An Application of Control System based on ARX Model about Regional Economic System

Shi Zheng
School of Economics and Management
Dalian Nationalities University, Dalian, Liaoning Province, China

E-mail: zhengshi1993@yahoo.com.cn

ABSTRACT

This paper focuses on the problem of designing a control scheme with discrete transfer function based on ARX model. One of the main objectives is to show how to identify the structure of ARX model as well as how to estimate the model's parameters. It is shown that the method proposed to tackle the above tasks make it possible to obtain a suitably accurate mathematical description of the system. This description allows developing a technique of system identification in regional economic system. Another objective is related with an application-oriented study regarding the proposed approaches. In particular, the paper presents the results concerning the application of the techniques for the regional economic system. The result shows that the method can realize the control of the regional economic development, and track the trace of the regional economic competitiveness dynamically.

Keywords: ARX parametric model, Nonlinear system, System identification, Discrete transfer function

Acknowledgement: This work was supported by the Liaoning Social Science Foundation. (Project No. L07DJY067) and P.H.D. support Foundation (20066201) of Dalian Nationalities University.

INTRODUCTION

Regional economic system is very complicated. The dynamic process has evident nonlinear features. Lots of models such as Time Series, Regression and Econometric Model which has linear features, can describe the relation between system input and output. However, the system reflects the relation about simple cause and effect. Thus, the system is the "product" of Newton mechanical causation theory. Great progress of regional economic system model has been made by scholars in this field within decades. Besides the achievement in transportation and space interaction model, other kinds of models have made a mighty advance. But it should be pointed out that lots of data and model construction skills of these models are based on the precondition of the assumption of real and reliable information. Actually, much data are 'weak' in this assumption, for instance, data measured by 'ordinal number' or nominal measurement. Thus, a complete set of technology (Multiple Dimensional Scaling, Ordinal Regression Analysis, Data Type Analysis, Logit and Probit Analysis, PLS and Lisrel Model, General Linear Model etc.) dealing with these 'weak' data has been rapidly developed recently(Peter Nijkamp,2001)". Nevertheless, there are still setbacks in these regional economic system models. We find that on the one hand, more and more variables are putted in regional economic system model; the structure of the model is getting more complex; the construction of the model is becoming more difficult. On the other hand, the implication of the model is just passable. It is necessary to blaze a different trail to construct regional economic system model in accordance with reality (Zhu ZH, 2005).

At present, nonlinear system is a hot point in System Engineering Field. Nonlinear Multiple ARX Model is applied in researches of Modal Identification (GaoWC et al 2003), Fault Detection (Zhang P et. Al 2000). The Identification Method of ARX Model and Extended Models are also becoming mature, for instance, Yi Ma, René Vidal(2005) proposed a method to acquire the algebraic linear solution to ARX Model. The integration of ARX Model and Fuzzy Control or Artificial Neural Network formed some new schemes of System Identification(Mechaqrane A. Zouak M. 2004; Aleksandar Lj. Juloski 2005; Bertil Thomas, Mohsen Soleimani-Mohseni 2006; Nelles O. 2001). These schemes are universally applied in the study of Complex System. Furthermore, Matlab "System Identification" Toolbox provides support for this research. Fuzzy control theory is applied in the field of engineering and medical extensively. For instance, Obeli C. et al.(1999) developed an expert system that could make alarms by integration of seven vital signs monitored on-line from cardiac surgical patients. Wu J. et al. (2005) demonstrate an example of using Artificial Intelligent in solving problems with complex and uncertain features in communication networks. Hadjimichael M.(2002) presents fuzzy expert system MEDEX, for forecasting gale-force winds in the Mediterranean. However, besides the basic work in the regional economic research, the deeper research with the application of fuzzy control theory has not been launched yet. The comprehensive evaluation of regional economic power is a work, which has more policy and principle meaning, so the scientific method should be adopted. Artificial evaluation method was applied several years ago. This method emphasized on quality analysis, which has more subjective element and lacks scientific analysis. Recently, Component Analysis and AHP method enhance the objective of the evaluation method, but they ignore the dynamic comparison of the evaluation result. AHP method regards eigen-vector responding to the largest eigen-value as the weightness of evaluation by comparison between two evaluation indices elements among all indices. It based on policymaker's preference, and ignored the objective interrelation among all indices. Component Analysis is on the basis of interrelation among all indices. It picks up several interdependent comprehensive variables, after making all indices convergence. Then it regards comprehensive variable's scores of sample as the evaluation basis. It relies on the sampling indices data thoroughly, so it can not reflect the policymaker's preference. In brief, although there some fundamental researches(Zheng S et al 2007; Zheng S et al 2008a; Zheng S et al 2008b; Zheng S et al 2009), the work which employed intelligent control in a complete scheme for a regional economic system has not been launched.

Several attempts have been made by our project team to realize intelligent control for a regional economic system such as the fuzzy logic, the fuzzy neural network, the genetic algorithm, the particle swarm optimization etc.. However, there are still some obstacles which should be conquered(Vassiliadis V, Dounias G 2009). The mainly obstacle is that the aforementioned methods can hardly deal with the regional economic controlling independently. Our fuzzy control scheme can acquired better control accuracy. But it has steady-state errors, limited adaptive ability and ineffective learning mechanism. Meanwhile, optimization efficiency of the membership function in fuzzy neural control is a long term question. During this period, if we can find an optimization model, and then design a classical controller based on that model, it will be conduced to finding a perfect scheme for the intelligent control for a regional economic system.

There are many methods available in OR area(Ye ZM 2007; Shoorehdeli MA, Teshnehlab M, Sedigh AK 2009). Among them, ARX parametric model can handle a nonlinear system like a regional economic system effectively (Peng H, Wu J. 2009; Peng H, Yang ZJ, Gui WH, et al. 2007).It is a kind of "black box" method (Peng H, Yang ZJ, Gui WH, et al 2007). The mechanism of the system is not needed, when an ARX parametric model is constructed. Model construction is very easy. In these aspects, it is superior to the "white box" and "grey box" method. The model is very intuitive compared with some "black box" methods such as the neural network and the fuzzy neural network etc..

The purpose of this paper is to show how to identify the structure of ARX model as well as how to estimate the model's parameters. Another purpose is related with an application-oriented study regarding the proposed approaches. Therefore, we make a comparison among several methods proposed by the author. The final aim of the research is to track the regional economic development dynamically, and realize its fuzzy control. The contribution of this paper shows that system identification and classical controller is useful in constructing regional economic system model and dynamically controlling the regional economic system.

SYSTEM IDENTIFICATION METHOD

2.1 System input and output

Classical economic theory takes the analysis of regional competitiveness as the most important aspect in understanding the operation of regional economic system. Generally, the enhancement of regional economic competitiveness depends on the transformation of the productive elements. The transformation means the changes not only in quantity but also in quality. So the present research adopts Romer's Economic Growth Model, TSCSREG (Time Series Cross Section Regression) in describing the changes of regional economy. However, this kind of model is linear and empirical one. The description of such models is lack of accuracy and reason. A substitution is to describe the relationship between indices of regional economic element and competitiveness. In other words, the method is to describe the system by means of the inputting indices and the outputting competitiveness. We have already completed this work in our previous research. This thought is to integrate the experts' knowledge (for example, evaluating index weightness) into the evaluation of regional competitiveness. If the experts' knowledge is relatively correct, the relationship between system input and output is relatively correct. In view of these above-mentioned, this paper regards Regional Competitiveness Core-elements as system input No.1 and Regional Competitiveness Auxiliary elements as system input No.2, and regards Regional Competitiveness as system output, so that the system feature can be described effectively.

2.2 ARX model

Parametric model is a kind of mathematical model, such as Difference Equation, Differential Equation and Space-Statement Equation etc. Among these models, we believe that ARX Model is the best one in describing regional economic system. The reason is as follows: Firstly, Space-Statement Equation Model can describe this kind of system, and it needs so much data which can hardly be found in our research. Secondly, regional competitiveness is a discrete variable. For example, if there is a change on regional administration policy, a new regional competitiveness will appear. As we know that Differential Equation can only describe the relationship among continuous variables. So this kind of models cannot be used. Thirdly, since Multiple AR Model can hardly use the data to estimate the parameters of the regional economic competitiveness elements in the same time point, and that it cannot preserve the this kind of model is also excluded. The simulation data of tested ARX Model not only has the same correlation as model construction data, but also has the same distribution characteristics. ARX Model is as follows:

$$A(q^{-1})y(k) = B(q^{-1})u(k-n_k) + e(k) \qquad (1)$$

In equation (1), $A(q^{-1})$ 、$B(q^{-1})$ is the parameters of the model, i.e. lagged operator or translation operator polynomial. n_k is the system latency. ARX Model is the dynamic model described by Difference Equation. $A(q^{-1})$ 、$B(q^{-1})$ can be estimated by System Identifica$tion. Thus, the regional nonlinear system will have the definite forms.

2.3 Parametric estimation process

Parametric estimation is the process which estimates the parameters of ARX Model by error criterion. The mature methods are Least Square Method and Improved Least Square Method (Charmet G. et al1998) (Generalized Least Square Method (Arif M. et al 1999) and Extended Least Square Method). Other methods include Error Predict Estimation Method, IV Estimation Method (Cedervall M. et al 1996)and Mathematical Approximation Method, such as Forward-backward Method, Yule-Walker Method (Haubruge S. et al 1998) , Burg Method (Subasil A. 2005), and Geometric Lattice

Method (Nyman K. L. 2005). Parametric estimation of ARX Model can be realized by MATLAB Toolbox.

THE APPLICATION OF SYSTEM IDENTIFICATION METHOD

3.1 The preliminary result and advantage of ARX model parametric estimation

Tapping indent command in MATLAB workspace, and loading 26 pairs of nominal measurement data, which represents regional competitiveness core elements and auxiliary elements respectively, then we select estimation method of parametric models. The preliminary estimation result shows: when model order is 4[4 4][1 1], loss function is 0.00010709. Akaike FPE (final predict error) is 0.00029066. This ARX441 Model is:

$$A(q^{-1})y(t)=B_1(q^{-1})u_{1t}+B_2(q^{-1})u_{2t}+e_t \quad (2)$$

Among them,

$$B_1(q^{-1})=-16.6162(7.0848)q^{-1}-1.0607(7.6645)q^{-2}$$
$$-8.0343(6.9126)q^{-3}-7.0418(6.7513)q^{-4}$$
$$B_2(q^{-1})=-5.4824(2.3802)q^{-1}-0.2452(2.5699)q^{-2}$$
$$-2.7207(2.2862)q^{-3}-2.35(2.2313)q^{-4}$$
$$A(q^{-1})=1-24.4559(10.0213)q^{-1}+0.6264(10.5431)q^{-2}$$
$$-11.2134(9.4104)q^{-3}-9.4384(8.7636)q^{-4}$$

Compared with other models mentioned above, ARX Model has some advantages, such as simple model structure, lower requirements for data (this method needs few data), similarity to the regional economic system or corresponding with regional economic system. Furthermore, this model has an important advantage that it can describe un-certainty and un-accuracy (i.e. fuzzy) system, since it has integrated the experts' knowledge into the nominal measurement data. In short, it is a good tool for the identification of the society and economic system.

3.2 Selection of model structure

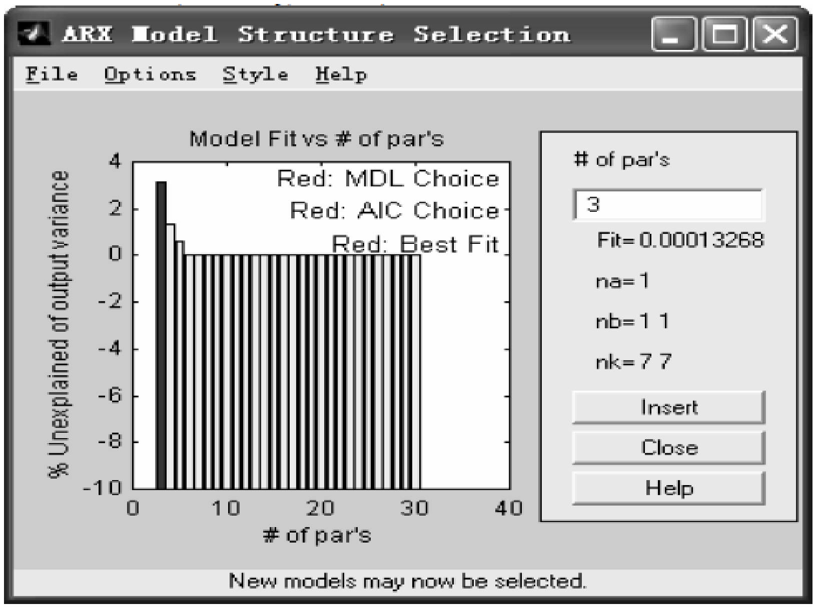
What the most important is to select the reasonable model structure parameter in system identification. In this paper, reasonable selection of the order in the ARX Model plays an important role. Applying ARXSTRUC function and GUI (graphical user interface) of MATLAB Toolbox, we can get the following interface (see figure 1).

Fig. 1 shows that black bode has the best goodness-of-fit. It is the best model structure. This ARX Model is:

$$[1-1.0019\ (0.5082)\,q^{-1}]\,y(t)=$$
$$-0.2555\ (0.3025)\,q^{-7}u_{1t}+$$
$$0.1006\ (0.1167)\,q^{-7}u_{2t}+e_t \quad (3)$$

Loss function is 0.0001485 and Akaike FPE is 0.00018724 in this model. This model has the simplest structure. Compared with ARX411 Model mentioned above, its loss function is higher than ARX411 Model (ARX441 model's loss function is 0.00010709 and ARX117 model's loss function is 0.0001485). However, its FPE is lower than ARX411 Model (ARX441 model's FPE is 0.00029066，ARX117 model's FPE is 0.00018724).

Figure 1: Selection of ARX Model Structure



3.3 Comparison between parametric estimation methods

The models mentioned above select a single method (Least Square Method) for Parametric Estimation. So we should seek a good estimation method in all kinds of mature methods. MATLAB Toolbox provides this function. IV Estimation Method is another mature method in Estimation of ARX Model. In this section, IV Estimation Method has been selected. Through lots of calculation, ARX117 model has been gotten in the following form:

$$[1-0.8131(0.0685)q^{-1}]y(t)=-0.1022(0.128)q^{-7}u_{1t}$$
$$+0.08216(0.0524)q^{-7}u_{2t}+e_t \qquad (4)$$

Loss function is 0.00013406 and Akaike FPE is 0.00016903 in this model. Compared with Least Square Method Estimation, its loss function and Akaike FPE is lower. (model (3)'s loss function is 0.0001485 and its FPE 为0.00018724). Thus, IV Estimation Method is better than Least Square Method in ARX Model Estimation. Model (4) is the final system identification result for the regional economic system.

Figure 2: Input1's Design of Single Input Single Output Controller

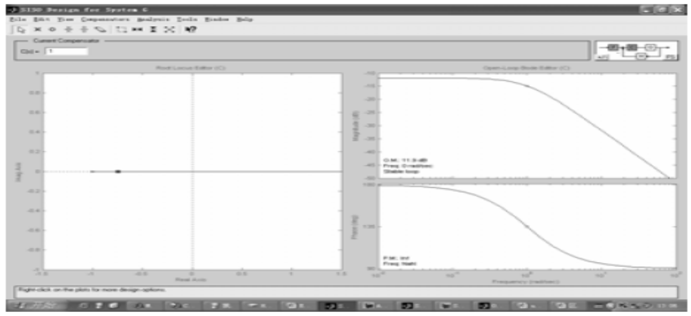
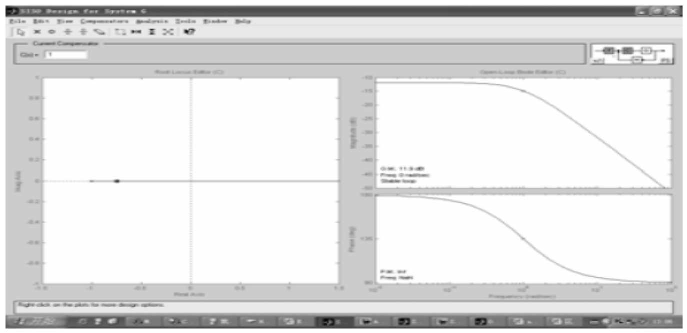


Figure 3: Input2's Design of Single Input Single Output Controller



SIMULATION OF ARX PARAMETRIC MODEL

4.1 Transformation of discrete transfer function from ARX model

According to the control system identification practice, ARX Model can be transformed into discrete transfer function. Equation (4) can be transformed as follows:

$$G(z) = \begin{bmatrix} -1.022/(z-0.8131) & 0 \\ 0 & 0.0826/(z-0.8131) \end{bmatrix} \qquad (5)$$

4.2 Constructing control model based on transfer function

Equation (5) can be rewritten in following form:

z = {[-1], [-0.5]; [0], [-2]};

$p = [-\ 0.8131\ ,0;0,-0.8131\ ]$;

$k = [-\ 0.1022,0;0,0.0826]$;

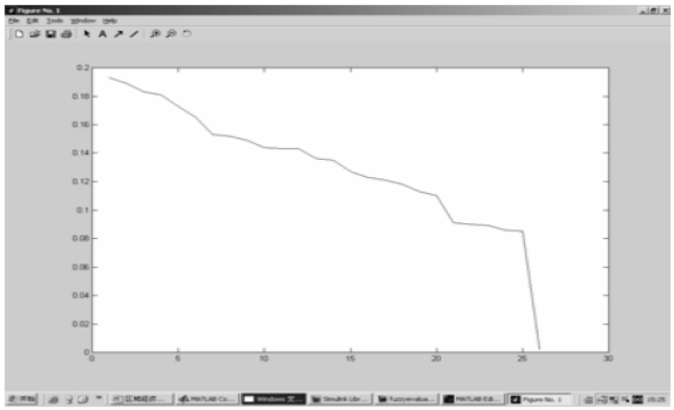
Transfer function can be transformed into zero pole gain model. Using the following command:

$$G = zpk(z, p, k)$$

4.3 Applying the GUI to design the controller based on transfer function

We can get two controllers by using *sisotool* in control box in Matlab.

Figure 4: Classical Fuzzy Evaluation Result



4.4 Auto Realization of Classical Controller

Using "Draw Simulink Controller" in "tool" menu, two Simulink control model can be gotten. Parallel connection of the two models can make it describe the multi-inputs and multi-outputs condition of the above ARX model. The comparison between Fig.4 and Fig.5 shows that the result of the design is effective after simulating the Simulink model.

Figure 5: Simulation Result of the Controller Based on ARX Model

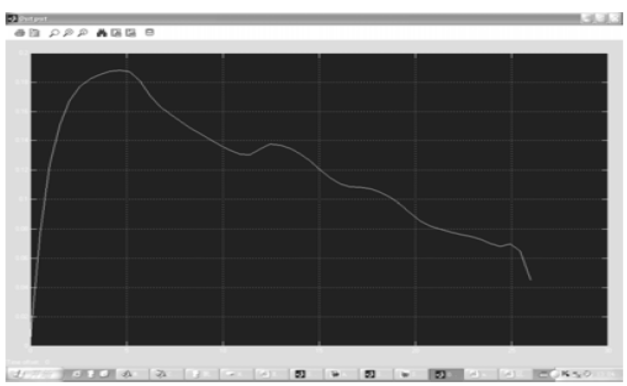
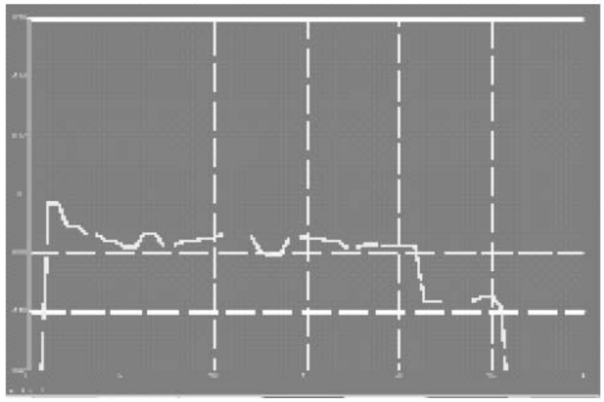


Figure 6: Regional Economic Evaluation System Simulation Output Curve
（19 rules simulation result）



4.5 Comparison between the classical control and other methods

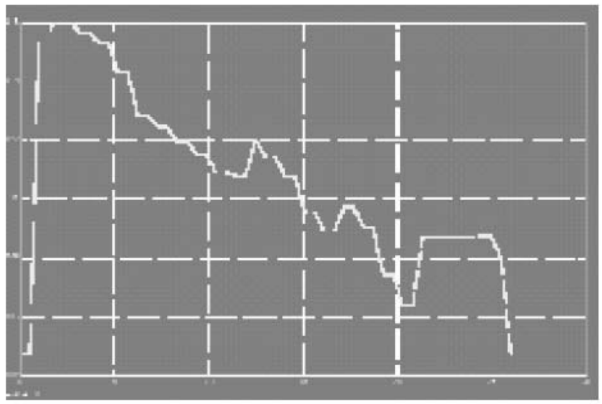
26 pairs of data of regional economic competitiveness elements were loaded from workspace and READFIS (‘rule1.fis‘) command were applied to load the fuzzy controller of the first group of rules (19 sentences). After designing the simulation model, the simulation output curve (see Fig.6) can be gotten. The result of regional competitiveness sequence acquired from simulation controlled under 19 sentences is in accordance with classical regional economic fuzzy evaluation. However, it was underestimated. It shows that the design of the first group of rules can track the trace of regional economic competitive-ness. But the result gotten from this controller is not satisfactory.

READFIS(‘rule2.fis‘) command was applied to load the fuzzy controller of the second group of rules (5 sentences). After designing the simulation model, the simulation output curve (see Fig.7) also can be gotten. It shows that the second group of fuzzy control rules can track the regional economic competitiveness exactly (see Fig. 7). The result of regional competitiveness sequence acquired from simulation controlled under 5 sentences can realize the alarm function in the area with high regional economic competitiveness, and can control the regional economic competitiveness under real time condition in the area with low regional economic competitiveness.

CONCLUSION

This paper discusses how to use system identification method in regional economic system. It presents a new idea of system identification based on fuzzy evaluation. It applies with parametric estimation to analyze data of the input and the output in the nonlinear system, and selects a regional economic system model from lots of nonlinear models by system identification method. The result is that ARX117 model is the best one

Figure 7: Regional Economic Evaluation System Simulation Output Curve
（5 rules simulation result）



and the IV estimation method is suggested to be used. Since this ARX model can reflect the complex feature of regional economic system by integration of experts' knowledge, we can design the most reasonable fuzzy controller for the regional system according to the ARX model. Thus, this paper also lays a reasonable foundation on fuzzy control of a regional economic system.

Future research on the utility of the ARX parametric model is also warranted. One work is that several control models will be designed based on the ARX parametric model to reduce the steady-state errors. The other work is to design a scheme to complement fuzzy control and fuzzy neural network control of a regional economic system. These researches is meaningful for the rapidly realization of the intelligent administration on Chinese regional economic.

This research was limited by virtue of the fact that a small amount of the sample was used to identify the ARX parametric model. It was also limited to a wide range of the samples. The lack of specific is another limitation. A specific set of data should be used to identify a model of a specific region, e.g. Northern east in China. Despite these limitations, this research changes the previous understanding of a regional economic system. It constructs a control model based on mathematical model. Employing the ARX parametric model, other researchers can make a deeper research on the relevant area about regional economic management. For instance, In order to make researches more practicality, the PD/PID control based on ARX model can be employed. Large amount of data also can be used to find a model with high accuracy.

At present, a software package is also needed for verifying the method in this paper. We have already designed one package for this aim. More limitations and advantages of this method can be found in our future research.

REFERENCES

Aleksandar Lj. Juloski, Heemels W.P.M.H., Giancarlo Ferrari-Trecate, et al (2005). Comparison of Four Procedures for the Identification of Hybrid Systems. *Hybrid Systems: Computation and Control: 8th International Workshop*, *HSCC 2005 Proceedings*, 354.

Arif M., Ishihara T. and Inooka H. (1999). Iterative Learning Control Utilizing the Error Prediction Method. *Journal of Intelligent and Robotic Systems,* **25**, 95–108.

Bertil T., Mohsen S-M (2006). Artificial neural network models for indoor temperature prediction: investigations in two buildings, *Neural Computing & Applications*, **4**, 41-49.

Cedervall M., Stoica P. (1996). System identification from noisy measurements by using instrumental variables and subspace fitting. *Circuits, Systems, and Signal Processing,* **15**, 275-290.

Charmet G., Cadalen T., Sourdille P. and M. Bernard (1998). An extension of the 'marker regression' method to interactive QTL. *Molecular Breeding*, **4**, 67–72.

Gao WC, Li YL, and Zou JX (2003). Action of multiple ARX model for modal identification of high - rise buildings, *Journal of Harbin Institute of Technology*.**12**, 1422-1425.

Haubruge S., Nguyen V. H., Strodior J. J. (1998). Convergence Analysis and Applications of the Glowinski-Le Tallec Splitting Method for Finding a Zero of the Sum of Two Maximal Monotone Operators. *Journal of Optimization Theory and Applications*, **6**, 645-673.

Hadjimichael M., Kuciauskas A. P. , Tag P. M., Bankert R. L., &Peak J. E. (2002). A Meteorological Fuzzy Expert System Incorporating Subjective User Input. *Knowledge and Information System*, **7**, 350-369.

Juloski, A. L., Heemels, W. P. M. H., Ferrari-Trecate, G., Vidal, R., Paoletti, S., & Niessen, J.H.G. (2005). Comparison of Four Procedures for the Identification of Hybrid Systems. *Hybrid Systems: Computation and Control: 8th International Workshop*, *HSCC 2005 Proceedings*, 354.

Mechaqrane A., Zouak M. (2004). A comparison of linear and neural network ARX models applied to a prediction of the indoor temperature of a building. *Neural Computing & Applications,* **4**, 32-37.

Nelles O. (2001). *Non-linear system identification: from classical approaches to neural networks and fuzzy model.* Springer, Berlin Heidelberg NewYork: 89-95.

Nijkamp P. (2001), *Handbook of Regional and Urban Economics.* Economic Science Press, **1**, 268, 269.

Nyman K. L. (2004) Linear Inequalities for Rank 3 Geometric Lattices, *Discrete Compute Geom,* **31**, 229–242.

Oberli C., Urzua J., Saez C., Guarini M., Cipriano A., Garayar B., Lema G., Canessa R., Sacco C. & Irarrazaval M.(1999), An Expert System for Monitor Alarm Integration. *Journal of Clinical Monitoring and computing*, **1**, 29-35.

Peng H., Wu J., Inoussa G., Deng QL &Nakano K. (2009).Nonlinear system modeling and predictive control using the RBF nets-based quasi-linear ARX model. *Control Engineering Practice*, **1**, 59-66.

Peng H, Yang ZJ, Gui WH, Wu M.,Shioya H. &Nakano K. (2007). Nonlinear system modeling and robust predictive control based on RBF-ARX model. *Engineering*

Applications of Artificial Intelligence, **2**, 1-9.

Peng H, Nakano K, Shioya H (2007). Nonlinear predictive control using neural nets-based local linearization ARX model-stability and industrial application. *IEEE Transactions on Control Systems Technology*, **1**, 130-143.

Shoorehdeli MA, Teshnehlab M, Sedigh (2009). AK Training ANFIS as an identifier with intelligent hybrid stable learning algorithm based on particle swarm optimization and extended Kalman filter. *Fuzzy Sets and Systems*,**4**, 922-948.

Subasil A., (2005). Application of Classical and Model-Based Spectral Methods to Describe the State of Alertness in EEG, *Journal of Medical Systems.***11**, 473-486.

Wu J. , Djemame K. (2005). A Fuzzy-Expert System-Based Structure for Active Queue Management, *Advances in Intelligent Computing: International Conference on Intelligent Computing ICIC*, HeFei, China.

Vassiliadis V, Dounias G (2009). Nature-Inspired Intelligence: A Review of Selected Methods and Applications. *International Journal on Artificial Intelligence Tools*. **8**, 487-516.

Ye ZM (2007). Modeling, identification, design, and implementation of nonlinear automotive idle speed control systems - An overview. *IEEE Transactions on Systems Man and Cybernetics Part C-Applications and Reviews.* **11**, 1137-1151

Ma Y., Vidal R. (2005). Identification of Deterministic Switched ARX Systems via Identification of Algebraic Varieties. *Hybrid Systems: Computation and Control: 8th International Workshop, HSCC 2005 Proceedings*, 449.

Zhang P, Shi LD (2000). Application of Black-box Models to Heating Ventilat and Air-conditioning Systems for Fault Detection, *Journal of Tongji University*,**12**, 679-683

Zheng S, Zheng W, and Jin X (2009). Regional economic evaluation system framework and algorithm based on fuzzy control. *Journal of Harbin Institute of Technology*, **3**,193-195.

Zheng S, Zheng W, and Jin X (2008). Design and implementation of a regional economic evaluation system based on fuzzy neural control .*Icicta*, **10**, 874-877.

Zheng S, Zheng W, and Jin X (2007). Estimation of ARX Parametric Model in Regional Economic System. *Systems Engineering*,**10**, 290-296.

Zheng S, Zheng W, and Jin X (2007). Fuzzy Integration Monitor Method in Regional Economic System and its Simulation. *26th Chinese Control Conference*, **7**, 2-4.

Zhu ZH (2005). A primary study of Regional Economic System Model, *Journal of Systemic Dialectics*, **7**, 74-77

Shi Zheng is Associate Professor of Economics and Management at Dalian Nationalities University, P. R. China. He earned his Ph.D. in Management at the School of Harbin Institute of Technology. He has taught at Dalian Nationalities University and conducted research with many research institutions like the informatics center at university of Reading etc. He has been a reviewer for *Resource and Energy Economics* and *IEEE Computer Society* for more than 4 years. His research publications have appeared in major Economics and Management journals including the *Systems Engineering, Networks and Spatial Economics, Journal of Harbin Institute of Technology,* among others. His specialty is System Engineering Economics. His study focuses on Fuzzy Control and Diagnosis on Regional Economic System and their Applications. He

currently has 3 pieces of the software products with independent intellectual property rights.

Appendix 1: The Applied Data in this Paper (The Author's Research Work of Project< Regional Economic Evaluation System Based on Fuzzy Control Theory>)

batch	Data year	Provinces/ municipalities	Transaction intention	Transaction behaviours	Transaction measurements	Government's Ability In resource allocation	Competitive -ness Core Elements	Competitive -ness auxiliary Elements	comprehensive Competitive -ness
29	2004	Sichuan	0.056425194	0.049978803	0.2351326	0.334637515	0.178658077	0.334637515	0.2176529
29	2004	Neimenggu	0.056677186	0.042321663	0.28210062	0.233942254	0.20942675	0.233942254	0.2155556
29	2004	Chongqing	0.043915445	0.061922552	0.232998767	0.30829216	0.178974769	0.30829216	0.2113041
29	2004	Shanxi	0.044579197	0.072693025	0.275991272	0.203617027	0.211275363	0.203617027	0.2093608
29	2004	Guangxi	0.051941094	0.126450633	0.325946351	0.019078668	0.25883155	0.019078668	0.1988933
29	2004	Ningxia	0.046074878	0.012940276	0.256327266	0.17102239	0.183987777	0.17102239	0.1807464
29	2004	Xizang	0.054148285	0.018618339	0.172337387	0.245831608	0.127772291	0.245831608	0.1572871
29	2004	Henna	0.049982057	0.038732656	0.276873025	0.012920935	0.204464404	0.012920935	0.1565785
29	2004	Hubei	0.05287646	0.023347845	0.28102631	0.010693955	0.204012061	0.010693955	0.1556825
29	2004	Shanghai	0.044868837	0.014081844	0.202228667	0.181483816	0.146705567	0.181483816	0.1554001
29	2004	Tianjin	0.043629358	0.036046067	0.176241852	0.197917794	0.133688017	0.197917794	0.1497455
29	2004	Shannxi	0.051275428	0.012972416	0.204790346	0.145635162	0.14871583	0.145635162	0.1479457
29	2004	Fujian	0.070381147	0.040463698	0.18547321	0.015462731	0.14257384	0.015462731	0.1435627
29	2004	Heilongjiang	0.049150026	0.042516594	0.249951561	0.013208494	0.186635681	0.013208494	0.1432789
29	2004	Jkiangxi	0.04515525	0.076990908	0.220950054	0.016855059	0.174206035	0.016855059	0.1348683
29	2004	Jiangsu	0.054150015	0.018724459	0.209765267	0.010209199	0.153708338	0.010209199	0.1178336
29	2004	Zhejiang	0.038451496	0.012834741	0.128088412	0.176703987	0.094596263	0.176703987	0.1151232
29	2004	Yunnan	0.050219732	0.006823777	0.147508172	0.130164953	0.107558816	0.130164953	0.1132104
29	2004	Beijing	0.039305506	0.022587189	0.19049769	0.01176435	0.140118945	0.01176435	0.1080303
29	2004	Anhui	0.045316495	0.013916143	0.113024202	0.174918342	0.084944827	0.174918342	0.1074382
29	2004	Hunan	0.046132863	0.040385514	0.180238675	0.013233378	0.137649037	0.013233378	0.1065451
29	2004	Shandong	0.029596766	0.000796101	0.117817662	0.156114573	0.084026463	0.156114573	0.1020485
29	2004	Gansu	0.039504258	0.033516527	0.168801038	0.014990693	0.127635629	0.014990693	0.0994744
29	2004	Guizhou	0.048710156	0.014226952	0.17020907	0.01499959	0.124867126	0.01499959	0.0974002
29	2004	Qinghai	0.037657087	0.001160819	0.128587796	0.101888066	0.0921869	0.101888066	0.0946122
29	2004	Jinlin	0.05129699	0.031119443	0.146956351	0.012622802	0.112866345	0.012622802	0.0878055
29	2004	Liaoning	0.047377395	0.01549604	0.142718762	0.011724399	0.106025721	0.011724399	0.0824504
29	2004	Guangdong	0.034045425	0.007325763	0.139825263	0.009192987	0.101111545	0.009192987	0.0781319
29	2004	Hainan	0.036316488	0.007029574	0.121193839	0.007676104	0.088319212	0.007676104	0.0681584
29	2004	Hebei	0.049704491	0.002625363	0.057070094	0.015851649	0.04393934	0.015851649	0.0369174
29	2004	Xinjiang	0.0364953	0.000119393	0.034738964	0	0.024676478	0	0.0346278