EXAMINING A MATHEMATICAL APPARATUS OF *Z*-APPROXIMATION OF FUNCTIONS FOR THE CONSTRUCTION OF AN ADAPTIVE ALGORITHM (p. 6–13)

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The result of this research is the proposed to mathematical apparatus and a procedure for constructing adaptive algorithm based on *Z*-approximation of functions. A given study is required to improve approaches to constructing algorithms that change their performance in response to changes in input information. This, in turn, significantly improves results in solving the problems that can be implemented using such an algorithm. For example, solving nonlinear problems, description of complex surfaces, search for information.

It has been shown that the solutions derived in the current study are in agreement with the application of the same algorithms for separate groups of functions used for approximation. These functions are used when constructing a direction to search for and provide an opportunity to build a model of error in *Z*-approximation using the initial or final approximations.

The definition of Z_m-approximation has been given as the approximation with a multiple interval reduction that simplifies recurrent formulae and is a feature of the presented approach. The proposed methodology and the basic algorithm make it possible to directly determine a series of common and hyperbolic functions using Z_m-approximations and parallel computing. Based on the research results, an adaptive algorithm has been presented to calculate arctg x as a function inverse to tg x.

The above can be used when constructing an adaptive search algorithm in the arrays of unstructured or poorly structured information. Such a search is employed for books and textbooks, uploaded to the Internet in formats jpeg, pdf, or as fragments of the specified formats. In this case, based on the adaptive algorithm, a special model is constructed, which can be implemented according to several variants with a change in direction.

Keywords: search algorithm, process distribution, recurrence record, residual, approximation.

References

1. Glushkov, V. M. et. al. (Eds.) (1974). Entsiklopediya kibernetiki. Kyiv: Glavnaya redaktsiya ukrainskoy sovetskoy entsiklopedii, 1228.
2. Filosofskyi entsyklopedychnyi slovnyk (2002). Kyiv: Abrys, 742.
3. Shennon, K. (1963). Raboty po teorii informatsii i kibernetike. Moscow: Inostrannaya literatura, 832.
4. Spink, A., Wolfram, D., Jansen, M. B. J., Saracevic, T. (2001). Searching the web: The public and their queries. Journal of the American Society for Information Science and Technology, 52 (3), 226–234. doi: https://doi.org/10.1002/1097-4571(2000)9999:9999<::aid-asi1591>3.0.co;2-r
5. Figueroa, A. (2015). Exploring effective features for recognizing the user intent behind web queries. Computers in Industry, 68, 162–169. doi: https://doi.org/10.1016/j.compind.2015.01.005
6. Ashmanov, I., Ivanov, A. (2011). Optimizatsiya i prodvizhenie saytov v poiskovyh sistemah. Sankt-Peterburg: Piter, 464.
7. Glushkov, V. M.; Mihalevich, V. S. et. al. (Eds.) (1990). Kibernetika. Vychislitel'naya tekhnika. Informatika. Izbrannye trudy. Vol. 3. Kibernetika i ee primenenie v narodnom hozyaystve. Kyiv: Naukova dumka, 224.
8. Glushkov, V. M. (1986). Kibernetika. Voprosy teorii i praktiki. Moscow: Nauka, 488.
9. Glushkov, V. M., Stogniy, A. A., Afanas'ev, V. N. (1973). Avtomatizirovannye informatsionnye sistemy. Moscow: Znanie, 64.
10. Akademik, V. M. (2003). Glushkov – pioner kibernetiki. Kyiv: Izdatel'stvo Yunior, 384.
11. Glushkov, V. M. (1987). Osnovy bezbumazhnoy informatiki. Moscow: Nauka, Gl. Red. fiz.-mat. lit., 552.
12. Pleskach, V. L, Zatonatska, T. H. (2011). Informatsiyni systemy i tekhnolohiyi na pidpryiemstvakh. Kyiv: Znannia, 718.
13. Hazewinkel, M. (Ed.) (1994). Encyclopaedia of Mathematics (set). Springer.
14. Kovalenko, O. V. (2016). Kontseptualni osnovy stvorennia bazy danykh naukovoho eksperymentu ta sposterezhennia. Matematychni mashyny i systemy, 2, 91–101.
15. Diaz, F. (2008). Autocorrelation and Regularization of Query-Based Retrieval Scores. Chap. 3. Amherst.
16. Beer, S. (1972). Brain of the Firm, Allen Lane. London: Herder and Herder, 416.
17. Beer, S. (1993). Designing Freedom. House of Anansi Press, 110.
18. Algorithms and Data Structures. Available at: https://people.inf.ethz.ch/wirth/AD.pdf
19. Knuth, D. E. (1997). The Art of Computer Programming. Vo. 1. Fundamental Algorithms. Reading, Massachusetts: Addison-Wesley, 664.
20. Kriazhych, O. O., Kovalenko, O. V., Ivanchenko, V. V. (2016). Sposib opysu zabrudnenoi terytoriyi: prohramna realizatsiya. Matematychne modeliuvannia v ekonomitsi, 2, 22–35.
21. Zoutendijk, G. (1960). Methods of feasible directions. A study in linear and non-linear programming. Elsevier Pub. Co., 178.
22. Wang, S., Kang, J., Degano, M., Buticchi, G. (2019). A Resolver-to-Digital Conversion Method Based on Third-Order Rational Fraction Polynomial Approximation for PMSM Control. IEEE Transactions on Industrial Electronics, 66 (8), 6383–6392. doi: https://doi.org/10.1109/tie.2018.2884209
23. Knuth, D. E. (1998). The Art of Computer Programming. Vol. 3: Sorting and Searching. Reading, Massachusetts: Addison-Wesley, 780.
24. Eyler, L. (1956). Integral'noe ischislenie. Vol. 1. Moscow: GITTL, 416.

25. Bahvalov, N. S., Zhidkov, N. P., Kobel'kov, G. M. (2008). Chislennye metody. Moscow: BINOM. Laboratoriya znaniy, 636.
26. Popov, B. A., Tesler, G. S. (1980). Priblizhenie funktsiy dlya tekhnicheskih prilozheniy. Kyiv: Naukova dumka, 352.
27. Vyshnevskyi, I. M., Haidar, H. P., Kovalenko, O. V. et. al. (2014). Radiatsiyni ta yaderni tekhnolohiyi v Instytuti yadernykh doslidzhen NAN Ukrainy. Kyiv: In-t yadernykh doslidzhen, 176 p.

IMPROVING CONTROL EFFICIENCY IN BUFFERING SYSTEMS USING ANTICIPATORY INDICATORS FOR DEMAND FORECASTING (p. 14–20)

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Optimization of the stock management process is associated with the search for a forecasting model, a method for generation of a forecasting time series, a model of logistic operation, determining a reasonable level of reserve stocks and establishing the optimization criterion.

Successful solution to the optimization problem in general can be achieved only if the whole complex of local management problems is successfully solved. In this case, the method of generation of a cointegrated time series of demand forecasting is the central element of the technology of optimal stocks management. This relates to the fact that probabilistic nature of demand is the main factor reducing efficiency of management in systems of this class.

It was shown that the proposed method for improving management efficiency can be used in any economic system due to the possibility of construction of a single logistic operation model.

The proposed approach is based on formation of a time series specifically designed to solve the problem of forecasting the demand in stocks buffering systems. Such a series contains both information on sales volumes and data related to consumer demand.

Since consumer activity is ahead of the process of physical consumption of products, it becomes possible to use anticipatory markers in forecasting problems.

The study of operational processes using a verified indicator of efficiency has confirmed the hypothesis of presence of anticipatory markers within the framework of the formed forecast time series.

It has been established that the maximum management efficiency can be achieved in the case of a lower construction accuracy of the forecast model. This is due to the fact that the logistic operation model takes into account the costs of movement of products and their valuation at the operation input and output.

Keywords: demand forecasting, operational forecasting, cointegrated demand series, resource usage efficiency.

References

1. Chase, C. (Ed.) (2012). Demand-Driven Forecasting: A Structured Approach to Forecasting. Wiley, 270. doi: https://doi.org/10.1002/9781119203612
2. Carta, S., Medda, A., Pili, A., Reforgiato Recupero, D., Saia, R. (2018). Forecasting E-Commerce Products Prices by Combining an Autoregressive Integrated Moving Average (ARIMA) Model and Google Trends Data. Future Internet, 11 (1), 5. doi: https://doi.org/10.3390/fi11010005
3. Martino, J. P. (1993). Technological forecasting for decision making. McGraw-Hill, 591.
4. Biegel, J. E. (1971). Production control: a quantitative approach. Prentice-Hall, 282.
5. Fedoseev, V. V., Garmash, A. N., Dayitbegov, D. M., Orlova, I. V., Polovnikov, V. A. (1999). Ekonomiko-matematicheskie metody i prikladnye modeli. Moscow: YuNITI, 391.
6. Awel, Y. M. (2018). Forecasting GDP Growth: Application of Autoregressive Integrated Moving Average Model. Empirical Economic Review, 1 (2), 1–16. doi: https://doi.org/10.29145/eer/12/010201
7. Lim, P. Y., Nayar, C. V. (2012). Solar Irradiance and Load Demand Forecasting based on Single Exponential Smoothing Method. International Journal of Engineering and Technology, 4 (4), 451–455. doi: https://doi.org/10.7763/ijet.2012.v4.408
8. Prestwich, S. D., Tarim, S. A., Rossi, R., Hnich, B. (2014). Forecasting intermittent demand by hyperbolic-exponential smoothing. International Journal of Forecasting, 30 (4), 928–933. doi: https://doi.org/10.1016/j.ijforecast.2014.01.006
9. Taylor, J. W. (2004). Volatility forecasting with smooth transition exponential smoothing. International Journal of Forecasting, 20 (2), 273–286. doi: https://doi.org/10.1016/j.ijforecast.2003.09.010
10. Ravinder, H. V. (2013). Forecasting With Exponential Smoothing Whats The Right Smoothing Constant? Review of Business Information Systems (RBIS), 17 (3), 117–126. doi: https://doi.org/10.19030/rbis.v17i3.8001
11. Alam, T. (2019). Forecasting exports and imports through artificial neural network and autoregressive integrated moving average. Decision Science Letters, 249–260. doi: https://doi.org/10.5267/j.dsl.2019.2.001
12. Tan, L., Wang, S., Wang, K. (2017). A new adaptive network-based fuzzy inference system with adaptive adjustment rules for stock market volatility forecasting. Information Processing Letters, 127, 32–36. doi: https://doi.org/10.1016/j.ipl.2017.06.012
13. Doszyń, M. (2019). Intermittent demand forecasting in the enterprise: Empirical verification. Journal of Forecasting. doi: https://doi.org/10.1002/for.2575
14. Lutsenko, I. (2015). Identification of target system operations. Development of global efficiency criterion of target operations. Eastern-European Journal of Enterprise Technologies, 2 (2 (74)), 35–40. doi: https://doi.org/10.15587/1729-4061.2015.38963
15. Lutsenko, I., Dmytriiev, I., Avanesova, N., Semenyshyna, I., Rozhnenko, Z., Danileyko, O. (2019). A method to form control over queuing systems taking into consideration the probabilistic character of demand. Eastern-European

Journal of Enterprise Technologies, 1 (3 (97)), 28–36. doi: https://doi.org/10.15587/1729-4061.2019.157201

16. Narayanan, A., Sahin, F., Robinson, E. P. (2019). Demand and order-fulfillment planning: The impact of point-of-sale data, retailer orders and distribution center orders on forecast accuracy. Journal of Operations Management. doi: https://doi.org/10.1002/joom.1026

17. Engle, R. F., Granger, C. W. J. (1987). Co-Integration and Error Correction: Representation, Estimation, and Testing. Econometrica, 55 (2), 251–276. doi: https://doi.org/10.2307/1913236

OPTIMAL PERFORMANCE OF 16-BIT ACYCLIC ADDERS OF BINARY CODES (p. 21–36)

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The conducted studies established the prospect for enhancing the performance of computing components, specifically, combinational 16-bit adders, based on the use of the principles of computation of digital signals of an acyclic model.

The application of an acyclic model for the synthesis of 16-bit parallel adders is designed for:

– the process of sequential (for lower bits) and parallel (for all other bits) computation of the sum and carry signals. Thanks to this approach, it becomes possible to reduce eventually the complexity of the hardware part without increasing the circuit depth;

– fixation (planning) of the adder circuit depth before its synthesis. This makes it possible to use the logical structure of transitive carry, which ensures the optimal adder circuit depth and does not increase its complexity.

Utilizing an acyclic model for the construction of 16-bit parallel adders is more beneficial in comparison with the analogs by the following factors:

– the lower cost development, since an acyclic model determines a simpler structure of a 16-bit adder;

– application of the latest developed logical structures of transitive carry, which makes it possible to decrease the delay of sum and carry signals, area, power consumption and to increase overall efficiency of 16-bit adders of binary codes.

Due to this, the possibility of obtaining optimal values of structure complexity and the depth of the adder circuit is ensured. In comparison with the analogs, it provides an increase in quality of indicator of 16-bit acyclic adders, such as power consumption, chip area by 15–27 %, depending on the chosen structure, and performance by 10–60 %.

There are some grounds to argue about the possibility of enhancing the performance of computing components, specifically, 16-bit adders of binary codes by using the principles of computation of digital signals of an acyclic model.

Keywords: optimal performance of acyclic adders, Ling Adder, Kogge-Stone Adder, Knowles Adder.

References

1. Solomko, M. (2018). Optimization of the acyclic adders of binary codes. Technology audit and production reserves, 3 (2 (41)), 55–65. doi: https://doi.org/10.15587/2312-8372.2018.133694

2. Solomko, M., Tadeyev, P., Zubyk, Y., Hladka, O. (2019). Reduction and optimal performance of acyclic adders of binary codes. Eastern-European Journal of Enterprise Technologies, 1 (4 (97)), 40–53. doi: https://doi.org/10.15587/1729-4061.2019.157150

3. Baba Fariddin, S., Vargil Vijay, E. (2013). Design of Efficient 16-Bit Parallel Prefix Ladner-Fischer Adder. International Journal of Computer Applications, 79 (16), 11–14. doi: https://doi.org/10.5120/13943-1784

4. Michael Preetam Raj, P., Sandeep, B., Sai Mallik Reddy, D., Ramanjaneyulu, P., Sai Pravallika, S. (2016). Design of Prefix Adder Amalgamation Reversible Logic Gates using 16 Bit Kogge Stone Adder. Indian Journal of Science and Technology, 9 (13). doi: https://doi.org/10.17485/ijst/2016/v9i13/87911

5. Shanil Mohamed, N., Siby, T. Y. (2014). 16-bit velocious fault lenient parallel prefix adder. 2014 International Conference on Electronics, Communication and Computational Engineering (ICECCE). doi: https://doi.org/10.1109/icecce.2014.7086612

6. Poornima, N., Bhaaskaran, V. S. K. (2015). Area Efficient Hybrid Parallel Prefix Adders. Procedia Materials Science, 10, 371–380. doi: https://doi.org/10.1016/j.mspro.2015.06.069

7. Payal, R., Goel, M., Manglik, P. (2015). Design and Implementation of Parallel Prefix Adder for Improving the Performance of Carry Lookahead Adder. International Journal of Engineering Research & Technology, 4 (12), 566–571. doi: https://doi.org/10.17577/ijertv4is120608

8. Vamshi Krishna, T., Niveditha, S., Mamatha, G. N., Sunil, M. P. (2018). Simulation study of brent kung adder using cadence tool. International Journal of Advance Research, Ideas and Innovations in Technology, 4 (3), 564–573. Available at: https://www.ijariit.com/manuscripts/v4i3/V4I3-1383.pdf

9. Padma Balaji, R. D., Tarun, P., Yeswanth Kumar, E., Anita Angeline, A. (2018). Design of 16-Bit Adder Structures-Performance Comparison. International Journal of Pure and Applied Mathematics, 118 (24). Available at: https://acadpubl.eu/hub/2018-118-24/3/492.pdf

10. Kaneko, M. (2019). A Novel Framework for Procedural Construction of Parallel Prefix Adders. 2019 IEEE International Symposium on Circuits and Systems (ISCAS). doi: https://doi.org/10.1109/iscas.2019.8702117

11. Krulikovskyi, B. B., Vozna, N. Ya., Hryha, V. M., Nykolaichuk, Ya. M., Davletova, A. Ya. (2017). Pat. No. 117572U UA. Sumator z pryskorenym perenosom. MPK G 06 F 7/38 (2006.01). No. u201701336; declareted: 13.02.2017; published: 26.06.2017, Bul. No. 12.

12. Gedam, S. K., Zode, P. P. (2014). Parallel prefix Han-Carlson adder. International Journal of Research in Engineering

and Applied Sciences, 02 (02), 81–84. Available at: http://www.mgijournal.com/pdf_new/Electronics/Swapna%20Gedam-1.pdf

13. Zeydel, B. R., Baran, D., Oklobdzija, V. G. (2010). Energy-Efficient Design Methodologies: High-Performance VLSI Adders. IEEE Journal of Solid-State Circuits, 45 (6), 1220–1233. doi: https://doi.org/10.1109/jssc.2010.2048730

14. Govindarajulu, S., Vijaya Durga Royal, T. (2014). Design of Energy-Efficient and High-Performance VLSI Adders. International Journal of Engineering Research, 3, 55–59. Available at: https://pdfs.semanticscholar.org/a54c/5727cdc2be7830ea734f15eb1ba9ecfc2110.pdf

15. Pinto, R., Shama, K. (2016). Efficient shift-add multiplier design using parallel prefix adder. International Journal of Control Theory and Applications, 9 (39), 45–53.

16. Kogge, P. M., Stone, H. S. (1973). A Parallel Algorithm for the Efficient Solution of a General Class of Recurrence Equations. IEEE Transactions on Computers, C-22 (8), 786–793. doi: https://doi.org/10.1109/tc.1973.5009159

17. Class ECE6332 Fall 12 Group-Fault-Tolerant Reconfigurable PPA. Available at: http://venividiwiki.ee.virginia.edu/mediawiki/index.php/ClassECE6332Fall12Group-Fault-Tolerant_Reconfigurable_PPA

18. Two-Operand Addition. Available at: https://pubweb.eng.utah.edu/~cs5830/Slides/addersx6.pdf

19. Knowles, S. (1999). A family of adders. Proceedings 14th IEEE Symposium on Computer Arithmetic (Cat. No.99CB36336). doi: https://doi.org/10.1109/arith.1999.762825

20. Sklansky, J. (1960). Conditional-Sum Addition Logic. IEEE Transactions on Electronic Computers, EC-9 (2), 226–231. doi: https://doi.org/10.1109/tec.1960.5219822

21. Han, T., Carlson, D. A. (1987). Fast area-efficient VLSI adders. 1987 IEEE 8th Symposium on Computer Arithmetic (ARITH). doi: https://doi.org/10.1109/arith.1987.6158699

22. Ladner, R. E., Fischer, M. J. (1980). Parallel Prefix Computation. Journal of the ACM, 27 (4), 831–838. doi: https://doi.org/10.1145/322217.322232

23. Brent, R., Kung, H. T. (1982). A Regular Layout for Parallel Adders. IEEE Transactions on Computers, C-31 (3), 260–264. doi: https://doi.org/10.1109/tc.1982.1675982

CONSTRUCTION OF METHODS FOR COMPUTING RECURRENCE PLOTS IN SPACE WITH A SCALAR PRODUCT (p. 37–44)

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The methods for calculation of recurrence plots in space with a scalar product were developed. They enable examining the properties and features of the vector of states of dynamical systems of various complexity in natural and social spheres. A new scientific result is the development of scientific-methodical apparatus to calculate recurrence plots of vectors of states of systems in metric spaces expanded on the basis of scalar product. Two methods for calculation of recurrence plots for vectors of states of complex dynamic systems, which are highly informative, moderately complex and universal in dimensionality of the studied space of states, were proposed. In practice, the proposed methods can be used to calculate and compare recurrence plots of states of the studied systems in metric spaces of different dimensionality without additional normalizing. The functionality of the proposed methods was verified based on experimental observations of concentrations of formaldehyde, ammonia and carbon monoxide in the atmosphere of an industrial city. It was established that at the values of angular size of the area of 10° and 30°, the proposed method for calculation of recurrence plots is more informative, less complex and invariant relative to dimensionality of the space of states. It was shown that the methods for calculation of recurrence plots in space with scalar product make it possible to use them if there are short-time intervals of the absence of observations. It was experimentally determined that in some cases of parameters, the results of computation of recurrence plots based on the developed methods coincide with the results obtained when using the known methods. This indicates a more general nature of the proposed methods.

Keywords: recurrence plots, state vector, atmospheric pollution, complex dynamic systems.

References

1. Pospelov, B., Rybka, E., Meleshchenko, R., Gornostal, S., Shcherbak, S. (2017). Results of experimental research into correlations between hazardous factors of ignition of materials in premises. Eastern-European Journal of Enterprise Technologies, 6 (10 (90)), 50–56. doi: https://doi.org/10.15587/1729-4061.2017.117789

2. Manuca, R., Savit, R. (1996). Stationarity and nonstationarity in time series analysis. Physica D: Nonlinear Phenomena, 99 (2-3), 134–161. doi: https://doi.org/10.1016/s0167-2789(96)00139-x

3. Webber, C., Marwan, N. (Eds.) (2015). Recurrence quantification analysis. Understanding Complex Systems. Springer. doi: https://doi.org/10.1007/978-3-319-07155-8

4. Marwan, N., Webber, C. L., Macau, E. E. N., Viana, R. L. (2018). Introduction to focus issue: Recurrence quantification analysis for understanding complex systems. Chaos: An Interdisciplinary Journal of Nonlinear Science, 28 (8), 085601. doi: https://doi.org/10.1063/1.5050929

5. Recurrence plots and cross recurrence plots. Available at: http://www.recurrence-plot.tk

6. Pospelov, B., Andronov, V., Rybka, E., Meleshchenko, R., Gornostal, S. (2018). Analysis of correlation dimensionality of the state of a gas medium at early ignition of materials. Eastern-European Journal of Enterprise Technologies, 5 (10 (95)), 25–30. doi: https://doi.org/10.15587/1729-4061.2018.142995

7. Takens, F. (1981). Detecting strange attractors in turbulence. Lecture Notes in Mathematics, 366–381. doi: https://doi.org/10.1007/bfb0091924

8. Pospelov, B., Andronov, V., Rybka, E., Popov, V., Semkiv, O. (2018). Development of the method of frequencytemporal representation of fluctuations of gaseous medium parameters at fire. Eastern-European Journal of Enterprise Technologies, 2 (10 (92)), 44–49. doi: https://doi.org/10.15587/1729-4061.2018.125926

9. Adeniji, A. E., Olusola, O. I., Njah, A. N. (2018). Comparative study of chaotic features in hourly wind speed using recurrence quantification analysis. AIP Advances, 8 (2), 025102. doi: https://doi.org/10.1063/1.4998674

10. Wendi, D., Marwan, N., Merz, B. (2018). In Search of Determinism-Sensitive Region to Avoid Artefacts in Recurrence Plots. International Journal of Bifurcation and Chaos, 28 (01), 1850007. doi: https://doi.org/10.1142/s0218127418500074

11. Donner, R. V., Balasis, G., Stolbova, V., Georgiou, M., Wiedermann, M., Kurths, J. (2019). Recurrence-Based Quantification of Dynamical Complexity in the Earth's Magnetosphere at Geospace Storm Timescales. Journal of Geophysical Research: Space Physics, 124 (1), 90–108. doi: https://doi.org/10.1029/2018ja025318

12. Garcia-Ceja, E., Uddin, M. Z., Torresen, J. (2018). Classification of Recurrence Plots' Distance Matrices with a Convolutional Neural Network for Activity Recognition. Procedia Computer Science, 130, 157–163. doi: https://doi.org/10.1016/j.procs.2018.04.025

13. Neves, F. M., Viana, R. L., Pie, M. R. (2017). Recurrence analysis of ant activity patterns. PLOS ONE, 12 (10), e0185968. doi: https://doi.org/10.1371/journal.pone.0185968

14. Ozken, I., Eroglu, D., Breitenbach, S. F. M., Marwan, N., Tan, L., Tirnakli, U., Kurths, J. (2018). Recurrence plot analysis of irregularly sampled data. Physical Review E, 98 (5). doi: https://doi.org/10.1103/physreve.98.052215

15. Eroglu, D., Marwan, N., Stebich, M., Kurths, J. (2018). Multiplex recurrence networks. Physical Review E, 97 (1). doi: https://doi.org/10.1103/physreve.97.012312

16. Oberst, S., Niven, R., Ord, A., Hobbs, B., Lester, D. (2017). Application of recurrence plots to orebody exploration data. Conference: Target. At University Club, University of Western Australia.

17. Webber, C. L., Ioana, C., Marwan, N. (Eds.) (2016). Recurrence Plots and Their Quantifications: Expanding Horizons. Springer Proceedings in Physics. doi: https://doi.org/10.1007/978-3-319-29922-8

18. Birleanu, F.-M., Candel, I., Ioana, C., Gervaise, C., Serbanescu, A., Serban, G. (2012). A vector approach to transient signal processing. 2012 11th International Conference on Information Science, Signal Processing and Their Applications (ISSPA). doi: https://doi.org/10.1109/isspa.2012.6310462

19. Ioana, C., Digulescu, A., Serbanescu, A., Candel, I., Birleanu, F.-M. (2014). Recent Advances in Non-stationary Signal Processing Based on the Concept of Recurrence Plot Analysis. Translational Recurrences, 75–93. doi: https://doi.org/10.1007/978-3-319-09531-8_5

20. Pospelov, B., Andronov, V., Rybka, E., Meleshchenko, R., Borodych, P. (2018). Studying the recurrent diagrams of carbon monoxide concentration at early ignitions in premises. Eastern-European Journal of Enterprise Technologies, 3 (9 (93)), 34–40. doi: https://doi.org/10.15587/1729-4061.2018.133127

21. Pospelov, B., Andronov, V., Rybka, E., Skliarov, S. (2017). Design of fire detectors capable of self-adjusting by ignition. Eastern-European Journal of Enterprise Technologies, 4 (9 (88)), 53–59. doi: https://doi.org/10.15587/1729-4061.2017.108448

22. Pospelov, B., Andronov, V., Rybka, E., Skliarov, S. (2017). Research into dynamics of setting the threshold and a probability of ignition detection by selfadjusting fire detectors. Eastern-European Journal of Enterprise Technologies, 5 (9 (89)), 43–48. doi: https://doi.org/10.15587/1729-4061.2017.110092

23. Marwan, N., Carmenromano, M., Thiel, M., Kurths, J. (2007). Recurrence plots for the analysis of complex systems. Physics Reports, 438 (5-6), 237–329. doi: https://doi.org/10.1016/j.physrep.2006.11.001

24. Mindlin, G. M., Gilmore, R. (1992). Topological analysis and synthesis of chaotic time series. Physica D: Nonlinear Phenomena, 58 (1-4), 229–242. doi: https://doi.org/10.1016/0167-2789(92)90111-y

25. Zbilut, J. P., Zaldivar-Comenges, J.-M., Strozzi, F. (2002). Recurrence quantification based Liapunov exponents for monitoring divergence in experimental data. Physics Letters A, 297(3-4), 173–181. doi: https://doi.org/10.1016/s0375-9601(02)00436-x

26. Thiel, M., Romano, M. C., Kurths, J., Meucci, R., Allaria, E., Arecchi, F. T. (2002). Influence of observational noise on the recurrence quantification analysis. Physica D: Nonlinear Phenomena, 171 (3), 138–152. doi: https://doi.org/10.1016/s0167-2789(02)00586-9

27. Kondratenko, O. M., Vambol, S. O., Strokov, O. P., Avramenko, A. M. (2015). Mathematical model of the efficiency of diesel particulate matter filter. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 6, 55–61.

28. Vasiliev, M. I., Movchan, I. O., Koval, O. M. (2014). Diminishing of ecological risk via optimization of fire-extinguishing system projects in timber-yards. Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 5, 106–113.

29. Dubinin, D., Korytchenko, K., Lisnyak, A., Hrytsyna, I., Trigub, V. (2017). Numerical simulation of the creation of a fire fighting barrier using an explosion of a combustible charge. Eastern-European Journal of Enterprise Technologies, 6 (10 (90)), 11–16. doi: https://doi.org/10.15587/1729-4061.2017.114504

30. Semko, A., Rusanova, O., Kazak, O., Beskrovnaya, M., Vinogradov, S., Gricina, I. (2015). The use of pulsed high-speed liquid jet for putting out gas blow-out. The International Journal of Multiphysics, 9 (1), 9–20. doi: https://doi.org/10.1260/1750-9548.9.1.9

31. Kustov, M. V., Kalugin, V. D., Tutunik, V. V., Tarakhno, E. V. (2019). Physicochemical principles of the technology of modified pyrotechnic compositions to reduce the chemical

pollution of the atmosphere. Voprosy Khimii i Khimicheskoi Tekhnologii, 1, 92–99. doi: https://doi.org/10.32434/0321-4095-2019-122-1-92-99

32. Vasyukov, A., Loboichenko, V., Bushtec, S. (2016). Identification of bottled natural waters by using direct conductometry. Ecology, Environment and Conservation, 22 (3), 1171–1176.

33. Pospelov, B., Rybka, E., Meleshchenko, R., Borodych, P., Gornostal, S. (2019). Development of the method for rapid detection of hazardous atmospheric pollution of cities with the help of recurrence measures. Eastern-European Journal of Enterprise Technologies, 1 (10 (97)), 29–35. doi: https://doi.org/10.15587/1729-4061.2019.155027

ALGORITHMIZING THE METHODS OF BASIS MATRICES IN THE STUDY OF BALACE INTERSECTORAL ECOLOGICAL AND ECONOMIC MODELS (p. 45–55)

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Ecological-economic models (such as Leontiev-Ford) play a special role in solving the fundamental problems of long-term planning, taking into account the factor of environmental management. On their basis, the task of justifying the magnitude of the costs of environmental protection can be implemented, considering the socio-economic effect and their distribution in the territorial-industry context.

Based on the proposed balance model, typical generalizations («extensions») of the model are highlighted, which, in general, increase its dimension, but do not «fall out» of the linear class. In particular, the issues of analyzing the impact on changes in the volume of gross sectoral issues as a result of changes in structural industry proportions are studied, corresponding to changes in the technological structure of the functioning of the ecological-economic system in the sectoral context.

In order to solve the problem, it was developed to use the algorithms of basis matrix method, which are equipped with the technology for determining solutions of the system of matrix linear equations in accordance with the changes and generalize the model. At the same time, changes may be experienced by individual elements or a group of elements, one or a group of rows (columns), in blocks of matrix submatrices. The proposed algorithms are implemented for the case of changes in the matrix of constraints of the original system without recalculation (again).

We considered various variants of changes in the model and their influence on the new solution in case of «perturbation» in submatrices of the constraint matrix (group of elements forming a block) of the model. In particular, the variant with the «inclusion («exclusion») of new blocks of submatrices, that is an increase (or decrease) in the dimension of the original constraint matrix of mathematical model. Such models are provided by a linear system, in particular, a system of linear algebraic equations (SLAE).

Such an approach makes it possible to carry out directional changes in the model in order to achieve the desired proportions of the «useful» and «harmful» component in the production structure (as a solution to the problem).

Further development of the proposed theory makes it possible to proceed to the study of aggregation issues of the balance scheme «input-output», determining a specific corridor of permissible changes in order to achieve a target reference point for the volume of sectoral output.

References

1. Ramochnaya konventsiya Organizatsii Obedinennyh Natsiy ob izmenenii klimata. Available at: https://www.un.org/ru/documents/decl_conv/conventions/climate_framework_conv.shtml

2. Kiotskiy protokol k Konventsii ob izmenenii klimata (2000). Bonn, 33.

3. Sustainable Innovation Forum. Available at: http://www.cop21paris.org

4. Wirth, D. (2017). The Paris Agreement as a New Component of the UN Climate Regime. International Organisations Research Journal, 12 (4), 185–214. doi: https://doi.org/10.17323/1996-7845-2017-04-185

5. Stavins, R. (2015). Linkage of Regional, National, and Sub-National Policies in a Future International Climate Agreement. Towards a Workable and Effective Climate Regime, 283–296.

6. Kokorin, A. (2016). New Factors and Stages of the Global and Russian Climate Policy. Economic Policy, 11 (1), 157–176. doi: https://doi.org/10.18288/1994-5124-2016-1-10

7. State and trends of carbon pricing. Available at: http://www.climateaction.org/images/uploads/documents/9781464810015.pdf

8. Kuramochi, T. et. al. (2017). Greenhouse gas mitigation scenarios for major emitting countries. NewClimate.

9. Green, F., Stern, N. (2017). China's changing economy: implications for its carbon dioxide emissions. Climate Policy, 17 (4), 423–442. doi: https://doi.org/10.1080/14693062.2016.1156515

10. Meinshausen, M., Jeffery, L., Guetschow, J., Robiou du Pont, Y., Rogelj, J., Schaeffer, M. et. al. (2015). National post-2020 greenhouse gas targets and diversity-aware leadership. Nature Climate Change, 5 (12), 1098–1106. doi: https://doi.org/10.1038/nclimate2826

11. Research on Output Growth Rates and Carbon Dioxide Emissions of the Industrial Sectors of EU-ETS: Final Report (2006). Oxford Economic Forecasting. Oxford, 67.

12. Voloshin, A. F., Goritsyna, I. A. Mekhanizmy raspredeleniya kvot na vybrosy po Kiotskomu protokolu. Available at: http://foibg.com/ibs_isc/ibs-10/ibs-10-p23.pdf

13. Onyshchenko, A. M., Onyshchenko, A. M. (2011). Metodolohiya matematychnoho modeliuvannia ekonomiko-ekolohichnoi vzaiemodiyi v umovakh realizatsiyi Kiotskoho protokolu. Ekonomichna kibernetyka, 4-6 (70-72), 17–26.

14. Capros P., Georgakopoulos P., Van Regemorter D., Proost S., Schmidt T. F. N., Koschel H. et. al. (1999). Climate Technology Strategies 2: The Macro-Economic Cost and Benefit of Reducing Greenhouse Gas Emissions in the European Union. Vol. 4. New York: Physica-Verlag Heidelberg, 224. doi: https://doi.org/10.1007/978-3-642-58690-3

15. Böhringer, C., Rutherford, T. F. (2010). The Costs of Compliance: A CGE Assessment of Canada's Policy Options under the Kyoto Protocol. World Economy, 33 (2), 177–211. doi: https://doi.org/10.1111/j.1467-9701.2009.01229.x

16. Skhreyver, A. (1991). Teoriya lineynogo i tselochislennogo programmirovaniya. Vol. 1. Moscow: Mir, 360.

17. Yudin, D. B., Gol'shteyn, E. G. (1964). Zadachi i metody lineynogo programmirovaniya. Moscow: Sovetskoe radio, 491.

18. Kudin, V. I., Lyashko, S. I., Hritonenko, N. V., Yatsenko, Yu. P. (2007). Analiz svoystv lineynoy sistemy metodom psevdobazisnyh matrits. Kibernetika i sistemniy analiz, 4, 119–127.

19. Bogaenko, V. A., Skopetskiy, V. V., Kudin, V. I. (2012). Ob osobennostey organizatsii vychisleniya na osnove metoda bazisnyh matrits. Kibernetika i sistemniy analiz, 4. P. 146–154.

20. Bogaenko, V. A., Skopetskiy, V. V., Kudin, V. I. (2009). Analiz vychislitel'nyh skhem modelirovaniya protsessov geogidrodinamiki. Problemy upravleniya i informatiki, 4, 62–72.

21. Voloshin, O., Kudin, V., Onyshchenko, A., Khrushch, L. (2017). Formation of priorities of national mezoekonomical politics under the conditions of implementation on of the Paris agreements. International journal «Information Models and Analyses», 6 (1), 68–83.

22. Voloshin, O., Kudin, V., Onyshchenko, A., Tverdokhlib, Y. (2018). Economic analysis of influence of implementation of international environmental. International Journal «Information Theories and Applications», 25 (2), 17–32.

MODELING THE PARALLELISM OF EMPIRICAL MODELS OF OPTIMAL COMPLEXITY USING A PETRI NET (p. 56–68)

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Many physical processes and phenomena in view of their complexity cannot be described analytically. In these cases, empirical modeling is applied. In this research, the method based on the genetic approach is used to construct empirical models of optimal complexity that have the form of a polynomial of assigned power. Implementation of the developed method requires a multiple solution of the system of linear algebraic equations. Solution of the system of linear algebraic equations is found by reducing the corresponding matrix to the upper diagonal form with unities on the main diagonal. Analysis of the algorithm showed that the procedure of reducing the matrix to the upper diagonal form has internal parallelism. Based on the created model of the computational process in the form of a Petri net, the strategy of construction of the parallel algorithm for solving the system of linear algebraic equations was developed. The essence of the strategy is that computations are performed on some parallel processors. One of them was assigned coordinating functions, and it was named master. Other processors – slaves are subordinated to the master. Division of computation volume is such that the number of rows of the matrix, which master operates is at least by unity more than the corresponding number of rows allocated to the servant. The effectiveness of the parallel algorithm for the proposed strategy was evaluated based of the criterion of the total number of arithmetic operations. The proposed strategy is an integral part of the process of synthesis of the empirical model of optimal complexity based on the genetic algorithms. Distribution of computational load between processors working in parallel (master and slaves) ensures the acceleration of the computational process by five times or more.

Keywords: empirical model, genetic algorithm, parallelism, Petri net, the number of operations.

References

1. Gorbiychuk, M. I., Schupak, I. V., Oskolip, T. (2011). Metod sinteza empiricheskih modeley s uchetom pogreshnostey izmereniy. Metody i pribory kontrolya kachestva, 2 (27), 67–76.

2. Gorbiychuk, M. I., Shufnarovych, M. A. (2010). The Method of Constructing Mathematical Models of Complex Processes on the Basis of Genetic Algorithms. Iskusstvenniy intellekt, 4, 50–57.

3. Gorbiychuk, M. I., Kohutiak, M. I., Vasylenko, O. B., Shchupak, I. V. (2009). Metod syntezu empirychnykh modelei na zasadakh henetychnykh alhorytmiv. Rozvidka ta rozrobka naftovykh i hazovykh rodovyshch, 4, 72–79.

4. Stepashko, V. S., Bulgakova, A. S. (2013). Obobschennyy iteratsionnyy algoritm metoda gruppovogo ucheta argumentov. Upravlyayuschie sistemy i mashiny, 2, 5–17.

5. Gupta, S., Bhardwaj, S., Bhatia, P. K. (2011). A reminiscent study of nature inspired computation. International Journal of Advances in Engineering & Technology, 1 (2), 117–125.

6. Voevodin, V., Antonov, A., Popova, N. (2019). Studying the Structure of Parallel Algorithms as a Key Element of High-Performance Computing Education. Lecture Notes in Computer Science, 199–210. doi: https://doi.org/10.1007/978-3-030-10549-5_16

7. Ortega, J. M. (1988). Introduction to parallel and vector solution of linear systems. Springer. doi: https://doi.org/10.1007/978-1-4899-2112-3

8. Dvukhglavov, D. E., Kulynych, V. E. (2017). Development of software solution for building route of a orders group delivery in presence of time constraints. Bulletin of National Technical University «KhPI». Series: System Analysis, Control and Information Technologies, 55, 64–71. doi: https://doi.org/10.20998/2079-0023.2017.55.11

9. Himich, A. N., Molchanov, I. N., Popov, A. V., Chistyakova, T. V., Yakovlev, M. F. (2008). Parallel'nye algoritmy resheniya zadach vychislitel'noy matematiki. Kyiv: Naukova dumka, 248.

10. Khimich, A. N., Popov, A. V., Polyankoa, V. V. (2011). Algorithms of parallel computations for linear algebra problems with irregularly structured matrices. Cybernetics and

Systems Analysis, 47 (6), 973–985. doi: https://doi.org/10.1007/s10559-011-9377-4

11. Rutkovskaya, D., Pilin'skiy, M., Rutkovskiy, L. (2004). Neyronnye seti, geneticheskie algoritmy i nechetkie sistemy. Moscow: Goryachaya liniya-Telekom, 452.

12. Bogatyrev, M. Yu. Invarianty i simmetrii v geneticheskih algoritmah. Available at: http://www.raai.org/conference/cai-08/files/cai-08_paper_287.pdf

13. Gladkov, L. A., Kureychik, V. V., Kureychik, V. M. (2006). Geneticheskie algoritmy. Moscow: FIZMATLIT, 320.

14. Gorbiychuk, M. I., Medvedchuk, V. M., Pashkovskyi, B. V. (2014). The parallelism in the algorithm of the synthesis of models of optimal complexity based on the genetic algorithms. Eastern-European Journal of Enterprise Technologies, 4 (2 (70)), 42–48. doi: https://doi.org/10.15587/1729-4061.2014.26305

15. Gorbiychuk, M. I., Shufnarovych, M. A. (2010). Metod syntezu matematychnykh modelei kolyvnykh protsesiv z nekratnymy chastotamy. Naukovyi visnyk Ivano-Frankivskoho natsionalnoho tekhnichnoho universytetu nafty i hazu, 1, 105–112.

16. Luszczek, P. (2009). Parallel Programming in MATLAB. The International Journal of High Performance Computing Applications, 23 (3), 277–283. doi: https://doi.org/10.1177/1094342009106194

17. Verzhbitskiy, V. M. (2002). Osnovy chislennyh metodov. Moscow: Vysshaya shkola, 840.

18. Paterson, Dzh. (2000). Teoriya setey Petri i modelirovanie sistem. Moscow: Mir, 263.

19. Marahovskiy, V. B., Rozenblyum, L. Ya., Yakovlev, A. V. (2014). Modelirovanie parallel'nyh protsessov. Seti Petri: kurs dlya sistemnyh arhitektorov, programmistov, sistemnyh analitikov, proektirovschikov slozhnyh sistem upravleniya. Sankt-Peterburg: Professional'naya literatura, 398.

20. Gorbiychuk, M. I., Medvedchuk, V. M., Lazoriv, A. N. (2016). Analysis of Parallel Algorithm of Empirical Models Synthesis on Principles of Genetic Algorithms. Journal of Automation and Information Sciences, 48 (2), 54–73. doi: https://doi.org/10.1615/jautomatinfscien.v48.i2.60

21. Korn, G., Korn, T. (1978). Spravochnik po matematike dlya nauchnyh rabotnikov i inzhenerov. Moscow: Nauka, 832.

22. Volkov, E. A. (1987). Chislennye metody. Moscow: Nauka, 248.