Model and Implementation Of System Evolving Algorithm with Distributed Beginning Population

Jerzy Tchórzewski[1], **Andrzej Ruciński**[2]
[1] Artificial Intelligence Division, Institute of Computer Science, University of Podlasie, ul. Sienkiewicza 51, 08-110 Siedlce, Poland, jtchorzewski@interia.pl
[2] Students Branch of Computer Science "GENBIT", Institute of Computer Science, University of Podlasie, ul. Sienkiewicza 51, 08-110 Siedlce, Poland

Abstract. This paper shows some results of using artificial intelligence methods for searching the new state of development system of electro energetic transmission network. In particular, is using evolving algorithm. Some experiments are prepared in MATLAB and Simulink environment.

Keywords. Artificial intelligence methods, evolving algorithm, electric power market, control theory.

1 Introduction

Model of Electric Power Market consists of seven subsystems, namely: Electric Power Station (SWE), Operator of Transmission System (OSP), Rotation Firm (PO), Electric Stock Exchange (GE), Operator of Distributed Systems (OSR), Receiver with TPA (TPA), Receiver without TPA (NTP)

To searching regularity of development of Power Market System is used their cybernetic model as is show on fig 1.

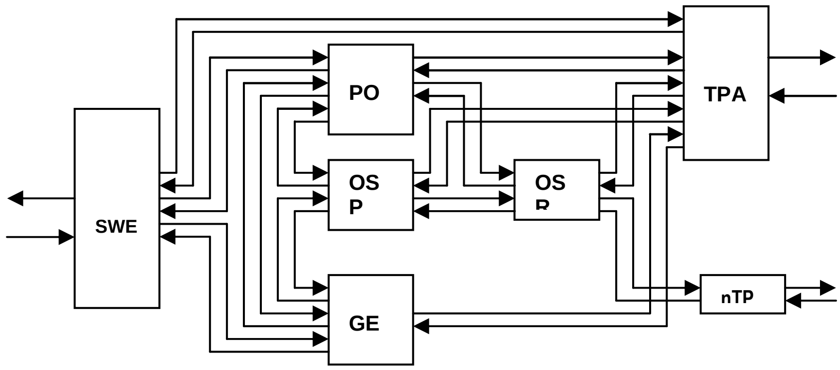


Figure 1. Cybernetic Model of Electric Power Market.
Symbols are in the text.

One of more important systems in the structure of competition on Electric Power Market is the operator of transmission system (*Polish: Operator Systemu Przesyłowego – OSP*). OSP administer on balance market and are responsible for quality and independence of electric energy supply to the receiver and for transmission of service disbursement [1,19,29-31,33,38-41,43].

Although prescription of regulation of electric power action gives priority to market stability before trade actions on the market, the market generates a lot of inconvenient practice situation for regulators system, which solves shout be follows quickly to avoid the situation, which can be unprofitable or catastrophic event for electroenergetic system.

So, transmission system operator is management of transmission network, distributed of charge distribution and transmission service purchase. Besides, the action of system OSP on electric power market is regulating through condition of concession getting of Energetic Regulate Office (*Polish: Urząd Regulacji Energetyki – URE*) and normalized particularly in regulations of balance market [ ]. In Poland as OSP is acting Polish Electro-energetic Network S.A Operator. (Polish: *Polskie Sieci Elektroenergetyczne S.A. – PSE SA Operator*). A model of system OSP is shown in fig. 2, besides is taken next symbols, namely:

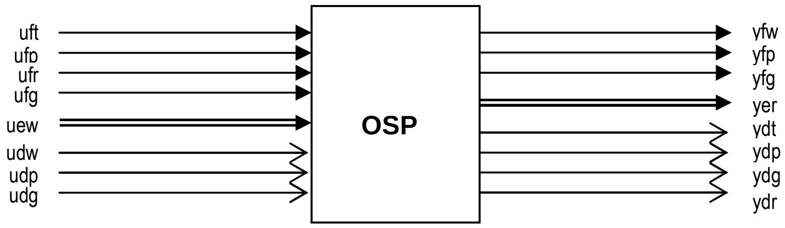


Figure 2. Model of OSP system. Symbols in the text

(1) Describe input:

uft –stream on title salestream of financial income on electric energy sold to TPA [thousands PLN];

ufp – stream of financial income on electric energy sold to PO [thousands PLN];

ufr – stream of financial income on electric energy sold to OSR [thousands PLN];

ufg – stream of financial income on electric energy sold to GE [thousands PLN];

uew – stream of electric energy physically transmitted from SWE to anther system [GWh];

udw – decision stream concerning purchase of electric energy from SWE through TPA [GWh];

udp tream of decision making of purchase electric energy from PO through TPA [GWh];

(2) Describe output:

yfw – stream of financial cost of purchase electric energy from SWE [thousands PLN];

yfp – stream of financial cost of purchase electric energy from PO [thousands PLN];
yfg – stream of financial cost of purchase electric energy from GE [thousands PLN];
yer – stream of electric energy of physic transmission from OSP to OSR [GWh];
ydt – stream of decision making of sale electric energy from OSP to TPA [GWh];
ydp – stream of decision making of sale electric energy from OSP to PO [GWh];
ydg – stream of decision making of sale electric energy from OSP to GE [GWh];
ydr – stream of decision making of sale electric energy from OSP to OSR [GWh];
(3) subsystems:
OSP – operator of transmission subsystem (Polish: operator systemu przesyłowego);
SWE – subsystem of energy generate (Polish: system wytwarzania energii)
PO – subsystem of manufacture trade;
TPA – manufacture, which action of rule TPA,
GE – energy stock-exchange;
OSR – operator of distribute subsystem.

(3) Describe subsystems:
OSP – operator of transmission subsystem (*Polish: operator systemu przesyłowego*);
SWE – subsystem of energy generate (*Polish: system wytwarzania energii*);
PO – subsystem of manufacture trade;
TPA – manufacture, which action of rule TPA;
GE – energy stock-exchange;
OSR – operator of distribute subsystem.

Goal of identification of OSP is searching dependences between object characteristics in settlement state or in time during being transitory process. And next on this base can be possible say about identification responsible static's characteristics or event dynamics properties [5,9,12,37].

Of this understanding of process is to short, and particularly when it is desirable to build object model with mechanism of development. In this case identification will be leading in long time with parametric and structure changing. System OSP for which is searching dependence between input and output streams are called identification object. So, for object from figure 1 system of transmission network action as object of identification, and streams input and output are responsible constructed as vectors of measurement data, and in this practice situation there are statistics data, which are taken from annals named as Statistic of Polish Electro-Energetic (*Polish: Statystyka Elektroenergetyki Polskiej*) [36].

Goal of such defined identification as above is chose the best model from class of models or appoint such vector of parameters in order that quality function receive minimal value. Dependence parameters vectors from measurement result is named identification algorithm.

2 Identification of OSP

Between a lot of problems in search model of Electric Power Market [19,29-3138-41] one of most important belong problems identification power market, in this identification of development of electro-energetic transmission network (ESP). Gaining model of development system of electric power market is one of more difficult task and don't to end precise, therefore to look such models leading identification market system and their subsystems. Besides of this identification of transmission system operator is possible to mark out control subsystem and executive subsystem, in this technology subsystem such as electro energetic transmission network (ESP).

2.1 Chose data for identification

For leading identification of ESP system choose responsible statistic data such as length of electro energetic line, number of electro energetic stations, numbers of networks transformer, electric energy stream getting to network from responsible power stations, etc. Examples of input data is placed in works [33,38-41].

System Identification Toolbox is equipped in graphical interface GUI, which is very useful by using identification analyze researching ESP system. It is possible such define programmer than parameters of program functions will be possible chose through menu or icons [4,33,38-41].

Having prepared data to identification can be possible their import to Workspace and next leading identification. In this case responsible characteristics ESP systems is getting at last in such form as matrix th, transmission form tf, zero-pole form zpk, state space ss, etc.

2.2 Identification of ESP system using System Identification Toolbox

In GUI menu can be possible chose Import option in case imported input and output data (fig. 3) and quickly get some characteristic of system ESP, which examples is shown in table 1 and in table 2.

System which is identified consists of eight inputs and eight outputs. For experiment matrix consist of eight input vectors and for each case is create separate model arx and tf, zpk, ***A,B,C,D*** also.

It is possible use to next standard function, namely:

$$th = arx([y,u],[na\ nb\ nk]), \tag{2}$$

where:

y, u – column vectors (input/output),

[na, nb, nk] – coefficient of equation described the model, na – number of pole (roots in denominate), nb – number of zero (roots of nominate), nk – deleted,

th – matrix in theta format.

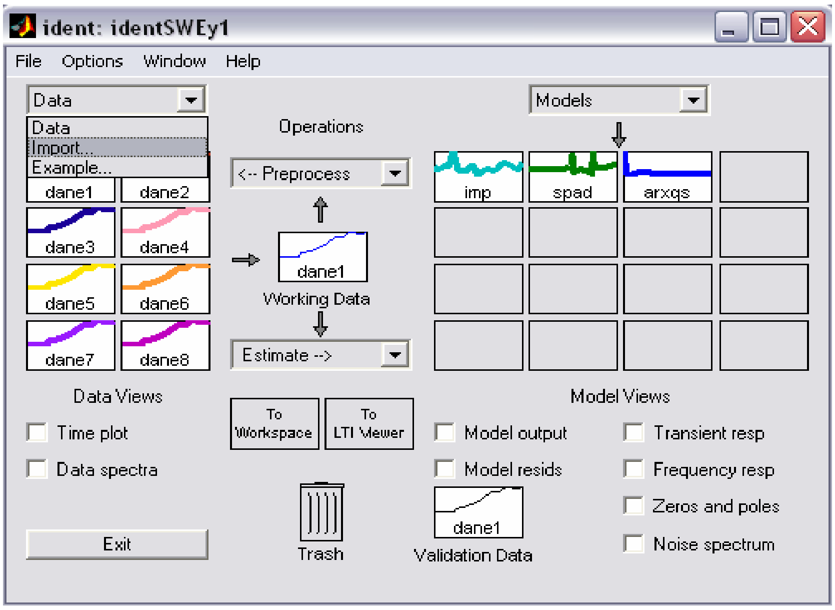


Figure 3. Graphical interface ident with examples contains characteristic of system OSP in area technology system ESP

Optimal choose of model structure is possible using iterations methods. After identification from matrix th is simple method to receive other models of systems, for example:

1) [l, m] = th2tf(th), (3)

where:

m – coefficient of denominate,
l - coefficient of nominate;

2) zpk = zpk(th), (4)

where:

z – zero,
p – pole;

Example of OSP model for output y1

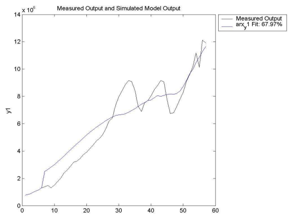
Table 1.

3	**yfw – stream of finance expenses which is bear on purchase electric energy from SWE [thousands PLN t]**		
4	**arx**		
A(q)	1 - 1.058 q^-1	B5(q)	38.03 q^-5
B1(q)	-6.089e-014 q^-5	B6(q)	-72.11 q^-5
B2(q)	-6.086e-015 q^-5	B7(q)	0
B3(q)	0.1972 q^-5	B8(q)	0
B4(q)	0		
5	**zpk**		
From u1 to y1	-6.0893e-014 ------------- z^4 (z-1.058)	From u5 to y1	38.0255 ------------- z^4 (z-1.058)
From u2 to y1	-6.086e-015 ------------- z^4 (z-1.058)	From u6 to y1	-72.1062 ------------- z^4 (z-1.058)
From u3 to y1	0.19717 ------------- z^4 (z-1.058)	From u7 to y1	2.2204e-016 -------------- z^10 (z-1.058)
From u4 to y1	2.2204e-016 -------------- z^10 (z-1.058)	From u8 to y1	2.2204e-016 -------------- z^10 (z-1.058)
num/den		From v@y1 to y1	586318.2868 z ------------- (z-1.058)
-6.0893e-014 ---------------- z^5 - 1.0578 z^4			
[a,b,c,d]		**compare**	

```
a1 =    1.0578    1.0000         0         0         0
             0         0    1.0000         0         0
             0         0         0    1.0000         0
             0         0         0         0    1.0000
        0          0          0         0          0

b1 =    0           0           0         0         0         0         0     0
        0           0           0         0         0         0         0     0
     0           0           0         0         0         0         0     0
     0           0           0         0         0         0         0     0
      -0.0000  -0.0000   0.1972     0   38.0255   -72.1062  0     0
c1 =    1    0    0    0    0

d1 =     0    0    0    0    0    0    0    0
```



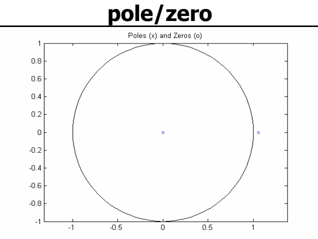
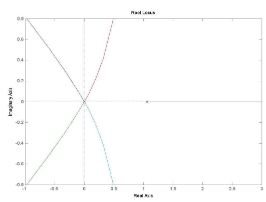
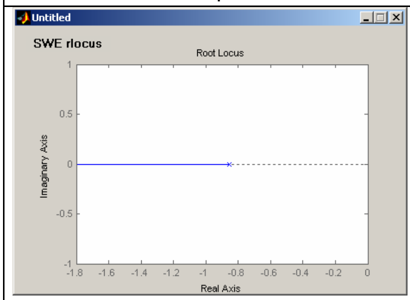
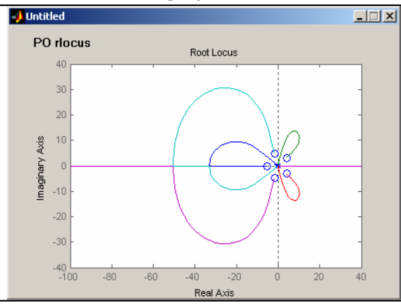
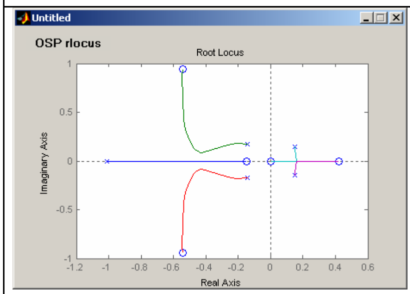
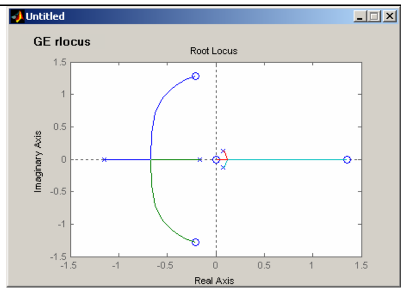
pole/zero	**rlocus**
	

Table 2. Some results of experiments of SAE action for OSP system

Algorithm parameters			
Number of population	30	Probability of crossover – level 1	0,6
Number of generation	100	Probability of crossover – level 2	0,6
Probability of mutation	0,02	Probability of crossover – level 3	0,6
SWE – Graph of rlocus		PO – graph of rlocus	
			
OSP –graph of rlocus		GE – graph of rlocus	
			

3) $[\boldsymbol{A}, \boldsymbol{B}, \boldsymbol{C}, \boldsymbol{D}] = \mathrm{th2ss(th)}$, (5)

where: ***A, B, C, D*** – matrixes of state surface.

For presentation of results is using next functions, namely: compare ([y u], th), rlocus(l,m), pzmap(l,m). First is taken discrete model and next continue.

2.3 System Evolving Algorithm SAE

For generate begin population is using artificial genetic code, which is receive directly from OSP model described in transmittance form. Each chromosome can be use on tired levels. On first level genes have value as coefficient of nominate and denominate of transmission function. On second level as gene is taken al formula of nominate and denominate of transmission function. And on third level is obtained as genes separate models with single output. For selected is using modified tourney method. Is obtain a lot of result, which is published for examples in paper [33,38-41].

Example on al level is contained in table 2. SAE is implemented in language MATLAB using GUI Builder. Programmer SAE is written data from file *.mat and next on this base is creating beginning population.

2.4 Artificial Gnetic code

Artificial genetic code is models code. On base of genetic code is possible searchsearch some information of system in this same way as using mathematical models [2,3,6-8,10,13,14,18,24,28,34,42]. Artificial genetic code is defined as a vector, namely:

$$K_g = [g_1, g_2, \ldots, g_i, \ldots, g_n), \qquad (6)$$

where: g_i is i – artificial gene.

By them each of genes may be as artificial genetic code also. So it is possible obtained artificial genetic code consisted of vectors, matrixes, tales of high rows, and even in form plug one genetic code inside another.

2.5 Chromosome building

Chromosome is possibility describing using three particular levels [11,15-17,20-23,25-27,35,38-41]. On high level are coefficient of nominate and denominate of discrete transmutation and as chromosome is using nominate and denominate. On the middle level as nominates and denominates is using genes. And on the lower level as genes are models of each subsystem.

For selection is using modified tourney method. Each chromosome is competitive with other, and as a winner is that which have better value of fitness function. So for adaptation flows next parameters: form of nominate, form of denominate, sign of parameters of nominate and denominate and sign of parameters of nominate and denominate.

3. Implementation of algorithm SAE in Matlab language

SAE application is elaboration using GUI Builder. Process consists of two steps, namely:
Step 1: generate of graphical interface of programme (*.fig),

Step 2: implementation of SAE algorithm using Matlab languages (*.m).

During identification of Power Market System was exported from MATLAB workspace data in transmutation form. It was next files: SWE.mat, PO.mat, OSP.mat and GE.mat.

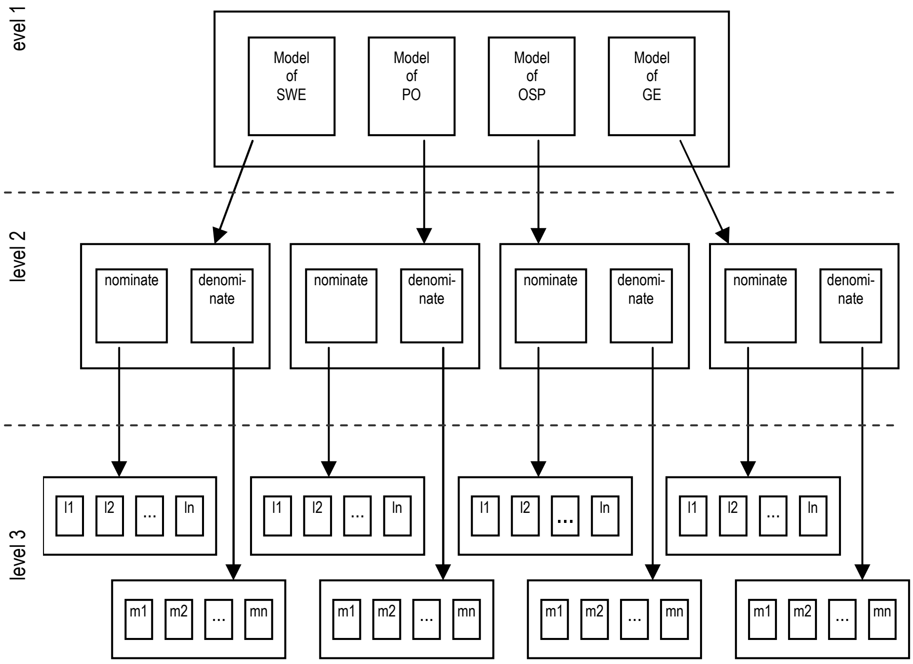


Figure 4. Scheme of chromosome building, l_i – i-nominate, m_i – i-denominate.

3.1. SAE Program

SAE Program is generic beginning population using **.mat* files. Next is going evaluation of chromosome, selections, crossover, mutation, etc. Condition of stopping algorithm is the reach numbers of population during working SAE algorithm. Further we have output data as a transmutation, which is presented using for example *rlocus* functions. Program is particularly described in papers [33,38-41].

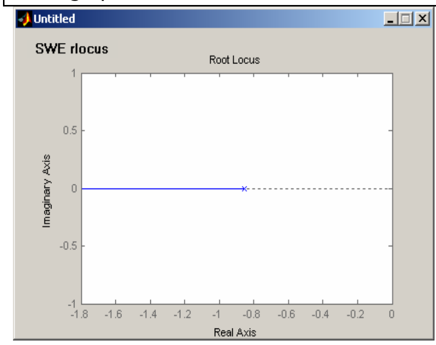
3.2. Examples of results

Goal of experiment is researching some results of action algorithm SAE using high probability of crossover on the all level of detail of chromosome. Some choice results is shows in table 3, and using a little probability of crossover on the all level of detail of chromosome (table 4).

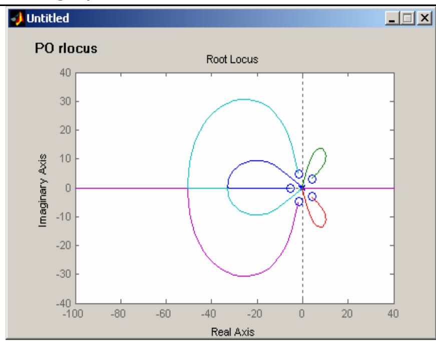
Table 3. Experiments results 4

Parameters of algorithm			
Number of population	30	Probability of crossover – level 1	0,6
Number of generation	100	Probability of crossover – level 2	0,6
Probability of mutation	0,02	Probability of crossover – level 3	0,6

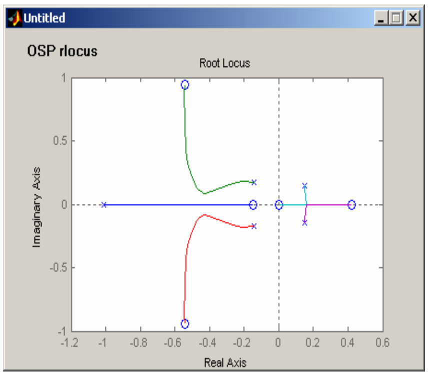
SWE graph of rlocus



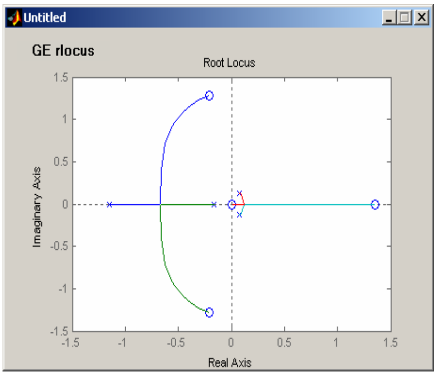
PO graph of rlocus



OSP - graph of rlocus



GE graph of rlocus



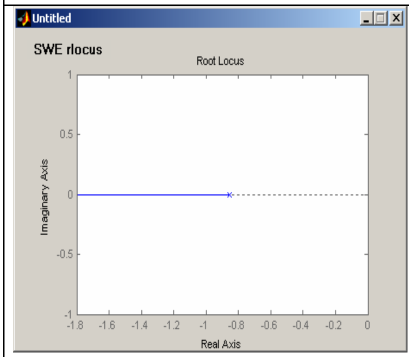
4. Final remarks

Algorithm SAE is elaborated on base control theory and systems. Implementation of system evolving algorithm is prepared in MATLAB environment using such toolbox's as System Identification Toolbox, Control System Toolbox. This elaborate will be continue

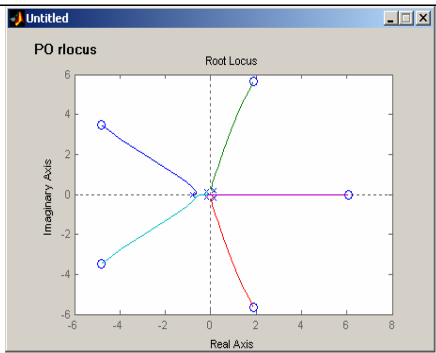
Table 4. Experiments results

Parameters of algorithm			
Number of population	30	**Probability of crossover - level 1**	0,1
Number of generation	100	**Probability of crossover – level 2**	0,1
Pr. mutacji	0,01	**Probability of crossover – level 3**	0,1

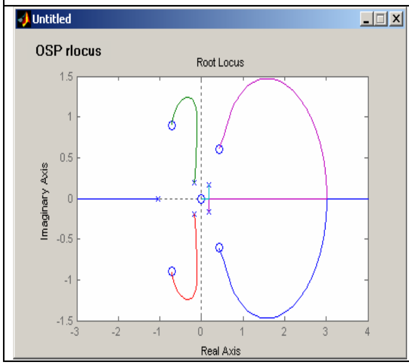
SWE - graph rlocus



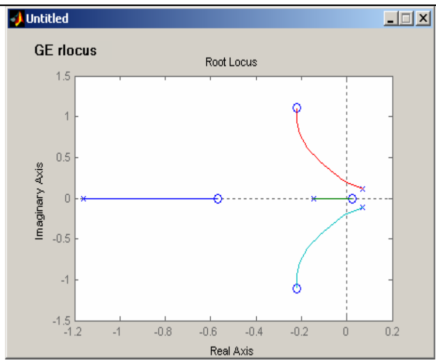
PO - graph rlocus



OSP - graph rlocus



GE - graph rlocus



References

1. Abdel-Magid Y.L., Abido M.A., Optimal Multi-objective Design of Robust Power System Stabilizers Using Genetic Algorithms. IEEE Transactions on Power Systems, August 2003, Vol. 18, No. 3.
2. Arabas J.: Lectures from evolutionary algorithms (Polish: *Wykłady z algorytmów ewolucyjnych*). WNT. Warszawa 2001.
3. Banzhaf W., Nordin P., Keller R. E., Francone F., Generic Programming An Introduction. Morgan Kaufmann, Feb. 1998.

4. Brzózka J., Exercises from automatic in MATLAB and Simulink (Polish: Ćwiczenia z automatyki w Matlabie i Simulinku). EDU-MIKOM, Warszawa 1997.
5. Bubnicki Z.: Identification of control objects (Polish: *Identyfikacja obiektów sterowania*. PWN, Warszawa, 1974.
6. Carlos A., Coello A., Veldhuizen V. and Lamont G.B., Evolutionary Algorithms for Solving Multi-Objective Problems. IEEE Transactions On Neural Networks, 2004.
7. Chambers L.D., Practical Handbook of Genetic Algorithms: Complex Coding Systems, Volume III. CRC Press, 1998.
8. Chambers L.D., The Practical Handbook of Genetic Algorithms: Applications, Second Edition. CRC Press, 2000.
9. Cichosz P., Self-learning Systems (Polish: Systemy uczące się). Wydawnictwa Naukowo-Techniczne, Warszawa 2000.
10. Coello C.A., Van Veldhuizen D.A, Lamont G.B., Evolutionary Algoritms for Solving Multi-Objective Problems. Kluwer Academic/Plenum Publishers, May 2002.
11. Contreras J., Klusch M., Krawczyk J. B., Numerical Solutions to Nash-Cournot Equilibria in Coupled Constrains Electricity markets. IEEE Transactions on Power Systems, February 2004, vol. 19, no. 1.
12. Coveney P., Highfield R., Boards of complex, in searching regularity in chaotic web (Polish: *Granice złożoności, w poszukiwaniu porządku w chaotycznym świecie*). Prószyński i Ska, Warszawa 1997.
13. Cytowski J., Methods and algorithms of artificial intelligence in numerical transforming signals (Polish: *Metody i algorytmy sztucznej inteligencji w cyfrowym przetwarzaniu sygnałów*). PLJ. Warszawa 1999.
14. Dumitrescu D., Lazzerini D., Jain L. C., Dumitrescu A., Evolutionary Computation. CRC Press, 2000.
15. Fogel D., Evolutionary Computation The Fossil Record. Natural Selection, Inc. 1998.
16. Fogel D., Evolutionary Computation: Toward a New Philosophy of Machine Intelligence, 2nd Edition. Natural Selection, Inc. 2000.
17. Ghosh S., Hardware Description Languages: Concepts and Principles. IEEE Press and John Wiley & Sons, Inc. 2000.
18. Goldberg D.E., Genetic algorithms and their aplications (Polish: *Algorytmy genetyczne i ich zastosowania*. Wydawnictwa Naukowo-Techniczne, Warszawa 1995.
19. Helt P., Parol M., Piotrowski P., Methods of artificial intelligence in electro energetic (Polish: *Metody sztucznej inteligencji w elektroenergetyce*). Oficyna Wydawnicza Politechniki Warszawskiej. Warszawa 2000.
20. Jain L.C., Fusion of Neural Networks, Fuzzy Sets, and Genetic Algorithms. CRC Press, November 1998.
21. Jain L.C., Martin N.M., Fusion of Neural Networks, Fuzzy Systems and Genetic Algorithms: Industrial Applications. CRC Press, 1998.

22. Karr C., Michael Freeman L., Industrial Applications of Genetic Algorithms. CRC Press, 1998.
23. Kłopotek M.A., Technical applications of evolutionary strategy (Polish: *Techniczne zastosowania strategii ewolucyjnych*). IV Krajowa Konferencja Naukowa nt. Sztuczna Inteligencja, SzI 15'2000. AP Siedlce 2000.
24. Kwaśnicka H., Boratyn G., Intelligence system of management of parameters of cooperative evolutionary algorithms (Polish: *Inteligentny system zarządzający parametrami współpracujących algorytmów ewolucyjnych*). Politechnika Wrocławska, Wrocław 2000.
25. Lai L.L., Intelligent System Applications in Power Engineering. WS, 1998.
26. Leite da Silva A.M., Guilherma de Carvallo Costa J.G., Transmission Loss Allocation: Part II: Multiple Interconnected Energy Markets. IEEE Transactions on Power Systems. November 2003, Vol. 18, No. 4.
27. Masters T., Neural network in practice (Polish: *Sieci neuronowe w praktyce*). Wydawnictwa Naukowo-Techniczne, Warszawa 1996.
28. Michalewicz Z., Genetic algorithms + data structure = evolutionary algorithms (Polish: Algorytmy Genetyczne + struktury danych = programy ewolucyjne). Wydanie III. Wydawnictwa Naukowo-Techniczne. Warszawa 2003.
29. Malko J., Weron A.: Electric Power Market. Acting machanism (Polish: *Rynek energii elektrycznej. Mechanizmy funkcjonowania*. CIRE. Warszawa, 1999.
30. Sobierajski M., Wikosz K.: Electro Energetic Network and Electric Power Market (Polish: *Sieci elektroenergetyczne a rynki energii elektrycznej)*. Problemy i perspektywy. Prace Naukowe Instytutu Energoelektryki Politechniki Wrocławskiej. OW PWr. Wrocław, 2000.
31. Papakamnenos D.J. and Dialynas E.V., Reliability and Cost Assessment of Power Transmission Networks in the Competitive Electrical Energy Market. IEEE Transactions on Power Systems. February 2004, Vol. 19, No. 1.
32. Statistic yearbook (Polish: *Rocznik Statystyczny*). Główny Urząd Statystyczny, Warszawa 1947-2003.
33. Ruciński A.: Model and implementation system genetic algorithm with distributed beginning population (Polish: *Model i implementacja systemowego algorytmu genetycznego z rozproszoną populacją początkową*). Praca magisterska pod kierunkiem dr inż. Jerzego Tchórzowskiego. Instytut Informatyki. Wydział Nauk Ścisłych. AP Siedlce 2004.
34. Rutkowska D., Piliński M., Rutkowski L., Neural network, genetic algorithm, and fuzzy systems (Polish: *Sieci neuronowe, algorytmy genetyczne i systemy rozmyte*. Wydawnictwo Naukowe PWN, Warszawa 1997.
35. Silva G. Vollenberg B.F., Zheng Ch., Application of Mechanisms design to Electric Power Markets. IEEE Transactions on Power Systems. February 2001, Vol. 16, No. 1.
36. Statistic of Polish Electro Energetic (Polish: *Statystyka Elektroenergetyki Polskiej*). Wydawnictwo Zjednoczenia Energetyków, Centrum Informatyki Energetyki, Agencja Rynku Energii S. A., Warszawa 1952-2003.
37. Szymański J. M., Sztuczne życie. WP, Warszawa 1991.

38. Tchórzewski J.: *Systemowe wspomaganie procesu badania prawidłowości rozwoju systemu sterowania na przykładzie elektroenergetycznej sieci przesyłowej*. Rozprawa naukowa nr 58. AP. Siedlce, 1999.
39. Tchórzewski J., Zarzycki I., Soćko M.: *Simulation of Electric Power Transmission Network Using Self-Organizing Neural Network*. [in:] Current Issues in Data and Knowledge Engineering. [ed.: De Baets B., a. others]. AOW EXIT. Warsaw 2004, (533-540).
40. Tchórzewski J., Skwierczyński P.: *Symulacja rynku energii elektrycznej w środowisku MATLAB-a i Simulik-ka*. [w:] Systems, 2004, Vol. 9.Special Issue 2/2. (1026-1036).
41. Tchórzewski J.: *Inżynieria rozwoju rynku energii elektrycznej. Zastosowania Komputerów w Elektrotechnice*. Materiały Konferencji Naukowo-Technicznej. Instytut Elektrotechniki Przemysłowej Politechniki Poznańskiej. Komitet Elektrotechniki Polskiej Akademii Nauk. Institute of Electrical and Electronics Engineers. Wyd. PP. Poznań 2005. (173-174).
42. Wierzchoń S.T., *Sztuczne systemy immunologiczne. Teoria i zastosowania*. EXIT, Warszawa 2001.
43. Zebulum R.S., Pacheco M.A., Be Vellasco M.M., Evolutionary Electronics: Automatic Design of Electronic Circuits and Systems by Genetic Algorithms. CRC Press, 2001.