results of these simulations are shown in Figure 12.

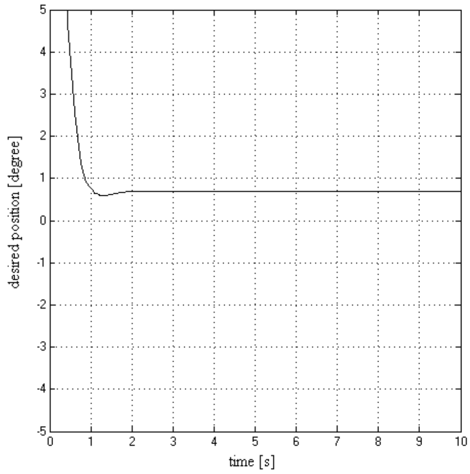

Figure 12. Position of stepper motor

IV. CONCLUSIONS

In this paper the feasibility of fuzzy control for stepper motor has been shown and illustrated in the above simulations. FLC optimal topology was determined using a software simulation of the dynamics of the stepper motor. The fuzzy control only requires 1.5 s for a final result, and this can be used without significantly increasing costs to implement an autonomous control system for non-destructive examination. Pein therefore confirms that the development of fuzzy control is relevant for quick nonlinear process control such as stepping motors.

ACKNOWLEDGMENT

The work has been funded by the Sectoral Operational Program Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU 187/1.5/S/155420. Work under Ph.D. stages, contract numbers: SD04/46 and SD04/04.

REFERENCES

[1] S. Shyu, R.M. Edwards, "A Robust Multivariable Feed Forward/Feedback Controller Design for an Integrated Power Control of Boiling Water Reactor Power Plants", Nucl. Technol., Vol. 140, pp. 129-146, 2002.

[2] G. Bosque, I. del Campo, "Fuzzy Systems, Neural Networks and Neuro-Fuzzy Systems: A Vision on their Hardware Implementation and Platforms Over Two Decades", Engineering Applications of Artificial Intelligence, Vol. 32, pp. 283-331, 2014.

[3] S.G. Karatkevich, L.V. Litvintseva, S.V. Ul'yanov, "Intelligent Control Systems. Design of Self Organized Robust Knowledge Bases in Contingency Control Situations", ISSN 1064-2307, International Journal of Computer and Systems Sciences, Vol. 50, No. 2, pp. 250-292, 2011

[4] L.A. Zadeh, "Fuzzy Sets. Information and Control", Vol. 8, pp. 338-353, 1965

[5] J.J. Buckley, "Sugeno Type Controllers are Universal Controllers, Fuzzy Sets and Systems", Vol. 53, pp. 299-303, 1993.

[6] J. Ross Timothy, "Fuzzy Logic: With Engineering Applications", 2nd Ed., Wiley Student Edition, UK.
[7] E.H. Mamdami, S. Assilian, "An Experiment in Linguistic Synthesis with a Fuzzy Logic Controller", International Journal of Man-Machine Studies, Vol. 7, No. 1, pp. 1-13, 1975.
[8] B. Kosko, "Fuzzy Systems as Universal Approximates", IEEE Int. Conf. on Fuzzy Systems, San Diego, CA, pp. 1153-1162, 1992.
[9] C.C. Lee, "Fuzzy Logic in Control Systems, Fuzzy Logic Controller", Part I, IEEE Trans. Systems Man Cybernet, Vol. 20, pp. 404-418, 1990.
[10] C.C. Lee, "Fuzzy Logic in Control Systems: Fuzzy Logic Controller", Part II, IEEE Trans. Systems Man Cybernet, Vol. 20, pp. 419-435, 1990.
[11] J. Chakraborty, et al., "Fuzzy Logic Based Feed Water Flow Control Model for Prototype Fast Breeder Reactor", ICCMS, Mumbai, 2010.
[12] D. Nauck, R. Kurse, "Foundations of Neuro-Fuzzy Systems", Wiley, Chirchester, 1997.
[13] T. Yano, T. Suzuki, M. Sonoda, M. Kaneko, "Basic Characteristics of the Developed Spherical Stepping Motor", International Conference on Intelligent, Robots and Systems, Kyoungyu, Korea, pp. 1393-1398, 1999.
[14] R.T. Fredriksen, "Application of the Closed-Loop Stepping Motor", IEEE Trans. Automat. Contr., Vol. AC-13, pp. 464-474, Oct. 1968.
[15] P.P. Acarnley, "Stepping Motors: A Guide to Modern Theory and Practice", Peter Peregrinus, London, p. 159, 1984.
[16] R. Yager, P. Filev, "Essentials of Fuzzy Modeling and Control", John Wiley & Sons, New York, p. 383, 1994.

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