ABSTRACT AND REFERENCES

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CONSTRUCTION OF AN ANALYTICAL METHOD FOR LIMITING THE COMPLEXITY OF NEURAL-FUZZY MODELS WITH GUARANTEED ACCURACY (p. 6–13)

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We have proposed an analytical method for limiting the complexity of neural-fuzzy models that provide for the guaranteed accuracy of their implementation when approximating functions with two or more derivatives. The method makes it possible to determine the required minimal number of parameters for systems that employ fuzzy logic, as well as neural models.

We have estimated the required number of neurons (terms) in a model, which ensure the accuracy required for the area of a model curve to approach the system one along the sections of function approximation. The estimate for an approximation error was obtained based on the residual members of decomposition, in the Lagrangian form, of areas of the approximated system function into a Maclaurin series. The results received make it possible to determine the required number of approximation sections and the number of neurons (terms) in order to ensure the assigned relative and absolute error of approximation.

We have estimated the required number of neurons (terms) that provide for the necessary accuracy of model implementation based on the maximum deviation between the system and model curves along the section of approximation. This makes it possible to select, depending on the assigned required accuracy, the number of terms of fuzzy variables, input and output variables, linguistic rules, coordinates of modal values along the axes of input and output variables.

To verify validity of the proposed solutions, we modeled the system curves in the Matlab/Simulink environment, which confirmed the guaranteed accuracy of their implementation in accordance with the analytical calculations reported earlier.

The results obtained could be applied in modern intelligent technical systems of management, control, diagnosis, and decision-making. Using the proposed methods for selecting and applying the minimal number of terms (neurons) would help reduce the required computing power in nonlinear systems.

Keywords: approximation, guaranteed accuracy, fuzzy logic, neural networks, imitation simulation.

References

1. Basov, H. H., Yatsko, S. I. (2005). Rozvytok elektrychnoho motorvahonnoho rukhomoho skladu. Ch. 2. Kharkiv: «Apeks+», 248.
2. Yatsko, S., Sytnik, B., Vashchenko, Y., Sidorenko, A., Liubarskyi, B., Veretennikov, I., Glebova, M. (2019). Comprehensive approach to modeling dynamic processes in the system of underground rail electric traction. Eastern-European Journal of Enterprise Technologies, 1 (9 (97)), 48–57. doi: https://doi.org/10.15587/1729-4061.2019.154520
3. Chao, C.-T., Sutarna, N., Chiou, J.-S., Wang, C.-J. (2017). Equivalence between Fuzzy PID Controllers and Conventional PID Controllers. Applied Sciences, 7 (6), 513. doi: https://doi.org/10.3390/app7060513
4. Helwa, M. K., Heins, A., Schoellig, A. (2018). Provably robust learning-based approach for high-accuracy tracking control of Lagrangian systems. 57th IEEE Conference on decision and control, 1–8.
5. Bryksin, V. A., Mihaylenko, V. S., Sytnik, B. T., Yac'ko, S. I. (2011). Realizaciya neyronechetkih modeley i regulyatorov garantirovannoy tochnosti. Informatsiyno-keruiuchi systemy na zaliznychnomu transporti, 4, 24–29.
6. Landowski, M. (2018). A discussion on «On the solution of a class of fuzzy system of linear equations». Sādhanā, 43 (12). doi: https://doi.org/10.1007/s12046-018-0972-1
7. Rakytianska, H. B. (2015). Neural-network approach to structural tuning of classification rules based on fuzzy relational equations. Eastern-European Journal of Enterprise Technologies, 4 (2 (76)), 51–57. doi: https://doi.org/10.15587/1729-4061.2015.47124
8. Liu, Y.-J., Gao, Y., Tong, S., Li, Y. (2016). Fuzzy Approximation-Based Adaptive Backstepping Optimal Control for a Class of Nonlinear Discrete-Time Systems With Dead-Zone. IEEE Transactions on Fuzzy Systems, 24 (1), 16–28. doi: https://doi.org/10.1109/tfuzz.2015.2418000
9. Lozynskyy, A., Demkiv, L. (2016). Synthesis of fuzzy logic controller of nonlinear dynamic system with variable parameters. Computational problems of electrical engineering, 6 (2), 91–98.
10. Orlowska-Kowalska, T., Kaminski, M., Szabat, K. (2010). Implementation of a Sliding-Mode Controller With an Integral Function and Fuzzy Gain Value for the Electrical Drive With an Elastic Joint. IEEE Transactions on Industrial Electronics, 57 (4), 1309–1317. doi: https://doi.org/10.1109/tie.2009.2030823
11. Chen, B., Liu, X. P., Ge, S. S., Lin, C. (2012). Adaptive Fuzzy Control of a Class of Nonlinear Systems by Fuzzy Approximation Approach. IEEE Transactions on Fuzzy Systems, 20 (6), 1012–1021. doi: https://doi.org/10.1109/tfuzz.2012.2190048
12. Anastassiou, G. A. (2014). Higher Order Multivariate Fuzzy Approximation by basic Neural Network Operators. Cubo (Temuco), 16 (3), 21–35. doi: https://doi.org/10.4067/s0719-06462014000300003
13. Piegat, A. (2001). Fuzzy Modeling and Control. Springer, 728. doi: https://doi.org/10.1007/978-3-7908-1824-6
14. Ronzhin, A., Rigoll, G., Meshcheryakov, R. (Eds.) (2018). Interactive collaborative Robotics. Proceedings of the Third International Conference on Interactive Collaborative Robotics, ICR. Springer, 302. doi: https://doi.org/10.1007/978-3-319-99582-3
15. Kimura, S., Sonoda, K., Yamane, S., Matsumura, K., Hatakeyama, M. (2007). Function approximation approach to the inference of neural network models of genetic networks. IPSJ Transactions on bioinformatics, 48, 9–19.

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INCREASING THE SHARE OF CORRECT CLUSTERING OF CHARACTERISTIC SIGNAL WITH RANDOM LOSSES IN SELF-ORGANIZING MAPS (p. 13–21)

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Analysis of methods for optimizing algorithms of functioning of the Kohonen neural networks, self-organizing maps (SOM), in terms of training speed and percentage of correct clustering was made. Effective optimization of self-organizing maps was determined by the second criterion, the enhanced self-organizing incremental neural network (ESOINN). It was established that in the case of incomplete input signal, that is the signal with losses at unknown time points, the share of correct clustering is unacceptably low with any SOM algorithms, both basic and optimized.

The incomplete signal was represented as the input vector of the neural network, the values of which are represented by a single array, that is without taking into consideration conformity of the moments of losses to the current values and without the possibility of determining these moments. A method for determining conformance of the incomplete input vector to the input layer of neurons to increase percentage of correct recognition was programmed and proposed. The method is based on finding the minimum distance between the current input vector and the vector of weights of each neuron. To reduce operating time of the algorithm, it was proposed to operate not with individual values of the input signal but their indivisible parts and the corresponding groups of input neurons. The proposed method was implemented for the SOM and ESOINN. To prove effectiveness of implementation of the basic algorithm of the SOM, its comparison with existing counterparts of other developers was made.

A mathematical model was developed for formation of examples of complete signals of a training sample on the basis of reference curves of the second order and a training sample was generated. In accordance with the training sample, training of all neural networks implemented with and without the proposed method was made. A diagram of simulation of losses was developed and test samples were generated for computational experiments with incomplete signals.

On the basis of experiments, efficiency of the proposed method for classification in terms of incomplete input signal on the basis of self-organizing maps was proved both for implementations of the basic algorithm of SOM and ESOINN.

Keywords: self-organizing map, SOM, ESOINN, Kohonen neural networks, signal with losses, losses in a time series, classification in terms of the characteristic signal.

References

1. Passoni, L. I., Dai Pra, A. I., Meschino, G. J., Guzman, M., Weber, C., Rabal, H., Trivi, M. (2014). Unsupervised learning segmentation for dynamic speckle activity images. arXiv. Available at: https://arxiv.org/abs/1408.3818
2. Fustes, D., Manteiga, M., Dafonte, C., Arcay, B., Ulla, A., Smith, K., Borrachero, R., Sordo, R. (2013). An approach to the analysis of SDSS spectroscopic outliers based on Self-Organizing Maps. arXiv. Available at: https://arxiv.org/abs/1309.2418
3. Meusinger, H., Brünecke, J., Schalldach, P., in der Au, A. (2017). A large sample of Kohonen selected E+A (post-starburst) galaxies from the Sloan Digital Sky Survey. Astronomy & Astrophysics, 597, A134. doi: https://doi.org/10.1051/0004-6361/201629139
4. Fraccalvieri, D., Bonati, L., Stella, F. (2013). Self Organizing Maps to efficiently cluster and functionally interpret protein conformational ensembles. Electronic Proceedings in Theoretical Computer Science, 130, 83–86. doi: https://doi.org/10.4204/eptcs.130.13
5. Kohonen, T. (1982). Self-organized formation of topologically correct feature maps. Biological Cybernetics, 43 (1), 59–69. doi: https://doi.org/10.1007/bf00337288
6. Su, M.-C., Liu, T.-K., Chang, H.-T. (2002). Improving the self-organizing feature map algorithm using an efficient initialization scheme. Tamkang Journal of Science and Engineering, 5 (1), 35–48.
7. Shapovalova, S. I., Sharaievskyi, H. I. (2007). Kompiuterne modeliuvannia karty samoorhanizatsiyi dlia rozviazannia zadachi rozpiznavannia syhnaliv. Visnyk natsionalnoho universytetu «Lvivska politekhnika», 574, 75–80.
8. Su, M.-C., Chang, H.-T. (1998). Genetic-algorithms-based approach to self-organizing feature map and its application in cluster analysis. 1998 IEEE International Joint Conference on Neural Networks Proceedings. IEEE World Congress on Computational Intelligence (Cat. No. 98CH36227). doi: https://doi.org/10.1109/ijcnn.1998.682372
9. El Golli, A. (2005). Speeding up the self organizing map for dissimilarity data. Proceedings of International Symposium on Applied Stochastic Models and Data Analysis. Brest, 709–713.
10. Conan-Guez, B., Rossi, F., El Golli, A. (2006). Fast algorithm and implementation of dissimilarity self-organizing maps. Neural Networks, 19 (6-7), 855–863. doi: https://doi.org/10.1016/j.neunet.2006.05.002
11. Cuadros-Vargas, E., Romero, R. F., Obermayer, K. (2003). Speeding up algorithms of SOM family for large and high dimensional databases. In Workshop on Self Organizing Maps. Kitakyushu.
12. Fritzke, B. (1994). Growing cell structures – A self-organizing network for unsupervised and supervised learning. Neural Networks, 7 (9), 1441–1460. doi: https://doi.org/10.1016/0893-6080(94)90091-4
13. Cao, M., Li, A., Fang, Q., Kaufmann, E., Kröger, B. J. (2014). Interconnected growing self-organizing maps for auditory and semantic acquisition modeling. Frontiers in Psychology, 5. doi: https://doi.org/10.3389/fpsyg.2014.00236
14. Cao, M., Li, A., Fang, Q., Kroger, B. J. (2013). Growing self-organizing map approach for semantic acquisition modeling. 2013 IEEE 4th International Conference on Cognitive Infocommunications (CogInfoCom). doi: https://doi.org/10.1109/coginfocom.2013.6719269
15. Furao, S., Hasegawa, O. (2006). An incremental network for on-line unsupervised classification and topology learning. Neural Networks, 19 (1), 90–106. doi: https://doi.org/10.1016/j.neunet.2005.04.006
16. Furao, S., Ogura, T., Hasegawa, O. (2007). An enhanced self-organizing incremental neural network for online unsupervised learning. Neural Networks, 20 (8), 893–903. doi: https://doi.org/10.1016/j.neunet.2007.07.008
17. Algoritm Uluchshennoy Samoorganizuyushcheysya Rastushchey Neyronnoy Seti (ESOINN). Available at: https://habr.com/post/206116
18. An enhanced self-organizing incremental neural network for online unsupervised learning. Available at: https://github.com/BelBES/ESOINN
19. Encog Machine Learning Framework. Available at: https://github.com/encog/encog-java-core
20. Neuroph – Java Neural Network Platform Neuroph. Available at: https://github.com/neuroph/neuroph
21. Self-Organizing Incremental Neural Network. Available at: https://github.com/fukatani/soinn
22. Growing Self-Organizing Map. Available at: https://github.com/philippludwig/pygsom

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ANALYSIS OF EFFICIENCY OF THE BIOINSPIRED METHOD FOR DECODING ALGEBRAIC CONVOLUTIONAL CODES (p. 22–30)

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It has been shown that convolutional codes are widely used, along with various decoding methods, to improve the reliability of information transmission in wireless telecommunication systems. The general principles of synthesis and the parameters and algebraic non-systematic convolutional codes with arbitrary coding rate and maximum achievable code distance have been shown.

The basic stages of the bioinspired method for decoding algebraic convolutional codes using a random shift mechanism have been presented. It has been shown that the essence of the presented decoding method implies applying the procedure of differential evolution with the heuristically determined parameters. In addition, this method uses information about the reliability of the adopted symbols to find the most reliable basis for the generalized generator matrix. The mechanism of random shift for the modification of the accepted sequence is additionally applied for the bioinspired search based on various most reliable bases of a generalized generator matrix.

The research results established that the bioinspired method for decoding algebraic convolutional codes ensures greater efficiency compared with the algebraic decoding method in the communication channel with additive white Gaussian noise. Depending on the parameters of the algebraic convolutional code and the necessary error coefficient, the energy gain from encoding ranges from 1.6 dB to 3 dB. It was shown that the presented bioinspired decoding method can be used for convolutional codes with a large code constraint length.

In doing so, the presented method for decoding algebraic convolutional codes is less efficient than the Viterbi decoding method and turbo codes at a sufficient number of decoding iterations.

Keywords: wireless telecommunication systems, convolutional codes, algebraic structure, decoding, bioinspired search.

References

1. Johannesson, R., Zigangirov, K. Sh. (Eds.) (2015). Fundamentals of convolutional coding. John Wiley & Sons, 668. doi: https://doi.org/10.1002/9781119098799
2. Ryan, W., Lin, S. (2009). Channel codes: Classical and modern. Cambridge University Press, 692. doi: https://doi.org/10.1017/cbo9780511803253
3. Piret, P. (1976). Structure and constructions of cyclic convolutional codes. IEEE Transactions on Information Theory, 22 (2), 147–155. doi: https://doi.org/10.1109/tit.1976.1055531
4. Roos, C. (1979). On the structure of convolutional and cyclic convolutional codes. IEEE Transactions on Information Theory, 25 (6), 676–683. doi: https://doi.org/10.1109/tit.1979.1056108
5. Gluesing-Luerssen, H., Schmale, W. (2004). On Cyclic Convolutional Codes. Acta Applicandae Mathematicae, 82 (2), 183–237. doi: https://doi.org/10.1023/b:acap.0000027534.61242.09
6. Gluesing-Luerssen, H., Schmale, W. (2006). On Doubly-Cyclic Convolutional Codes. Applicable Algebra in Engineering, Communication and Computing, 17 (2), 151–170. doi: https://doi.org/10.1007/s00200-006-0014-9
7. Gomez-Torrecillas, J., Lobillo, F. J., Navarro, G. (2016). A New Perspective of Cyclicity in Convolutional Codes. IEEE Transactions on Information Theory, 62 (5), 2702–2706. doi: https://doi.org/10.1109/tit.2016.2538264
8. Rosenthal, J., York, F. V. (1999). BCH convolutional codes. IEEE Transactions on Information Theory, 45 (6), 1833–1844. doi: https://doi.org/10.1109/18.782104
9. Rosenthal, J., Smarandache, R. (1999). Maximum Distance Separable Convolutional Codes. Applicable Algebra in Engineering, Communication and Computing, 10 (1), 15–32. doi: https://doi.org/10.1007/s002000050120
10. Prihod'ko, S. I., Kuznecov, A. A., Gusev, S. A., Kuzhel', I. E. (2004). Algebraicheskoe postroenie nesistematicheskih svertochnyh kodov. Systemy obrobky informatsiyi, 8 (69), 170–175.
11. Viterbi, A. (1967). Error bounds for convolutional codes and an asymptotically optimum decoding algorithm. IEEE Transactions on Information Theory, 13 (2), 260–269. doi: https://doi.org/10.1109/tit.1967.1054010
12. Gluesing-Luerssen, H., Helmke, U., Iglesias Curto, J. (2010). Algebraic decoding for doubly cyclic convolutional codes. Advances in Mathematics of Communications, 4 (1), 83–99. doi: https://doi.org/10.3934/amc.2010.4.83
13. Gomez-Torrecillas, J., Lobillo, F. J., Navarro, G. (2017). A Sugiyama-Like Decoding Algorithm for Convolutional Codes. IEEE Transactions on Information Theory, 63 (10), 6216–6226. doi: https://doi.org/10.1109/tit.2017.2731774
14. Prihod'ko, S. I., Kuz'menko, D. M. (2008). Method of decoding of algebraic convolution codes. Systemy obrobky informatsiyi, 2 (69), 12–17.
15. Ortin, J., Garcia, P., Gutierrez, F., Valdovinos, A. (2009). Two step SOVA-based decoding algorithm for tailbiting codes. IEEE Communications Letters, 13 (7), 510–512. doi: https://doi.org/10.1109/lcomm.2009.090810
16. Bushisue, S., Suyama, S., Nagata, S., Miki, N. (2017). Performance Comparison of List Viterbi Algorithm of Tail-Biting Convolutional Code for Future Machine Type Communications. IEICE Transactions on Communications, E100.B (8), 1293–1300. doi: https://doi.org/10.1587/transcom.2016fgp0018
17. Han, Y. S., Wu, T.-Y., Chen, P.-N., Varshney, P. K. (2018). A Low-Complexity Maximum-Likelihood Decoder for Tail-Biting Convolutional Codes. IEEE Transactions on Communications, 66 (5), 1859–1870. doi: https://doi.org/10.1109/tcomm.2018.2790935
18. Kao, J. W. H., Berber, S. M., Bigdeli, A. (2009). A General Rate K/N Convolutional Decoder Based on Neural Networks with Stopping Criterion. Advances in Artificial Intelligence, 2009, 1–11. doi: https://doi.org/10.1155/2009/356120
19. Rajbhandari, S., Ghassemlooy, Z., Angelova, M. (2012). Adaptive «soft» sliding block decoding of convolutional code using the artificial neural network. Transactions on Emerging Telecommunications Technologies, 23 (7), 672–677. doi: https://doi.org/10.1002/ett.2523

20. Azouaoui, A., Chana, I., Belkasmi, M. (2012). Efficient Information Set Decoding Based on Genetic Algorithms. International Journal of Communications, Network and System Sciences, 05 (07), 423–429. doi: https://doi.org/10.4236/ijcns.2012.57052
21. Azouaoui, A., Belkasmi, M., Farchane, A. (2012). Efficient Dual Domain Decoding of Linear Block Codes Using Genetic Algorithms. Journal of Electrical and Computer Engineering, 2012, 1–12. doi: https://doi.org/10.1155/2012/503834
22. Berkani, A., Azouaoui, A., Belkasmi, M., Aylaj, B. (2017). Improved Decoding of linear Block Codes using compact Genetic Algorithms with larger tournament size. International Journal of Computer Science Issues, 14 (1), 15–24. doi: https://doi.org/10.20943/01201701.1524
23. Shtompel, M. (2016). Soft decoding algebraic convolutional codes based on natural computing. Informatsiyno-keruiuchi systemy na zaliznychnomu transporti, 5, 14–18.
24. Price, K., Storn, R. M., Lampinen, J. A. (2005). Differential evolution: A practical approach to global optimization. Springer, 539. doi: https://doi.org/10.1007/3-540-31306-0
25. Jin, W., Fossorier, M. P. C. (2007). Reliability-Based Soft-Decision Decoding With Multiple Biases. IEEE Transactions on Information Theory, 53 (1), 105–120. doi: https://doi.org/10.1109/tit.2006.887510

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DEVELOPMENT OF THE PROCEDURE FOR INTEGRATED APPLICATION OF SCENARIO PREDICTION METHODS (p. 31–38)

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The paper proposes a procedure for the integrated application of methods for scenario analysis and prediction, represented by graphs of the «tree» type. The task on analysis of risks in software projects has been considered, the cause of which are the possible programming errors that lead to failures in the operation of systems and software. The joint use of a failure tree and a probability tree makes it possible to generate the sequences of scripts for the implementation of an adverse event, whose main cause is possible defects or errors in software or data, as well as to assess the probabilities of their realization. Such an approach allows the identification of the overall result of the influence of certain risk-forming factors (defects) on the development of possible negative consequences (failures and malfunctions) or damage to the operation of complex software systems. This makes it possible to timely identify and propose effective mechanisms to manage software risk in order to reduce and eliminate them.

A procedure has been proposed for aggregating individual probabilistic expert assessments of the occurrence of a risk event. Such an approach makes it possible to obtain group expert estimates assessing the feasibility of a risk event based on the constructed system of random events into a generalized expert assessment. The probabilities of the occurrence of a risk event, thus obtained, are used when constructing a probability tree and calculating the ratios of probabilistic inference using it. Aggregation of individual expert estimates is carried out by combining them based on a mathematical apparatus of the theory of evidence and the theory of plausible and paradoxical reasoning. It was established that in order to improve quality of the results of combining it is appropriate to establish an order for combining expert evidence and apply one of the rules of conflict redistribution as a combination rule.

Numerical calculations of the proposed procedure for integrated application of a failure tree and a probability tree are provided. The results obtained make it possible to run a more in-depth analysis of the examined software systems and objects, and are aimed at improving the quality and effectiveness of managing risks in software projects caused by defects in programs and data.

Keywords: fault tree, probability tree, risks of software projects, script analysis, combination rules.

References

1. Pereverza, K. (2011). Scenario method for analysis of complex social systems. System research and information technologies, 1, 133–143.
2. Amer, M., Daim, T. U., Jetter, A. (2013). A review of scenario planning. Futures, 46, 23–40. doi: https://doi.org/10.1016/j.futures.2012.10.003
3. Bishop, P., Hines, A., Collins, T. (2007). The current state of scenario development: an overview of techniques. Foresight, 9 (1), 5–25. doi: https://doi.org/10.1108/14636680710727516
4. Trofimova, M. S., Trofimov, S. M. (2015). The review of methods and techniques of the systems analysis in relation to management quality of the enterprise. Vestnik Permskogo nacional'nogo issledovatel'skogo politekhnicheskogo universiteta. Elektrotekhnika, informacionnye tekhnologii, sistemy upravleniya, 14, 74–85.
5. Ispol'zovanie metoda «scenariev budushchego» v strategicheskom upravlenii. Obrazovatel'niy sayt Viktorovoy T.S. Available at: http://www.viktorova-ts.ru/page299/page433/index.html
6. Kovalenko, I. I., Shved, A. V., Melnik, A. V. (2014). Probability analysis of risk-contributing factors in organizational tasks of ship repair. Shipbuilding & Marine Infrastructure, 2 (2), 111–119.
7. Baig, A. A., Ruzli, R., Buang, A. B. (2013). Reliability analysis using fault tree analysis: a review. International Journal of Chemical Engineering and Applications, 4 (3), 169–173. doi: https://doi.org/10.7763/ijcea.2013.v4.287
8. Shubin, R. A. (2012). Nadezhnost' tekhnicheskih sistem i tekhnogenniy risk. Tambov: FGBOU VPO TGTU, 80.
9. Nikitenko, Yu. V. (2015). Peculiaritys applying of construction metod of refusial for estimation of accident rate by military industry. Modern problems of science and education, 2. Available at: http://www.science-education.ru/ru/article/view?id=21831
10. Tonitsa, O. V., Yeremenko, I. V. (2010). Kompiuterne modeliuvannia system analizu bezpeky tekhnolohichnykh obiektiv. Visnyk Nats. tekhn. un-tu «KhPI». Seriya: Systemnyi analiz, upravlinnia ta informatsiyni tekhnolohiyi, 67, 45–50.
11. Kovalenko, O. (2018). Quality analysis and quantitative assessment of risks methods of software development. Control, Navigation and Communication Systems, 3 (49), 116–125. doi: https://doi.org/10.26906/sunz.2018.3.116
12. Shurigin, O. V. (2009). Methodical bases of analysis of refuses are in the systems of treatment information standards of armament and military technique. Systemy ozbroiennia i viyskova tekhnika, 4, 178–181.
13. Tarasyuk, O. M., Gorbenko, A. V., Kharchenko, V. S., Motora, Ju. V. (2010). Example of complex application of formal methods of requirements specification and dependability analysis of computer-based control systems. Systemy obrobky informatsiyi, 8 (89), 83–89.
14. Targoutzidis, A. (2010). Incorporating human factors into a simplified «bow-tie» approach for workplace risk assessment. Safety

Science, 48 (2), 145–156. doi: https://doi.org/10.1016/j.ssci.2009.07.005
15. Jacinto, C., Silva, C. (2010). A semi-quantitative assessment of occupational risks using bow-tie representation. Safety Science, 48 (8), 973–979. doi: https://doi.org/10.1016/j.ssci.2009.08.008
16. Ruijters, E., Stoelinga, M. (2015). Fault tree analysis: A survey of the state-of-the-art in modeling, analysis and tools. Computer Science Review, 15-16, 29–62. doi: https://doi.org/10.1016/j.cosrev.2015.03.001
17. Ferdous, R., Khan, F., Sadiq, R., Amyotte, P., Veitch, B. (2011). Fault and Event Tree Analyses for Process Systems Risk Analysis: Uncertainty Handling Formulations. Risk Analysis, 31 (1), 86–107. doi: https://doi.org/10.1111/j.1539-6924.2010.01475.x
18. Svetun'kov, S. G. (2009). Metody social'no-ekonomicheskogo prognozirovaniya. Vol. 1. Sankt-Peterburg: SPbGUEF, 147.
19. Uzga-Rebrov, O. (2004). Modern concepts and applications of probability theory. Rezekne: RA Izdevnieciba, 292.
20. Kovalenko, I. I., Shved, A. V. (2012). Metody ekspertnogo ocenivaniya scenariev. Nikolaev: CHGU im. Petra Mogily, 156.
21. Shved, A. (2017). Probabilistic risk analysis of investment projects under uncertainty. 2017 9th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS). doi: https://doi.org/10.1109/idaacs.2017.8095072
22. Smarandache, F., Dezert, J., Tacnet, J. (2010). Fusion of sources of evidence with different importances and reliabilities. 2010 13th International Conference on Information Fusion. doi: https://doi.org/10.1109/icif.2010.5712071
23. Uzga-Rebrovs, O. I. (2010). Nenoteiktibu parvaldisana. Part 3. Rezekne: RA Izdevnieciba, 560.
24. Kovalenko, I., Shved, A. (2018). Development of a technology of structuring group expert judgments under various types of uncertainty. Eastern-European Journal of Enterprise Technologies, 3 (4 (93)), 60–68. doi: https://doi.org/10.15587/1729-4061.2018.133299
25. Shved, A., Davydenko, Y. (2016). The analysis of uncertainty measures with various types of evidence. 2016 IEEE First International Conference on Data Stream Mining & Processing (DSMP). doi: https://doi.org/10.1109/dsmp.2016.7583508
26. Jousselme, A.-L., Maupin, P. (2012). Distances in evidence theory: Comprehensive survey and generalizations. International Journal of Approximate Reasoning, 53 (2), 118–145. doi: https://doi.org/10.1016/j.ijar.2011.07.006
27. Pavlovskaya, O. O. (2009). Static methods of assessment of software. Vestnik Yuzhno-Ural'skogo gosudarstvennogo universiteta. Seriya: Komp'yuternye tekhnologii, upravlenie, radioelektronika, 10, 35–37.
28. Orlov, A. I., Savinov, Yu. G., Bogdanov, A. Yu. (2012). Experience of expert estimation of the conditional probabilities of a rare events during developing automated system for forecasting and prevention of aviation accidents. Izvestiya Samarskogo nauchnogo centra Rossiyskoy akademii nauk, 14 (4 (2)), 501–506.

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DEVELOPMENT OF METHODS FOR STRUCTURAL AND LOGICAL MODEL UNIFICATION OF METAKNOWLEDGE FOR ONTOLOGIES EVOLUTION MANAGING OF INTELLIGENT SYSTEMS (p. 38–47)

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The relevance of the study is due to the importance and necessity of unifying the construction and use of intelligent decision support systems for managing complex industrial facilities and systems.

The aim of the study is to substantiate the unified approach to managing knowledge bases of various configurations and develop unified mathematical models of operations on ontology elements.

The method for managing the evolution of ontologies of professional fields, based on the unification of the structural-logical model of metaknowledge representation, is proposed.

The method of unification of the structural-logical model of evolution of ontology incorporation is developed. Formal linguistic models are developed, the similarity of forms of knowledge representation and evolutionary inheritance within the general ontology incorporation are proved. For the synthesis of the model of incorporation of the evolutionary inheritance of ontologies, the subtasks of the development of models of the evolutionary inheritance of concepts, graphs and ontologies of KB levels are solved. The model provides an opportunity of a single approach to the interpretation of the interaction structures of concepts for all KB levels.

The generalized model of the signal graph of the KB structure levels is developed. The model includes the atomic concept, signal, node potential, node activity, threshold of node sensitivity to the input signal. A set of formal models of basic operations on the signal graph of the KB necessary for the interpretation and computing of knowledge forms is developed. The metarule syntax and the formal-linguistic basis are developed. Formalisms of the labeling parameter and labeling function of the KB signal graph are introduced. Labeling models are introduced into the general model of the signal graph of the KB.

Possibilities of applying the developed models of the signal graph of the knowledge base to various professional areas are investigated. It is shown that the proposed metaknowledge models do not depend on forms of representation and formalisms of professional ontologies. This allows the use of a single knowledge management mechanism in any intelligent decision support systems. The method of effective dynamic management of the structure of all KB levels and inference process depending on the input parameters of the intelligent system is proposed.

Keywords: ontology incorporation, model context, graph labeling, metaproduction, knowledge representation, signal graph, decision support system.

References

1. Bartolomey, P. I., Tashchilin, V. A. (2015). Informacionnoe obespechenie zadach elektroenergetiki. Ekaterinburg, 108.
2. Morkun, V., Tron, V. (2014). Ore preparation multi-criteria energy-efficient automated control with considering the ecological and economic factors. Metallurgical and Mining Industry, 5, 4–7. Available at: http://www.metaljournal.com.ua/assets/Journal/1-Morkun-Tron.pdf
3. Besanger, Y., Eremia, M., Voropai, N. (2013). Major Grid Blackouts: Analysis, Classification, and Prevention. Handbook of Electrical Power System Dynamics, 789–863. doi: https://doi.org/10.1002/9781118516072.ch13
4. Smolovik, S. V. (2008). Rol' «chelovecheskogo faktora» v razvitii krupnyh sistemnyh avariy. ELEKTROENERGETIKA, 1 (1), 16–19.
5. Avariynist na obiektakh elektroenerhetyky Ukrainy u 2005 rotsi. Haluzevyi informatsiynyi dokument (2005). Obiednannia enerhetychnykh pidpryiemstv «Haluzevyi rezervno-investytsiynyi fond rozvytku enerhetyky». Kyiv: Vydavnytstvo «Enerhiya», 102.

6. Kalibataitė, G. (2011). The Importance of Meta-Knowledge for Business and Information Management. Social Technologies, 1 (1), 163–178.
7. Nasrollahi, S. N., Mokhtari, H., Seyedein, M. (2011). Meta-analysis: An Approach to Synthesizing and Evaluating Research on Knowledge and Information Science. Iranian Journal of Information Processing & Management, 29 (2), 293–316.
8. Morkun, V., Tcvirkun, S. (2014). Investigation of methods of fuzzy clustering for determining ore types. Metallurgical and Mining Industry, 5, 12–15. Available at: http://www.metaljournal.com.ua/assets/Journal/3-MorkunTs.pdf
9. Rodriguez-Rojas, L. A., Cueva-Lovelle, J. M., Tarazona-Bermudez, G. M., Montenegro-Marin, C. E. (2013). Open Data as a key factor for developing expert systems: a perspective from Spain. International Journal of Interactive Multimedia and Artificial Intelligence, 2 (2), 51. doi: https://doi.org/10.9781/ijimai.2013.226
10. Ligeza, A. (2001). Knowledge Representation and Inference for Analysis and Design of Database and Tabular Rule-Based Systems. Computer Science, 3 (1), 13–60.
11. Miah, S. J., Genemo, H. (2016). A Design Science Research Methodology for Expert Systems Development. Australasian Journal of Information Systems, 20. doi: https://doi.org/10.3127/ajis.v20i0.1329
12. Morkun, V., Morkun, N., Tron, V. (2015). Formalization and frequency analysis of robust control of ore beneficiation technological processes under parametric uncertainty. Metallurgical and Mining Industry, 5, 7–11. Available at: http://www.metaljournal.com.ua/assets/MMI_2014_6/MMI_2015_5/001-Morkun.pdf
13. Kuznecov, O. P., Suhoverov, V. S., Shipilina, L. B. (2010). Ontologiya kak sistematizaciya nauchnyh znaniy: struktura, semantika, zadachi. Trudy konferencii «Tekhnicheskie i programmnye sredstva sistem upravleniya, kontrolya i izmereniya». Moscow: IPU RAN, 762–773.
14. Al-Emran, M., Mezhuyev, V., Kamaludin, A., Shaalan, K. (2018). The impact of knowledge management processes on information systems: A systematic review. International Journal of Information Management, 43, 173–187. doi: https://doi.org/10.1016/j.ijinfomgt.2018.08.001
15. Sedighi, S. M., Javidan, R. (2012). Semantic query in a relational database using a local ontology construction. South African Journal of Science, 108 (11/12). doi: https://doi.org/10.4102/sajs.v108i11/12.1107
16. Ruy, F. B., Guizzardi, G., Falbo, R. A., Reginato, C. C., Santos, V. A. (2017). From reference ontologies to ontology patterns and back. Data & Knowledge Engineering, 109, 41–69. doi: https://doi.org/10.1016/j.datak.2017.03.004
17. Duer, S., Wrzesień, P., Duer, R. (2017). Creating of structure of facts for the knowledge base of an expert system for wind power plant's equipment diagnosis. E3S Web of Conferences, 19, 01038. doi: https://doi.org/10.1051/e3sconf/20171901038
18. Xamena, E., Brignole, N. B., Maguitman, A. G. (2017). A Structural Analysis of topic ontologies. Information Sciences, 421, 15–29. doi: https://doi.org/10.1016/j.ins.2017.08.081
19. Gadomski, A. M. (1989). From Know-how to How-to- Know: An Approach to Knowledge Ordering for Specification of Complex Problems (TOGA methodology). Presented at the International Symposium on Computational Intelligence. Milan.
20. Shabanov-Kushnarenko, Yu. P. (1984). Teoriya intellekta. Matematicheskie sredstva. Kharkiv, 144.
21. Dudar', Z. V., Kalinichenko, O. V., Shabanov-Kushnarenko, S. Yu. (2000). About a method and problems of the theory of intellect. I. Radioelektronika i informatika, 2, 112–122.
22. Shabanov-Kushnarenko, S. Yu., Kudhair Abed Tamer, Leschynskaya, I. A. (2013). The predicative approach to non-obvious knowledge formalization. Systemy obrobky informatsiyi, 9, 113–116.
23. Bashmakov, A. I., Bashmakov, I. A. (2005). Intellektual'nye informacionnye tekhnologii. Moscow, 304.
24. Genesereth, M. R., Fikes, R. E. (1992). Knowledge Interchange Format. Reference Manual. Computer Science Department, Stanford University Stanford, California, 68.
25. Yalovec, A. L. (2011). Predstavlenie i obrabotka znaniy s tochki zreniya matematicheskogo modelirovaniya problemy i resheniya. Kyiv: Naukova dumka, 339.
26. Gignoux, J., Chérel, G., Davies, I. D., Flint, S. R., Lateltin, E. (2017). Emergence and complex systems: The contribution of dynamic graph theory. Ecological Complexity, 31, 34–49. doi: https://doi.org/10.1016/j.ecocom.2017.02.006
27. Wiener, G. (2016). On constructions of hypotraceable graphs. Electronic Notes in Discrete Mathematics, 54, 127–132. doi: https://doi.org/10.1016/j.endm.2016.09.023

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SYNTHESIS OF A TREND'S INTEGRAL ESTIMATE BASED ON A TOTALITY OF INDICATORS FOR A TIME SERIES DATA (p. 48–56)

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The need for a qualitative estimation of social processes, trends, and activities executed by social governing institutions has been considered. It was determined that the information openness, availability of processing and informational tools create the conditions for efficient administration.

An analysis of trends for a time series in the indicators' dynamics has been performed. The number of priority indicators for analysis and generalization was limited to four, the data were selected from reports by the World Bank, Obozrevatel.ua, and Transparency International. The unified norm has been introduced, which would ensure the comparability of indicators that generate the conclusion on the state, trends, and processes. One of the norms that are applied for Euclidean spaces has been introduced.

The system of basic estimation of the integral indicator has been substantiated, based on data about management efficiency, quality of regulation, political stability, absence of violence and CPI index. Expressions for estimation of prognostic values for the integral indicator were derived. It was proposed to use a lower boundary as the estimate to analyze the efficiency of public administration activities.

Modeling of the processes of estimation of the integral indicator was performed and a five-year time series for the integral indicator was obtained. The relation between an error of the integral indicator, the size of the sliding window, jumps in first and second derivative from a generalized time series and a permissible error has been represented as a limited inequality. It was proposed to introduce the system of representation and mapping of time series in dimensionless, limited spaces by rotation at an angle around the common axis. The definitions were introduced, the theorem about retaining the local values for relative dimensions and errors were introduced. The influence of the quadratic form on a local relative error of the integral indicator has been shown. The prediction of the development was performed and the assessment of public administration activities was given based on the estimate of the integral indicator.

Keywords: integral indicator, efficiency of quadratic norm, decomposition norm, constraint on inequality of norm, geometric inequality.

References

1. Pro Derzhavnyi suverenitet Ukrainy: Deklaratsiya vid 16.07.1990 r. No. 55-XII. Verkhovna Rada URSR. Available at: http://zakon3.rada.gov.ua/laws/show/55-12
2. Osnovni napriamy ekonomichnoi polityky v umovakh nezalezhnosti: Postanova vid 25.10.1991 r. No. 1698-XII. Verkhovna Rada Ukrainy. Available at: http://zakon3.rada.gov.ua/laws/show/1698-12
3. Osnovy natsionalnoi ekonomichnoi polityky: Postanova vid 24.03.1992 r. No. 2226-XII. Verkhovna Rada Ukrainy. Available at: http://zakon3.rada.gov.ua/laws/show/2226-12
4. Transparency International Ukraine. Available at: https://ti-ukraine.org/
5. Beglytsia, V. P., Tsyplitska, O. O. (2018). Corruption and economic development: the role of the state. Scientific Bulletin of Polissia, 1 (1 (13)), 135–141. doi: https://doi.org/10.25140/2410-9576-2018-1-1(13)-135-141
6. Derzhavna sluzhba v Ukraini u 2005–2012 rokakh (osnovni pokaznyky yakisnoho ta kilkisnoho skladu) (2013). Info-Light. Available at: http://infolight.org.ua/content/derzhavna-sluzhba-v-ukrayini-u-2005-2012-rokah-osnovni-pokazniki-yakisnogo-ta-kilkisnogo-skladu
7. Ukraina tretia v sviti po doli «tinovoi» ekonomiky (2017). Obozrevatel. Available at: https://www.obozrevatel.com/ukr/finance/ukraina-potrapila-v-rejting-krain-iz-tinovoyu-ekonomikoyu.htm?obozrevatellang=uk
8. Zosymova, Zh. S. (2013). Foreign experience international management and can be used in Ukraine. Visnyk Odeskoho natsionalnoho universytetu. Ekonomika, 18 (3 (1)), 158–161. Available at: http://nbuv.gov.ua/UJRN/Vonu_econ_2013_18_3(1)__42
9. Max Weber: The Theory of Social and Economic Organization (1947). New York: Oxford University Press, 436. Available at: https://books.google.ru/books?id=G3TYBu6-4G0C&printsec=frontcover&hl=ru#v=onepage&q&f=false
10. Khachaturian, Kh. V. (2009). Pereorientatsiya derzhavnoho upravlinnia na potreby hromadian: nova yevropeiska model ta Ukraina. Visnyk Kyivskoho mizhnarodnoho universytetu, 8. Available at: http://www.kymu.edu.ua/vmv/v/08/khachaturian.htm
11. Pro zakhody shchodo vprovadzhennia Kontseptsiyi administratyvnoi reformy v Ukraini: Ukaz vid 22.07.1998 r. No. 810. Available at: http://zakon3.rada.gov.ua/laws/show/810/98
12. ISO 37001:2016. Systema upravlinnia zakhodamy borotby z koruptsieiu. Vymohy iz rekomendatsiiamy dlia vykorystannia. Available at: http://pecb.com.ua/wp-content/uploads/2017/02/ISO-37001_2016_ukr.pdf
13. Corruption Perception Index 2017. Transparency International. Available at: https://www.transparency.org/news/feature/corruption_perceptions_index_2017
14. Worldwide Governance Indicators. The World Bank. Available at: http://info.worldbank.org/governance/wgi/#reports
15. Hodakov, V. E., Sokolova, N. A., Kiriychuk, D. L. (2014). O razvitii osnov teorii koordinacii slozhnyh system. Problemy informatsiynykh tekhnolohiy, 2, 12–21.
16. Trunov, A. (2016). Realization of the paradigm of prescribed control of a nonlinear object as the problem on maximization of adequacy. Eastern-European Journal of Enterprise Technologies, 4 (4 (82)), 50–58. doi: https://doi.org/10.15587/1729-4061.2016.75674
17. Trunov, A. (2016). Recurrent approximation as the tool for expansion of functions and modes of operation of neural network. Eastern-European Journal of Enterprise Technologies, 5 (4 (83)), 41–48. doi: https://doi.org/10.15587/1729-4061.2016.81298
18. Petrov, E. G. (2014). Koordinacionnoe upravlenie (menedzhment) processami realizacii resheniy. Problemy informatsiynykh tekhnolohiy, 2, 6–11.
19. Petrov, K. E., Kryuchkovskiy, V. V. (2009). Komparatornaya strukturno-parametricheskaya identifikaciya modeley skalyarnogo mnogofaktornogo ocenivaniya. Herson: Oldi-plyus, 294.
20. Trunov, A. (2016). Criteria for the evaluation of model’s error for a hybrid architecture DSS in the underwater technology ACS. Eastern-European Journal of Enterprise Technologies, 6 (9 (84)), 55–62. doi: https://doi.org/10.15587/1729-4061.2016.85585
21. Trunov, A. (2015). An adequacy criterion in evaluating the effectiveness of a model design process. Eastern-European Journal of Enterprise Technologies, 1 (4 (73)), 36–41. doi: https://doi.org/10.15587/1729-4061.2015.37204
22. Tsay, R. S. (2010). Analysis of Financial Time Series. John Wiley & Sons. doi: https://doi.org/10.1002/9780470644560
23. Enders, W. (1994). Applied econometric time series. New York: Wiley and Sons, 433.
24. Trukhan, S. V., Bidiuk P. I. (2015). Methods of building mathematical models ofactuarial processes. Eastern-European Journal of Enterprise Technologies, 1 (4 (73)), 27–35. doi: https://doi.org/10.15587/1729-4061.2015.36486
25. Bidiuk, P. I., Borysevych, A. S. (2008). Otsiniuvannia parametriv modelei iz zastosuvanniam metodu Monte-Karlo dlia markovskykh lantsiuhiv. Naukovi pratsi Chornomorskoho derzhavnoho universytetu imeni Petra Mohyly. Ser.: Kompiuterni tekhnolohiyi, 90 (77), 21–37.
26. Shchelkalin, V. N. (2015). A systematic approach to the synthesis of forecasting mathematical models for interrelated non-stationary time series. Eastern-European Journal of Enterprise Technologies, 2 (4 (74)), 21–35. doi: https://doi.org/10.15587/1729-4061.2015.40065
27. Bidyuk, P., Gozhyj, A., Szymanski, Z., Kalinina, I., Beglytsia, V. (2018). The Methods Bayesian Analysis of the Threshold Stochastic Volatility Model. 2018 IEEE Second International Conference on Data Stream Mining & Processing (DSMP). doi: https://doi.org/10.1109/dsmp.2018.8478474
28. Trunov, A. (2017). Recurrent transformation of the dynamics model for autonomous underwater vehicle in the inertial coordinate system. Eastern-European Journal of Enterprise Technologies, 2 (4 (86)), 39–47. doi: https://doi.org/10.15587/1729-4061.2017.95783
29. Trunov, A., Belikov, A. (2015). Application of recurrent approximation to the synthesis of neural network for control of processes phototherapy. 2015 IEEE 8th International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS). doi: https://doi.org/10.1109/idaacs.2015.7341389
30. Trunov, A. (2016). Peculiarities of the interaction of electromagnetic waves with bio tissue and tool for early diagnosis, prevention and treatment. 2016 IEEE 36th International Conference on Electronics and Nanotechnology (ELNANO). doi: https://doi.org/10.1109/elnano.2016.7493041
31. Trunov, A. (2017). Theoretical predicting the probability of electron detachment for radical of cell photo acceptor. 2017 IEEE 37th International Conference on Electronics and Nanotechnology (ELNANO). doi: https://doi.org/10.1109/elnano.2017.7939776
32. Trunov, A. (2017). Recurrent Approximation in the Tasks of the Neural Network Synthesis for the Control of Process of Phototherapy. Computer Systems Healthcare and Medicine. Denmark, 213–248.
33. Trunov, A., Malcheniuk, A. (2018). Recurrent network as a tool for calibration in automated systems and interactive simulators. Eastern-European Journal of Enterprise Technologies, 2 (9 (92)), 54–60. doi: https://doi.org/10.15587/1729-4061.2018.126498
34. Trunov, A., Fisun, M., Malcheniuk, A. (2018). The processing of hyperspectral images as matrix algebra operations. 2018 14th International Conference on Advanced Trends in Radioelecrtronics, Telecommunications and Computer Engineering (TCSET). doi: https://doi.org/10.1109/tcset.2018.8336305

35. Gil-Lafuente, A. M. (2005). Fuzzy Logic In Financial Analysis. Springer-VerlagBerlin Heiderberg, 450. doi: https://doi.org/10.1007/3-540-32368-6
36. Trunov, A. (2018). Transformation of operations with fuzzy sets for solving the problems on optimal motion of crewless unmanned vehicles. Eastern-European Journal of Enterprise Technologies, 4 (4 (94)), 43–50. doi: https://doi.org/10.15587/1729-4061.2018.140641
37. Batuner, L. A., Pozin, M. E. (1971). Matematicheskie metody v himicheskoy tekhnike. Leningrad: Himiya, 824.
38. Ivahnenko, A. G. (1981). Induktivniy metod samoorganizacii modeley slozhnyh sistem. Kyiv: Naukova dumka, 296.
39. Marchuk, G. I. (1977). Metody vychislitel'noy matematiki. Moscow: Nauka, 456.
40. Dykhta, L., Kozub, N., Malcheniuk, A., Novosadovskyi, O., Trunov, A., Khomchenko, A. (2018). Construction of the method for building analytical membership functions in order to apply operations of mathematical analysis in the theory of fuzzy sets. Eastern-European Journal of Enterprise Technologies, 5 (4 (95)), 22–29. doi: https://doi.org/10.15587/1729-4061.2018.144193
41. Ivahnenko, A. G. (2005). Obraznoe myshlenie kak soglasovanie rezul'tatov deduktivnogo myshleniya i variantov induktivnogo myshleniya. Upravlyayushchie sistemy i mashiny, 2, 3–7.
42. Madala, H. R., Ivakhnenko, G. (1994). Inductive learning algorithms for complex systems modeling. CRC Press.
43. Ivahnenko, A. G., Savchenko, E. A., Ivahnenko, G. A., Sinyavskiy, V. L. (2007). Problemy induktivnogo dvuhurovnevogo monitoringa slozhnyh processov. Upravlyayushchie sistemy i mashiny, 3, 13–21.
44. Ivahnenko, A. G., Stepashko, V. S. (1985). Pomekhoustoychivost' modelirovaniya. Kyiv: Naukova dumka, 216.
45. Korneychuk, N. P., Ligun, A. A., Doronin, V. V. (1982). Approksimaciya s ogranicheniyami. Kyiv: Naukova dumka, 252.
46. Popov, B. A., Tesler, G. S. (1980). Priblizhenie funkciy dlya tekhnicheskih prilozheniy. Kyiv: Naukova dumka, 352.
47. Popov, B. A., Malachivskiy, P. S. (1984). Nailuchshie chebyshevskie priblizheniya summoy mnogochlena i nelineynyh funkciy. Lviv, 70.

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DEVELOPMENT OF A METHOD FOR STRUCTURAL OPTIMIZATION OF A NEURAL NETWORK BASED ON THE CRITERION OF RESOURCE UTILIZATION EFFICIENCY (p. 57–65)

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At present, mathematical models in the form of artificial neural networks (ANNs) are widely used to solve problems on approximation. Application of this technology involves a two-stage approach that implies determining the structure for a model of ANN and the implementation of its training. Completion of the learning process makes it possible to derive a result of the approximation whose accuracy is defined by the complexity of ANN structure. In other words, increasing the ANN complexity allows obtaining a more precise result of training.

In this case, obtaining the model of ANN that implements approximation at the assigned accuracy is defined as the process of optimization.

However, an increase in the ANN complexity leads not only to the improved accuracy, but prolongs the time of computation as well.

Thus, the indicator «assigned accuracy» cannot be used in the problems on determining the optimum neural network architecture. This relates to that the result of the model structure selection and the process of its training, based on the required accuracy of approximation, might be obtained over a period of time unacceptable for the user.

To solve the task on structural identification of a neural network, the approach is used in which the model's configuration is determined based on a criterion of efficiency. The process of implementation of the constructed method implies adjusting a time factor related to solving the problem and the accuracy of approximation.

The proposed approach makes it possible to substantiate the principle of choosing the structure and parameters of a neural network based on the maximum value for the indicator of effective use of resources.

Keywords: artificial neural network, structure optimization, approximation of functions, efficiency criterion.

References

1. Gorban', A. N. (1998). Generalized approximation theorem and computational capabilities of neural networks. Siberian J. of Numer. Mathematics, 1 (1), 11–24.
2. Nelles, O. (2001). Nonlinear System Identification. From Classical Approaches to Neural Networks and Fuzzy Models. Springer, 785. doi: https://doi.org/10.1007/978-3-662-04323-3
3. Diniz, P. S. R. (2008). Adaptive Filtering: Algorithms and Practical Implementation. Springer. doi: https://doi.org/10.1007/978-0-387-68606-6
4. Mykhailenko, O. (2015). Research of adaptive algorithms of laguerre model parametrical identification at approximation of ore breaking process dynamics. Metallurgical and Mining Industry, 6, 109–117.
5. Mykhailenko, O. (2015). Ore Crushing Process Dynamics Modeling using the Laguerre Model. Eastern-European Journal of Enterprise Technologies, 4 (4 (76)), 30–35. doi: https://doi.org/10.15587/1729-4061.2015.47318
6. Haykin, S. (2009). Neural Networks and Learning Machines. Pearson, 938.
7. Yang, J., Ma, J., Berryman, M., Perez, P. (2014). A structure optimization algorithm of neural networks for large-scale data sets.

2014 IEEE International Conference on Fuzzy Systems (FUZZ-IEEE). doi: https://doi.org/10.1109/fuzz-ieee.2014.6891662
8. Han, S., Pool, J., Tran, J., Dally, W. (2015). Learning both Weights and Connections for Efficient Neural Network. Proceedings of Advances in Neural Information Processing Systems.
9. Liu, C., Zhang, Z., Wang, D. (2014). Pruning deep neural networks by optimal brain damage. INTERSPEECH 2014, 1092–1095.
10. Tresp, V., Neuneier, R., Zimmermann, H. G. (1996). Early Brain Damage. Proceedings of the 9th International Conference on Neural Information Processing Systems NIPS96, 669–675.
11. Christiansen, N. H., Job, J. H., Klyver, K., Hogsbrg, J. (2012). Optimal Brain Surgeon on Artificial Neural Networks in Nonlinear Structural Dynamics. In Proceedings of 25th Nordic Seminar on Computational Mechanics.
12. Babaeizadeh, M., Smaragdis, P., Campbell, R. H. (2016). NoiseOut: A Simple Way to Prune Neural Networks. Proceedings of 29th Conference on Neural Information Processing Systems (NIPS 2016). Barcelona.
13. He, T., Fan, Y., Qian, Y., Tan, T., Yu, K. (2014). Reshaping deep neural network for fast decoding by node-pruning. 2014 IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP). doi: https://doi.org/10.1109/icassp.2014.6853595
14. Takeda, R., Nakadai, K., Komatani, K. (2017). Node Pruning Based on Entropy of Weights and Node Activity for Small-Footprint Acoustic Model Based on Deep Neural Networks. Interspeech 2017, 1636–1640. doi: https://doi.org/10.21437/interspeech.2017-779
15. Islam, M., Sattar, A., Amin, F., Yao, X., Murase, K. (2009). A New Adaptive Merging and Growing Algorithm for Designing Artificial Neural Networks. IEEE Transactions on Systems, Man, and Cybernetics, Part B (Cybernetics), 39 (3), 705–722. doi: https://doi.org/10.1109/tsmcb.2008.2008724
16. Arifovic, J., Gençay, R. (2001). Using genetic algorithms to select architecture of a feedforward artificial neural network. Physica A: Statistical Mechanics and its Applications, 289 (3-4), 574–594. doi: https://doi.org/10.1016/s0378-4371(00)00479-9
17. Fiszelew, A., Britos, P., Ochoa, A., Merlino, H., Fernández, E., García-Martínez, R. (2007). Finding Optimal Neural Network Architecture using Genetic Algorithms. Advances in Computer Science and Engineering Research in Computing Science, 27, 15–24.
18. Yang, S.-H., Chen, Y.-P. (2012). An evolutionary constructive and pruning algorithm for artificial neural networks and its prediction applications. Neurocomputing, 86, 140–149. doi: https://doi.org/10.1016/j.neucom.2012.01.024
19. Lutsenko, I. (2016). Definition of efficiency indicator and study of its main function as an optimization criterion. Eastern-European Journal of Enterprise Technologies, 6 (2 (84)), 24–32. doi: https://doi.org/10.15587/1729-4061.2016.85453
20. Lutsenko, I., Fomovskaya, E., Oksanych, I., Koval, S., Serdiuk, O. (2017). Development of a verification method of estimated indicators for their use as an optimization criterion. Eastern-European Journal of Enterprise Technologies, 2 (4 (86)), 17–23. doi: https://doi.org/10.15587/1729-4061.2017.95914
21. Lutsenko, I., Fomovskaya, O., Vihrova, E., Serdiuk, O., Fomovsky, F. (2018). Development of test operations with different duration in order to improve verification quality of effectiveness formula. Eastern-European Journal of Enterprise Technologies, 1 (4 (91)), 42–49. doi: https://doi.org/10.15587/1729-4061.2018.121810
22. Lutsenko, I., Oksanych, I., Shevchenko, I., Karabut, N. (2018). Development of the method for modeling operational processes for tasks related to decision making. Eastern-European Journal of Enterprise Technologies, 2 (4 (92)), 26–32. doi: https://doi.org/10.15587/1729-4061.2018.126446