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 2016	Issue 28	Volume 8	Number 3	Pages 32-35

CRITERIA FOR DETERMINATION OF MEMBERSHIP FUNCTION TYPE IN FUZZY MANAGEMENT OF REGIME PARAMETERS OF ELECTRIC NETWORKS

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Abstract- In this paper the flow of reactive power and voltage parameters are considered in a fuzzy logic unit control mode on the basis of the evaluation criteria for selecting the type of membership function variables. As a result a passive algorithm in a real power network is used based on the results of the fuzzy logic scheme.

Keywords: Power Engineering, Reactive Power, Voltage, Fuzzy Cluster, Fuzzy Neural Network, Membership Function (MF).

I. INTRODUCTION

Real information of distribution electric power system including reactive power, currents, voltages units, etc. are used as the parameters in a fuzzy process. One of the main problems of the application of fuzzy neural network model is to identify the type of functions belonging to the input linguistic variables [1-4].

In general, the theory of fuzzy sets of the main characteristics of fuzzy models, including the establishment of membership function (MF) is considered as one of the most important issues. So, the subsequent decision-making in the media on the transactions is carried out through their MF.

Statistical data are used for establishment and evaluation of MF parametric approach. Depending on the nature of the issues to be resolved, the analytical and numerical parameters are considered and described to the conventional linguistic relations as MF using mathematical functions in order to make efficient use of resources expression [2, 4, 5].

The MF issues are developed as type of statistic evaluations with more determination based on the opinions of a group of experts. The expert denotes the given information to the function on the basis of identity analytics [5].

Belonging to the function of the problem, the parametric form is often favorable. In this case, the issue of the MF establishment related to appointment of its parameters are numerical values.

The number of MF parameters is usually up to four. The resolution of various issues, triangle, trapezium, exponential, Gaussian, sigmoid, "call" and Pi-shaped MF media are widely used.

Pending the issue of one or multi form is depending on the direction of MF adoption of certain considerations. In addition to being available, the investigation is underway in this direction. Managing the optimal solution to the issue mostly depends on the formation of the signal.

The results presents that the electric parameters of the network including reactive power and voltage are used to manage the intellectual non-fuzzy neural network model (ANFIS: adaptive network based fuzzy interface system - adaptive fuzzy neural system) [6, 7]. The fuzzy variables terms ("small", "medium", "large", "very large" etc.) are considered to improve the efficiency of the evaluation criteria and selection of MF-media.

II. ASSESSMENT ALGORITHM OF MEMBERSHIP FUNCTION TYPE

The MF evaluation criteria in order to determine the type of evaluation are carried out with the use of Matlab software package. Average square error in setting the criteria are accepted. In other words, the knowledge-based fuzzy neural Sugeno-parametric model is used for the identification of a (P, B) that will find the functional vector, E.

$$\min\ E = \sqrt{\frac{1}{M}\sum_{r=1}^{M}\left(y_r - F\left(P, B, X_r\right)\right)^2} \tag{1}$$

where, M is the number of sample data; P is the parameters of the input vector of functions belonging to the linguistic variables terms; B is Sugeno knowledge base of regulations stating consequent matrix coefficients of linear functions $F(P, B, X_r)$, (y_r, X_r) the set of input vector and $X_r(P, B)$ is Suqeno non-fuzzy knowledge base. The Pi-shaped form and function should be considered as belonging function [1, 2]:

$$\mu(x)=\begin{cases}0, & \text{if} \quad x\le a\\ 2\cdot\left(\frac{x-a}{b-a}\right)^2, & \text{if} \quad a\le x\le \frac{a+b}{2}\\ 1-2\cdot\left(\frac{x-b}{b-a}\right)^2, & \text{if} \quad \frac{a+b}{2}\le x\le b\\ 1-2\cdot\left(\frac{x-c}{d-c}\right)^2, & \text{if} \quad c\le x\le \frac{c+d}{2}\\ 2\cdot\left(\frac{x-d}{d-c}\right)^2, & \text{if} \quad \frac{c+d}{2}\le x\le d\\ 0, & \text{if} \quad x\ge d\end{cases} \tag{2}$$

where, in P = [a, b, c, d]; [a, d] is fuzzy majority carrier; and [b, c] is fuzzy cluster core. In this case, the rate of execution relative to the jth order is as the following [1]:

$$\tau_{rj}^{*}=\frac{\prod_{i=1}^{n}\left[\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right]}{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)\right]} \tag{3}$$

The k is iterative calculation of P expression vector as follows:

$$P_{ji}^{(k+1)}=P_{ji}^{(k)}-\alpha\cdot\frac{\partial E^{(k)}}{\partial P_{ji}} \tag{4}$$

$\frac{\partial E}{\partial P}$ is written as gradient vector

$$\frac{\partial E^{(k)}}{\partial P_{ji}}=e\cdot\sum_{i=1}^{n}\left(\bar{b}_{i,0}+\sum_{i=1}^{n}\bar{b}_{ji}x_i\right)\cdot\frac{\partial \tau}{\partial P_{ji}} \tag{5}$$

The Equations (2) and (3) based vector $\frac{\partial \tau}{\partial P_{ji}}$ for $j=\overline{1,m}$ statements are written as follows:

$$\frac{\partial \tau_i}{\partial a_{ji}}=\frac{\partial}{\partial a_{ji}}\left\{\frac{\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)}{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)\right]}\right\} \tag{6}$$

$$\frac{\partial \tau_i}{\partial b_{ji}}=\frac{\partial}{\partial c_{ji}}\left\{\frac{\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)}{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)\right]}\right\} \tag{7}$$

If $x\le a$ then $\frac{\partial \tau}{\partial P_{ji}}=0$ and when $a\le x\le\frac{a+b}{2}$ then $\mu_{Pi}(x)=2\cdot\left(\frac{x-a}{b-a}\right)^2$.

$$\frac{\partial \tau_i}{\partial a_{ji}}=\frac{\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)\cdot\left(x_i-b_{ji}\right)}{\left(b_{ji}-a_{ji}\right)^3}\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)^2\right]-}{}\rightarrow$$

$$\rightarrow\frac{-\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)^2\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)\cdot\left(x_i-b_{ji}\right)}{\left(b_{ji}-a_{ji}\right)^3}\right]}{\left\{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)^2\right]\right\}^2} \tag{8}$$

$$\frac{\partial \tau_i}{\partial b_{ji}}=\frac{\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)^2}{\left(b_{ji}-a_{ji}\right)^3}\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)^2\right]-}{}\rightarrow$$

$$\rightarrow\frac{-\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)^2\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)^2}{\left(b_{ji}-a_{ji}\right)^3}\right]}{\left\{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\left(\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right)^2\right]\right\}^2} \tag{9}$$

Similarly, $\frac{a+b}{2}\le x\le b$ and $c\le x\le\frac{c+d}{2}$ for the cases in Equations (8), (9) and (2) up to (5), taking into account in setting the parameters of MF will receive the following respective formulas:

For position $a\le x\le\frac{a+b}{2}$:

$$a_{ji}^{(k+1)}=a_{ji}^{(k)}-\alpha\cdot e\cdot\sum_{j=1}^{m}\left(\bar{b}_{i,0}+\sum_{i=1}^{n}\bar{b}_{ji}x_i\right)\cdot$$

$$\cdot\frac{\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)\cdot\left(x_i-b_{ji}\right)}{\left(b_{ji}-a_{ji}\right)^2}\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right]-}{}\rightarrow$$

$$\rightarrow\frac{-\prod_{i=1}^{n}\mu\left(x_i,a_{ji},b_{ji}\right)\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)\cdot\left(x_i-b_{ji}\right)}{\left(b_{ji}-a_{ji}\right)^3}\right]}{\left\{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right]\right\}^2}$$

$$b_{ji}^{(k+1)}=b_{ji}^{(k)}-\alpha\cdot e\cdot\sum_{j=1}^{m}\left(\bar{b}_{i,0}+\sum_{i=1}^{n}\bar{b}_{ji}x_i\right)\cdot$$

$$\frac{\cdot\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)^2}{\left(b_{ji}-a_{ji}\right)^3}\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right]-}{}\rightarrow$$

$$\rightarrow\frac{-\prod_{i=1}^{n}\mu\left(x_i,a_{ji},b_{ji}\right)\cdot\sum_{j=1}^{m}\left[\prod_{i=1}^{n}4\cdot\frac{\left(x_i-a_{ji}\right)^2}{\left(b_{ji}-a_{ji}\right)^3}\right]}{\left\{\sum_{j=1}^{m}\left[\prod_{i=1}^{n}\mu_{Pi}\left(x_i,a_{ji},b_{ji}\right)\right]\right\}^2}$$

III. MODELING RESULTS

Four terms for linguistic variables are accepted in the modelling [6-8]. As a result, the rule 144 was site partial Sugeno fuzzy knowledge base. After that, the model of ANFIS complex algorithm is used in the software application and Matlab model brought a shape.

The ANFIS-model data is used in order to form the qualifying standard and training of teaching scheme of 14 states of the power network. ETAP software package is used for reporting the regime. The report contains the results of the input nodes including the voltage and reactive power signals which have been used in teaching and learning, as well as the test process.

Fuzzy neural network was 40 era. Four inputs (2 reactive powers and 2 voltages) signal for each terms are set up for adopting based on the Pi-shaped MF terms. It forms the network of load modes characteristic of the procedure and the required selective reporting of results.

The ANFIS results are shown in Table 1 for the various forms of MF terms of fuzzy control model. The test data on the comparative effectiveness report are also shown. The reactive powers of distribution network are adopted as fuzzy logic-based intelligent workflows to control the input variables node voltage terms based on the "bell" form of MF selection rule. So all of the criteria for error point setting process has a more favorable price.

Table 1. Sugeno-type setting for the performance of the functions of identity model

Relation Functions	Learning errors		Number of learning epochs		Period of methods, second
	Report on data	Under test data	Report on data	Under test data	
"Call" form MF	5.96×10^{-5}	0.2	2	40	17
Sigmoid MF	2.96×10^{-4}	0.625	9	70	29
Gauss MF	2.31×10^{-4}	3.71	2	60	50
Pi-forma MF	5.93×10^{-4}	1.18	4	63	> 60

Figure 1 denotes to 43 states of real distribution network scheme as "call" shape which are developed and refined on the basis of MF Sugeno fuzzy neural model. The voltage profile is shown in order to check the effectiveness of two regimes including reactive power compensation cases before and after compensation. Therefore, reactive power flows considering the MF affects improve the voltage profile of the network.

Daily load of reactive power compensation regimes before and after compensation are shown in Figure 2 for the loss of active power of the network based on fuzzy logic description. Referring to the figures, the maximum load time (18th regime) is reduced by up to 25% loss of power. The power loss reduction trend is also evident in other modes.

IV. CONCLUSION

In this paper, the power and voltage parameters of the proposed network are analyzed based on the fuzzy-logic process and evaluation of selection criteria using various member functions.

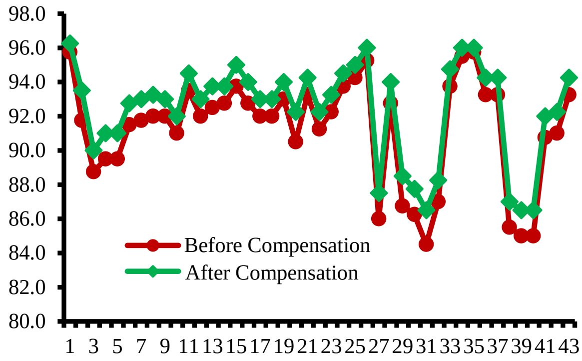

Figure 1. A real network node for voltage profile

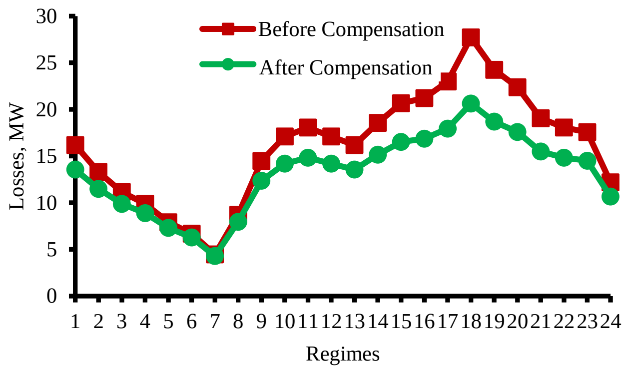

Figure 2. The curves of change of power loss

Setting of reactive power flows for the network are carried out in tension node management for a "call" shaped MF Sugeno fuzzy neural network model database which is the advantage of the proposed method.

The scheme of distribution power network is based on the results of the reactive power flows and reporting of the regime based on fuzzy-logic process efficiencies.

REFERENCES

[1] S.D. Shtovba, "Design of Fuzzy Systems Means of Matlab", Goryacshayaliniya-Telecom, M., p. 288, 2007.
[2] I. Hayashi, T. Furuhashi, "Fuzzy Neural Networks", Asakura-Shoten, Tokyo, Japan, 1996 (in Japanese).
[3] A.N. Borisov, O.A. Krumberg, I.P. Fedorov, "The Adoption of Models Based on Fuzzy Decision", Examples of Using, Zinatne, Riga, p. 184, 1990.
[4] M.G. Semenenco, I.V. Knyazeva, S.I. Cshernyayev, "Problems of Choice of Membership Functions of Fuzzy Sets in Modeling Systems", International Journal of Applied and Basic Research, No. 8, pp. 165-166, 2013.
[5] R.A. Aliyev, R.R. Aliyev, "The Theory of Intelligent Systems and its Application", Chashiogli, Baku, p. 720, 2001.
[6] R.A. Aliyev, A.K. Arabskiy, O.B. Arno, S.I. Gunkin, E.G. Talibov, "Information Systems for GAS Production Processes", The State of the Art and Perspectives, Nedra, Moscow, p. 462, 2014.
[7] H.B. Guliyev, "Synthesis Base of Fuzzy Knowledge ANFIS-Control of Reactive Capacity and Voltage in Distributive Electric Networks", Reliability: Theory &

Applications, Vol. 8, No. 4, Issue 31, San Diego, USA, pp. 53-59, 2013.
[8] H.B. Guliyev, "Algorithm Settings of ANFIS-Model to Control by Streams of Reactive Capacity and Knots Voltage in Distributed Electric Networks", Journal of Power Engineering Problems, Baku, No. 1, pp. 19-30, 2014.
[9] N.R. Rahmanov, N.M. Tabatabaei, H.B. Guliyev, "Optimization Algorithms for Improving the Operation Control in Power System with Distributed Generation", International Journal on Technical and Physical Problems of Engineering (IJTPE), Issue 21, Vol. 6, No. 4, pp. 15-21, December 2014.

BIOGRAPHIES

Arif Mamed Hashimov was born in Shahbuz, Nakhchivan, Azerbaijan on September 28, 1949. He is a Professor of Power Engineering (1993); Chief Editor of Scientific Journal of "Power Engineering Problems" from 2000; Director of Institute of Physics of Azerbaijan National Academy of Sciences (Baku, Azerbaijan) from 2002 up to 2009; Academician from 2007; the First Vice-President of Azerbaijan National Academy of Sciences from 2007 up to 2013; and Director of Azerbaijan Research Institute of Energetics and Energy Design from 2014 till now. He is laureate of Azerbaijan State Prize (1978); Honored Scientist of Azerbaijan (2005); Cochairman of International Conferences on "Technical and Physical Problems of Power Engineering" (ICTPE) and Editor in Chief of International Journal on "Technical and Physical Problems of Engineering" (IJTPE). Now he is a High Consultant in "Azerenerji" JSC, Baku, Azerbaijan. His research areas are theory of non-linear electrical Networks with distributed parameters, neutral earthing and ferroresonant processes, alternative energy sources, high voltage physics and techniques, electrical physics. His publications are 300 articles and patents and 5 monographs.

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