ABSTRACT AND REFERENCES

MATHEMATICS AND CYBERNETICS – APPLIED ASPECTS

OPTIMAL SYNTHESIS OF DIGITAL COUNTERS IN THE FIBONACCI CODES WITH THE MINIMAL FORM OF REPRESENTATION (p. 4-10)

Oleksiy Borysenko, Svitlana Matsenko, Igor Kulik, Olga Berezhna, Olexandr Matsenko

At present, requirements for speed performance and noise immunity in the work of the counters increase. Among the existing structures, the Fibonacci counters meet such requirements. Their drawback is transfer while calculating from the minimal form of representation of the Fibonacci numbers to the maximal form and, consequently, to the use of operations of convolution and deconvolution, which decreases speed, noise immunity and increases required hardware expenses.

We propose for the Fibonacci counters to use only minimal form of representation of the Fibonacci numbers, which excludes operations of convolution and deconvolution. Based on it, the method of the Fibonacci calculation in the minimal form is developed and its logical model is built in the form of a set of logical operations, whose fulfillment leads to the Fibonacci calculation. It gives the possibility to design the method of synthesis of the Fibonacci counters with the optimal ratio of performance speed, noise immunity and amount of hardware expenses for specific conditions of its work.

The advantage of the Fibonacci counters with the minimal form is their increased noise immunity. It is due to both the nature of the Fibonacci calculation itself, which works in the excess codes, and to the absence of transfers to the maximal form, where it is permitted to have the forbidden combinations. In this case, the probability of detecting errors grows with an increase in the number of bits of counter.

Keywords: Fibonacci numbers, minimal form, Fibonacci counters, noise immunity, high performance speed.

References

1. Goryachev, A. E., Degtyar, S. A. (2012). Metod generacii perestanovok na osnove faktorialnyx chisel s ispolzovaniem dopolnyayushhego massiva. Visnik Sumskogo derzhavnogo universitetu. Seriya Tehnichni nauki, 4, 86–93.
2. Borysenko, O. A., Kalashnikov, V. V., Protasova, T. A., Kalashnikova, N. I.; Silva, R. N. (Ed.) (2014). A New Approach to the Classification of Positional Numeral Systems. Series Frontiers of Artificial Intelligence and Applications (FAIA). IOS Press (The Netherlands), 262, 441–450.
3. Vorobev, N. N. (1969). Chisla Fibonachchi. Moscow: Nauka, 144.
4. Monteiro, P., Newcomb, R. (1976). Minimal and Maximal Fibonacci Representations: Boolean Generation. The Fibonacci Quarterly, 14 (1), 613–638.
5. Vajda, S. (1989). Fibonacci & Lucas Numbers, and the Golden Section. Ellis Horwood limited, 192.
6. Staxov, A. P. (1977). Vvedenie v algoritmicheskuyu teoriyu izmerenij. Moscow: Sov. radio, 288.
7. Staxov, A. P. (2012). Kody Fibonachchi i zolotoj proporcii kak alternativa dvoichnoj sistemy schisleniya. Chast 1. Germany: Academic Publishing, 305.
8. Gupta, N., Agarval, A., Goyal, G. (2015). United States Patent No. US8983023 B2. Digital Self-Gated Binary Counter. No. US 13/935,552; declared: 04.07.2013; published: 17.03.2015, 23.
9. Yeh, C.-H., Parhami, B., Wang, Y. (2000). Designs of Counters with Near Minimal Counting/Sampling Period and Hardware Complexity. Pacific Grove, CA, USA, 894–898. doi: 10.1109/acssc.2000.910642
10. Thamaraiselvan, K., Gayathri, C., Divya, N. (2013). A High Speed CMOS Parallel Counter Using Pipeline Partitioning. International Journal of Engineering Research, 2 (8), 491–495.
11. Bindu, S., Vineeth, V., Paulin, J. (2015). A Review on High Speed CMOS Counter Using Altera MAX300A. International Journal of Advanced Research in Computer and Communication Engineering, 4 (12), 589–592. doi: 10.17148/ijarcce.2015.412140
12. Azarov, O. D., Chernyak, O. I., Murashhenko, O. G. (2015). Shvidkodiyuchij reversivnij fibonachchievij lichilnik. Informacijni texnologii ta komp'yuterna inzheneriya, 1, 27–32.
13. Azarov, O. D., Chernyak, O. I. (2015). Metod shvidkodiyuchoi obernenoi lichbi z linijnim zrostannyam aparaturnix vitrat pri naroshhuvanni rozryadnosti. Visnyk Vinnyc'kogo politehnichnogo instytutu, 2 (119), 57–61.
14. Azarov, O. D., Chernyak, O. I., Murashhenko, O. G. (2014). Metod pobudovi shvidkodiyuchix fibonachchievix lichilnikiv. Problemy informatyzacii' ta upravlinnja, 2 (46), 5–8.
15. Borysenko, O. A., Stahov, O. P. (2014). Pat. na vynahid № 104939 U Ukrajna. MPK H03K 23/00 (2014.01). Pereshkodostijkyj lichyl'nyk impul'siv Borysenko-Stahova. № 201210506; declareted: 05.09.2012; published: 25.03.2014, Byul. 6

LOCALIZATION OF VECTORS–PATTERNS IN THE PROBLEMS OF PARAMETRIC CLASSIFICATION WITH THE PURPOSE OF INCREASING ITS ACCURACY (p. 10-20)

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The problem of the accuracy of classification, determined by the share of the correctly classified objects with the use of parametric methods of pattern recognition, is examined. In particular, we analyzed the influence of deviation from the normal law of distribution of variables of the space of features – random variables, in essence – and the inequality of covariance matrices of classes on the accuracy of classification. It was found that the inequality of covariance matrices of the divided classes leads to the shift of the dividing surface; however, the magnitude of this displacement may not become the essential factor, which influences the accuracy of classification. It is shown for the space of variables of dimensionality (N×2) that for the randomly selected classes inside the square with the length of the edge, equal to two, the accuracy of classification for classes A and B proves to be different and depends on the position of the straight line, which divides the classes. It is shown that localization of vectors-patterns in the space of features can be selected in accordance with the plans of full factorial experiment (FFE). Due to this localization, the equality of covariance matrices of the classes is ensured and the share of the correctly classified objects increases. We proposed, to overcoming the main shortcoming of the given research, connected to the absence of functional

dependencies, which make it possible to quantitatively evaluate the accuracy of classification at various variants of arrangement of FFE plans, to use the methods of experimental optimization. Its purpose is the selection of such coordinates of the centers of plans and their geometric characteristics for classes A and B, which ensure the maximum share of the correctly classified objects based on the obtained decision rules. The realization of this approach may become the reserve for the increase in the accuracy of classification with application of the methods of parametric optimization.

Keywords: parametric classification, covariance matrix, pattern recognition, accuracy of classification of objects, vector-pattern, cluster.

References

1. Nemrodov, D., Niemeier, M., Mok, J. N. Y., Nestor, A. (2016). The time course of individual face recognition: A pattern analysis of ERP signals. NeuroImage, 132, 469–476. doi: 10.1016/j.neuroimage.2016.03.006
2. Liu, L., Fieguth, P., Zhao, G., Pietikäinen, M., Hu, D. (2016). Extended local binary patterns for face recognition. Information Sciences, 358-359, 56–72. doi: 10.1016/j.ins.2016.04.021
3. Florindo, J. B., Bruno, O. M. (2016). Local fractal dimension and binary patterns in texture recognition. Pattern Recognition Letters, 78, 22–27. doi: 10.1016/j.patrec.2016.03.025
4. Barajas-García, C., Solorza-Calderón, S., Álvarez-Borrego, J. (2016). Classification of fragments of objects by the Fourier masks pattern recognition system. Optics Communications, 367, 335–345. doi: 10.1016/j.optcom.2016.01.059
5. Kushnirenko, O. A., Cadchenko, A. V., Troyanskiy, A. V. (2013). Correlation algorithm of recognition of character information with low-complexity of technical implementation. Eastern-European Journal of Enterprise Technologies, 3 (9 (63)), 42–45. Available at: http://journals.uran.ua/eejet/article/view/14848/12650
6. Kasian, K., Bratchykov, V., Shkarupylo, V. (2015). Development of modified method for text recognition in standardized picture. Eastern-European Journal of Enterprise Technologies, 3 (2 (75)), 11–17. doi: 10.15587/1729-4061.2015.43047
7. Fraze-Frazenko, A. (2012). Method for the regularization of ill-posed problems of recognition in CCTV. Technology audit and production reserves, 6 (4 (8)), 19–20. Available at: http://journals.uran.ua/tarp/article/view/5638/5080
8. Anokhin, M. (2014). Moving objects recognition method by their video images. Eastern-European Journal of Enterprise Technologies, 4 (9 (70)), 33–37. doi: 10.15587/1729-4061.2014.26275
9. Voloshyn, N. (2012). Identification of iris sign in automated systems of iridology based on Petri Nets. Technology audit and production reserves, 4 (1 (6)), 5–6. Available at: http://journals.uran.ua/tarp/article/view/4767/4418
10. Alfaro-Ponce, M., Argüelles, A., Chairez, I. (2016). Pattern recognition for electroencephalographic signals based on continuous neural networks. Neural Networks, 79, 88–96. doi: 10.1016/j.neunet.2016.03.004
11. Nesterenko, S. A., Stanovskiy, A. O., Oborotova, O. O. (2015). The wireless computer networks state recognition over the three-dimensional field of directions. Technology audit and production reserves, 6 (2 (26)), 28–35. doi: 10.15587/2312-8372.2015.56825
12. Unglert, K., Radić, V., Jellinek, A. M. (2016). Principal component analysis vs. self-organizing maps combined with hierarchical clustering for pattern recognition in volcano seismic spectra. Journal of Volcanology and Geothermal Research, 320, 58–74. doi: 10.1016/j.jvolgeores.2016.04.014
13. Stuper, A. J., Brugger, W. E., Jurs, P. C. (1979). Computer Assisted Studies of Chemical Structure and Biological Function. Published by John Wiley & Sons.
14. Hartmann, K., Lezki, E., Schafer, V. (1974). Statistische Versuchsplanung und auswertung in der Stoffwirtschaft. Leipzig.
15. Pavlenko, V. D., Fomin, A. A. (2001). Povyishenie tochnosti postroeniya reshayuschego pravila v metodah statisticheskoy klassifikatsii. Elektronnoe modelirovanie, 23 (4), 61–68.
16. Vasenko, Y. (2012). Technology for improved wear iron. Technology audit and production reserves, 1 (1 (3)), 17–21. Available at: http://journals.uran.ua/tarp/article/view/4870/4521
17. Ponomarenko, O. I., Trenev, N. S. (2013). Computer modeling of crystallization processes as a reserve of improving the quality of pistons of ICE. Technology audit and production reserves, 6 (2 (14)), 36–40. Available at: http://journals.uran.ua/tarp/article/view/19529/17205
18. Ignaszaka, Z., Popielarskia, P., Krawiecb, K. (2007). Contribute to quantitative identification of casting defects based on computer analysis of X-ray images. Archives of foundry engineering, 7 (4 (18/4)), 89–94.
19. Lin, Z., Lyu, M. R., King, I. (2011). MatchSim: a novel similarity measure based on maximum neighborhood matching. Knowledge and Information Systems, 32 (1), 141–166. doi: 10.1007/s10115-011-0427-z
20. Arsirii, E., Manikaeva, O., Vasilevskaja, O. (2015). Development of the decision support subsystem in the systems of neural network pattern recognition by statistical information. Eastern-European Journal of Enterprise Technologies, 6 (4 (78)), 4–12. doi: 10.15587/1729-4061.2015.56429
21. Fraze-Frazenko, A. (2012). Algorithm of study neural network for image recognition. Technology audit and production reserves, 4 (1 (6)), 33–34. Available at: http://journals.uran.ua/tarp/article/view/4781/4432
22. Fertsev, A. A. (2012). Uskorenie obucheniya neyronnoy seti dlya raspoznavaniya izobrazheniy s pomoschyu tehnologii NVidia Cuda. Vestnik Samarskogo gosudarstvennogo tehnicheskogo universiteta, 1 (26), 183–191.
23. Unglert, K., Radić, V., Jellinek, A. M. (2016). Principal component analysis vs. self-organizing maps combined with hierarchical clustering for pattern recognition in volcano seismic spectra. Journal of Volcanology and Geothermal Research, 320, 58–74. doi: 10.1016/j.jvolgeores.2016.04.014
24. Fakhar, K., El Aroussi, M., Saidi, M. N., Aboutajdine, D. (2016). Fuzzy pattern recognition-based approach to biometric score fusion problem. Fuzzy Sets and Systems. doi: 10.1016/j.fss.2016.05.005
25. Perova, I. G. (2014). Adaptive treatment of these medico-biological researches by methods of computational intelligence. Eastern-European Journal of Enterprise Technologies, 1 (4 (67)), 24–28. doi: 10.15587/1729-4061.2014.21202
26. Demin, D. A., Pelikh, V. F., Ponomarenko, O. I. (1998). Complex alloying of grey cast iron. Litejnoe Proizvodstvo, 10, 18–19.
27. Demin, D. A. (1998). Change in cast iron's chemical composition in inoculation with a Si-V-Mn master alloy. Litejnoe Proizvodstvo, 6, 35.

INTERVAL FUZZY MODELING OF COMPLEX SYSTEMS UNDER CONDITIONS OF INPUT DATA UNCERTAINTY (p. 20-28)

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Modeling natural systems and processes often requires making decisions under conditions of data uncertainty. There are a number of applications, in which obtaining data about the system is a time- and resource-consuming process. That is why it is advisable to develop decision making mathematical models and methods capable of functioning on input data that has gaps.

In the scope of this research an aggregated interval type-2 fuzzy data classification model was built. Interval type-2 fuzzy set mathematics operates membership grades in an interval form. This allows to take uncertainties intrinsic for an input vector into account, and enables working with an input vector that has gaps instead of some of the values. The proposed system supports involving one or more experts on early stages of the decision making process, more specifically in the phase of informative feature extraction. A feature set provided by every expert generates a separate model with an interval output. Such an approach achieves incorporating expert's knowledge and experience into the decision making process along with information accumulated in the experimental data set. The results of multiple models are subsequently aggregated into a single interval, which is a generalized interval estimation of the system's status based on data available at the moment, and allows to get an idea of the uncertainty associated with the decision taken.

It is also allowed to integrate third party models based on other decision making methods and technologies, such as a modification of the PCM cluster analysis method with interval membership grades.

The aggregated model was adapted for approximate evaluation of groundwater extraction perspective on different states of hydrogeological exploration. It was determined that in some cases it can save significant cost and human resources.

Keywords: fuzzy logic system, interval fuzzy sets, uncertainty, cluster analysis.

References

1. Bardachev, Yu. N., Krjuchkovskyj, V. V., Malomuzh, T. V. (2010). Metodologicheskaya predpochtitelnost intervalnyih ekspertnyih otsenok pri prinyatii resheniy v usloviyah neopredelennosti. Visnyk Kharkivsjkogho nacionaljnogho universytetu, 890, 18–28.
2. Pankratova, N. D., Zavodnyk, V. V. (2004). Sistemnyiy analiz i otsenivanie dinamiki ekologicheskih protsessov. Systemni doslidzhennja ta informacijni tekhnologhii, 2, 47–59.
3. Borevskiy, B. V., Drobnohod, N. I., Yazvin, L. S. (1989). Otsenka zapasov podzemnyih vod. Kyiv: Vyscha shk. Golovnoe izd-vo, 407.
4. Kondratenko, N. R., Snihur, O. O. (2015). Ocinka perspektyvnosti arteziansjkoi sverdlovyny z vykorystannjam ekspertnykh znanj. Materialy statej P'jatoi Mizhnarodnoi naukovo-praktychnoi konferencii "Informacijni tekhnologhii ta komp'juterna inzhenerija", 219–221.
5. Minaev, Yu. N. (2003). Metodyi i algoritmyi resheniya zadach identifikatsii i prognozirovaniya v usloviyah neopredelennosti v neyrosetevom logicheskom bazise. Moscow: Goryachaya Liniya-Telekom, 205.
6. Cai, W., Chen, S., Zhang, D. (2007). Fast and robust fuzzy c-means clustering algorithms incorporating local information for image segmentation. Pattern Recognition, 40 (3), 825–838. doi: 10.1016/j.patcog.2006.07.011
7. De Andrés, J., Lorca, P., de Cos Juez, F. J., Sánchez-Lasheras, F. (2011). Bankruptcy forecasting: A hybrid approach using Fuzzy c-means clustering and Multivariate Adaptive Regression Splines (MARS). Expert Systems with Applications, 38 (3), 1866–1875. doi: 10.1016/j.eswa.2010.07.117
8. Wang, J., Kong, J., Lu, Y., Qi, M., Zhang, B. (2008). A modified FCM algorithm for MRI brain image segmentation using both local and non-local spatial constraints. Computerized Medical Imaging and Graphics, 32 (8), 685–698. doi: 10.1016/j.compmedimag.2008.08.004
9. Martyniuk, T. B., Kupershtein, L. M., Medvid, A. V., Kozhemiako, A. V., Wojcik, W., Yuchshenko, O. (2013). Applications of discriminant analysis methods in medical diagnostics. Optical Fibers and Their Applications 2012, 8698, 4. doi: 10.1117/12.2019733
10. Oliveira, J. V., Pedrycz W. (2007). Advances in Fuzzy Clustering and Its Applications. John Wiley & Sons Ltd., 435.
11. Kondratenko, N. R., Snihur, O. O. (2012). Intervaljna nechitka klasteryzacija na osnovi aljternatyvnykh kryteriiv jakosti. Naukovi visti NTUU «KPI», 2, 59–66.
12. Martyniuk, T. B., Kozhemiako, A. V., Kupershtein, L. M. (2015). Formalization of the Object Classification Algorithm. Cybernetics and Systems Analysis, 51 (5), 751–756. doi: 10.1007/s10559-015-9767-0
13. Kondratenko, N. R., Zelinsjka, N. B., Kuzemko, S. M. (2003). Diaghnostyka ghipotyreozu na osnovi nechitkoi loghiky z vykorystannjam intervaljnykh funkcij nalezhnosti. Naukovi visti NTUU «KPI», 4, 39–46.
14. Zeng, J., Liu, Z.-Q. (2007). Type-2 Fuzzy Sets for Pattern Classification: A Review. 2007 IEEE Symposium on Foundations of Computational Intelligence, 193–200. doi: 10.1109/foci.2007.372168
15. Kondratenko, N. R., Snihur, O. O. (2014). Nechitke modeljuvannja v zadachi ocinky jakosti zobrazhenj lazernykh pljam. Systemni doslidzhennja ta informacijni tekhnologhii, 3, 7–16.
16. Liang, Q., Mendel, J. M. (2001). MPEG VBR video traffic modeling and classification using fuzzy technique. IEEE Transactions on Fuzzy Systems, 9 (1), 183–193. doi: 10.1109/91.917124
17. Zaychenko, Yu. P., Esfandiyarfard, M., Zaika, A. I. (2007). Analiz investitsionnogo portfelya na osnove prognozirovaniya kursov aktsiy. Visnyk Nacionalnogo tekhnichnogo universytetutu Ukrainy «KPI», 47, 168–179.
18. Liang, Q., Mendel, J. M. (2000). Interval type-2 fuzzy logic systems: theory and design. IEEE Transactions on Fuzzy Systems, 8 (5), 535–550. doi: 10.1109/91.873577
19. Mendel, J. M. (2000). Uncertainty, fuzzy logic, and signal processing. Signal Processing, 80 (6), 913–933. doi: 10.1016/s0165-1684(00)00011-6
20. Ocampo-Duque, W., Ferré-Huguet, N., Domingo, J. L., Schuhmacher, M. (2006). Assessing water quality in rivers with fuzzy inference systems: A case study. Environment International, 32 (6), 733–742. doi: 10.1016/j.envint.2006.03.009
21. Gharibi, H., Mahvi, A. H., Nabizadeh, R., Arabalibeik, H., Yunesian, M., Sowlat, M. H. (2012). A novel approach in water quality assessment based on fuzzy logic. Journal of Environmental Management, 112, 87–95. doi: 10.1016/j.jenvman.2012.07.007

22. Yan, H., Zou, Z., Wang, H. (2010). Adaptive neuro fuzzy inference system for classification of water quality status. Journal of Environmental Sciences, 22 (12), 1891–1896. doi: 10.1016/s1001-0742(09)60335-1
23. Zou, Z., Yun, Y., Sun, J. (2006). Entropy method for determination of weight of evaluating indicators in fuzzy synthetic evaluation for water quality assessment. Journal of Environmental Sciences, 18 (5), 1020–1023. doi: 10.1016/s1001-0742(06)60032-6
24. Iliev, B., Lindquist, M., Robertsson, L., Wide, P. (2006). A fuzzy technique for food- and water quality assessment with an electronic tongue. Fuzzy Sets and Systems, 157 (9), 1155–1168. doi: 10.1016/j.fss.2005.12.014
25. Simeonov, V., Stratis, J. A., Samara, C., Zachariadis, G., Voutsa, D., Anthemidis, A. et. al. (2003). Assessment of the surface water quality in Northern Greece. Water Research, 37 (17), 4119–4124. doi: 10.1016/s0043-1354(03)00398-1
26. Dahiya, S., Singh, B., Gaur, S., Garg, V. K., Kushwaha, H. S. (2007). Analysis of groundwater quality using fuzzy synthetic evaluation. Journal of Hazardous Materials, 147 (3), 938–946. doi: 10.1016/j.jhazmat.2007.01.119
27. Singh, B., Dahiya, S., Jain, S., Garg, V. K., Kushwaha, H. S. (2007). Use of fuzzy synthetic evaluation for assessment of groundwater quality for drinking usage: a case study of Southern Haryana, India. Environmental Geology, 54 (2), 249–255. doi: 10.1007/s00254-007-0812-9
28. Dou, C., Woldt, W., Dahab, M., Bogardi, I. (1997). Transient Ground-Water Flow Simulation Using a Fuzzy Set Approach. Ground Water, 35 (2), 205–215. doi: 10.1111/j.1745-6584.1997.tb00076.x
29. Li, J., Huang, G. H., Zeng, G., Maqsood, I., Huang, Y. (2007). An integrated fuzzy-stochastic modeling approach for risk assessment of groundwater contamination. Journal of Environmental Management, 82 (2), 173–188. doi: 10.1016/j.jenvman.2005.12.018
30. Nobre, R. C. M., Rotunno Filho, O. C., Mansur, W. J., Nobre, M. M. M., Cosenza, C. A. N. (2007). Groundwater vulnerability and risk mapping using GIS, modeling and a fuzzy logic tool. Journal of Contaminant Hydrology, 94 (3-4), 277–292. doi: 10.1016/j.jconhyd.2007.07.008
31. Dixon, B. (2005). Applicability of neuro-fuzzy techniques in predicting ground-water vulnerability: a GIS-based sensitivity analysis. Journal of Hydrology, 309 (1-4), 17–38. doi: 10.1016/j.jhydrol.2004.11.010
32. Dixon, B. (2005). Groundwater vulnerability mapping: A GIS and fuzzy rule based integrated tool. Applied Geography, 25 (4), 327–347. doi: 10.1016/j.apgeog.2005.07.002
33. Kondratenko, N. R. (2014). Pidvyshhennya adekvatnosti nechitkykh modelej za rakhunok vykorystannya nechitkykh mnozhyn typu 2. Naukovi visti NTUU «KPI», 6, 56–61.
34. Ivahnenko, A. G. (1987). Modelirovanie slozhnyih sistem po eksperimentalnyim dannyim. Moscow: Rado i svyaz, 120.
35. Kondratenko, N. R. (2016). Application of Type-2 Membership Functions in Fuzzy Logic Systems. Research Bulletin of the National Technical University of Ukraine "Kyiv Politechnic Institute", 2, 43–50. doi: 10.20535/1810-0546.2016.2.51636
36. Karnik, N. N., Mendel, J. M., Qilian Liang. (1999). Type-2 fuzzy logic systems. IEEE Transactions on Fuzzy Systems, 7 (6), 643–658. doi: 10.1109/91.811231
37. Kondratenko, N. R., Snihur, O. O. (2015). Evolyucijnyj poshuk informatyvnykh oznak iz zaluchennyam eksperta v zadachi ocinky yakosti arteziansjkoi vody. Visnyk Vinnycjkogho politekhnichnogho instytutu, 3, 96–101.
38. Harkevich, A. A. (Ed.) (1959). Teoriya informatsii i ee prilozheniya (sbornik perevodov). Moscow: Fizmatgiz, 328.

SUMMATION OF BINARY CODES WITHOUT CARRY (p. 28-41)

Mykhailo Solomko, Liudmyla Zubyk, Peter Olshansky, Vitalii Nazaruk

The paper considers the operation of summation of binary codes in the scheme of a multi digit parallel adder without carry. The process of the operation of summation uses a pairing algorithm that provides for a logarithmic complexity to the algorithm of the calculation in the adder's scheme. Since the codes for the operation of summation, known in the literature, such as Galois field codes, the XAND codes, are defined by the systems of recurrent codes that contain one of the initial codes of complete combinatorial system with repetition, then the given codes are a particular case of the class of combinatorial systems of binary codes with a ring structure and initial code of complete combinatorial system with repetition. Therefore, the only basis of the mentioned systems of binary codes indicates the usefulness of their classification generalization, within the framework of the operation of summation, on the basis of a single criterion – an object of binary codes. Thus, the generalization of the classification of binary codes simplifies the structure of the subject area, increases the variety of systems of binary codes, in particular, for their application in arithmetic operations with binary numbers. It was established that the properties of the recurrent method of the synthesis of binary codes allow focusing the principle of building codes in the range of complete combinatorial system with repetition, which ensures reduction of the thesaurus of the parallel adder of binary codes without carry.

The results of this study may be a component of the technology of designing electronic computing systems because:

– they expand the apparatus of obtaining recurrent binary codes for their application in the information technology;

– they provide a possibility to control the selection of the code at the stage of designing a computing device;

– they help predict the impact of the implementation of the selected code for the solution of problems of the information systems;

– they minimize hardware costs associated with the selection of the system of binary code for the calculation.

Keywords: adder, combinatorial system with repetition, binary codes, summation of binary codes, cascade scheme, class of combinatorial systems, instance of the class, thesaurus, logarithmic complexity.

References

1. Nikolaichuk, Y. M. (2010). Teoriya djerel informatsii [Theory sources]. Ternopil: TzOv Terno-Graf., 534.
2. Nikolaichuk, Y. M., Zastavna, O. M., Gumen, P. V. (2012). Theoretical foundations and principles of arithmetic logic unit vertically through information technology. News of Khmelnytsky national university, 2, 190–196. Available at: http://www.nbuv.gov.ua/old_jrn/natural/Vchnu_tekh/2012_2/49nic.pdf
3. Solomko, M., Krulikovskyi, B., Nikolaichuk, Y. M. (2015). Parallel adder carry no transfer in logic elements XAND. Proceedings of the National University «Lviv Polytechnic» Computer systems and networks, 830, 145–158. Available at: http://ena.lp.edu.ua:8080/xmlui/bitstream/handle/ntb/32480/21-145-158.pdf?sequence=4&isAllowed=y

4. Gopinath, B., Sangeetha, N., Jenifer nancy, S., Umarani, T. (2015). Design and Implementation of High Speed Carry Select Adder. International Journal of Engineering Research & Technology (IJERT), 4 (02), 419–422. Available at: https://zenodo.org/record/33085/files/Design_and_Implementation_of_High_Speed_Carry_Select_Adder.pdf
5. Deepthi, E., Rani, V. M., Manasa, K. (2015). Performance Analysis of a 64-bit signed Multiplier with a Carry Select Adder Using VHDL. IJCSNS International Journal of Computer Science and Network Security, 15 (11), 91–94. Available at: http://paper.ijcsns.org/07_book/201511/20151118.pdf
6. Solomko, M., Krulikovskyi, B. (2016). Study of carry optimization while adding binary numbers in the rademacher number-theoretic basis. Eastern-European Journal of Enterprise Technologies, 3/4 (81), 56–63. doi: 10.15587/1729-4061.2016.70355
7. Maity, S., Prasad De, B., Singh, A. Kr. (2012). Design and Implementation of Low-Power High-Performance Carry Skip Adder. International Journal of Engineering and Advanced Technology (IJEAT), 1 (4), 212–218. Availabnle at: http://202.120.43.103/Downloads4/20150616101558803.pdf
8. Singh, R. P. P., Kumar, P., Singh, B. (2009). Performance Analysis of 32-Bit Array Multiplier with a Carry Save Adder and with a Carry-Look-Ahead Adder. International Journal of Recent Trends in Engineering, 2 (6), 83–86. Available at: http://searchdl.org/public/journals/2009/IJRTET/2/6/307.pdf
9. Sajid, A., Nafees, A., Rahman, S. (2013). Design and Implementation of Low Power 8-bit Carry-look Ahead Adder Using Static CMOS Logic and Adiabatic Logic. International Journal of Information Technology and Computer Science, 5 (11), 78–92. doi: 10.5815/ijitcs.2013.11.09
10. Srinivasa Rao, N., Satyanarayana, P. (2015). Serial Adder using Reversible Gates. International Journal of Advanced Research in Computer and Communication Engineering, 4 (5), 498–501. Available at: http://www.ijarcce.com/upload/2015/may-15/IJARCCE%20105.pdf
11. Joshi, D. D., Singh, J. K. (2014). Design and Implementation of 16-bit Ripple Carry Adder for Low Power in 45nm CMOS Technology. International Journal of Emerging Technology and Advanced Engineering, 4 (1), 216–220.
12. Nykolajchuk, Ja. M. (2012). Kody polja Galua: teorija ta zastosuvannja. Ternopil': TzOV Terno-Graf, 576.
13. Martynjuk, T. B. (2000). Rekursyvni algorytmy bagatooperandnoi' obrobky informacii'. Vinnycja: "UNIVERSUM-Vinnycja", 216.
14. Martynjuk, T. B., Homjuk, V. V. (2005). Metody ta zasoby paralel'nyh peretvoren' vektornyh masyviv danyh. Vinnycja: "UNIVERSUM-Vinnycja", 202.
15. Hamaiun, V. P. (1990). On the development of computational structures mnogooperandnyh. Control systems and machines, 4, 31–33.
16. Hamaiun, V. P. (1999). Theoretical bases, algorithms and structures in operational processing. Kyiv, 33.

AN INVESTIGATION OF THE REDUCTION MODEL POWER INFLUENCE ON THE ACCURACY OF THE OBJECT'S POSITION ASSESSMENT USING RELATIVE METHOD (p. 42-49)

Artem Pohorelov, Vadym Savanevych, Serhii Udovenko

We investigated the influence of the reduction model power on the accuracy of the object's position assessment using the relative method. The research considered reduction polynomials of the third and fifth power, their influence on the accuracy of the celestial object's position assessment and distribution of reference stars in the frame. The result of the analysis showed the presence of a sinusoidal component in the dependence of the residual of parameters of celestial objects when the cubic reduction model is used. It also showed almost complete elimination of this component in case of using the fifth-power reduction model, which increased the number of reference stars in the frame's edges as well as accuracy indicators of position assessments of celestial objects. The assessment criteria of significance of the reduction model coefficients using the Fisher's f-criteria proved the validity of application of the polynomial model with the power, that is higher than cubic.

The results of the research can be used to improve the accuracy of estimation of celestial objects positions in the frame in the CCD-automated processing systems, which assess the position of objects in the entire field of view of the telescope.

Keywords: astrometric reduction, digital frame, celestial object, reduction model, assessment of accuracy indicators.

References

1. Pankaj, J. (2015). An introduction to astronomy and astrophysics. Boca Raton: CRC Press, 365.
2. Kieran, J. E., Mohamed, M. G. (2014). Astronomy and Big Data. Springer Press, 104. doi: 10.1007/978-3-319-06599-1
3. Kiselev, A. A. (1989). Teoreticheskie osnovanija fotograficheskoj astrometrii. Moscow: Nauka, Gl. red. Fiz-mat. lit, 264.
4. Sasian, M. J. (2013). Introduction to aberrations in optical imaging systems. Edinburgh: Cambridge University Press, 261.
5. Duma, D. P. (2007). Zagal'na astrometrija. Kyiv: Naukova dumka, 600.
6. Zacharias, N., Finch, C. T., Girard, T. M., Henden, A., Bartlett, J. L., Monet, D. G., Zacharias, M. I. (2013). The fourth us naval observatory CCD astrograph catalog (UCAC4). The Astronomical Journal, 145 (2), 44. doi: 10.1088/0004-6256/145/2/44
7. Roeser, S., Demleitner, M., Schilbach, E. (2010). The PPMXL catalog of positions and proper motions on the ICRS. Combining USNO-B1.0 and the two micron all sky survey (2MASS). The Astronomical Journal, 139 (6), 2440–2447. doi: 10.1088/0004-6256/139/6/2440
8. Fedorov, P. N., Akhmetov, V. S., Shulga, V. M. (2014). The reference frame for the XPM2. Monthly Notices of the Royal Astronomical Society, 440 (1), 624–630. doi: 10.1093/mnras/stu291
9. Akhmetov, V. S., Fedorov, P. N., Velichko, A. B., Shulga, V. M. (2015). The kinematics parametersof the Galaxy using data of modern astrometric catalogues. Odessa Astronomical Publications, 28 (2), 154–157.
10. Andruk, V. M., Pakuliak, L. K., Golovnia, V. V. et. al. (2015). Catalog of pasitions and B-magnitudes of stars in the circumpolar region of Northen Sky Survey (FON) project. Odessa Astronomical Publication, 28 (2), 192–195.
11. Andruk, V. M., Relke, H., Protsyuk, Yu. I. et. al. (2015). Comparision of zero zone catalogues of the FON program based on the Kyiv and Kitab observations. Odessa Astronomical Publications, 28 (2), 188–191.
12. Robert, V., De Cuyper, J.-P., Arlot, J.-E., De Decker, G., Guibert, J. et. al. (2011). A new astrometric reduction of photographic plates using the DAMIAN digitizer: improving the dynamics of the Jovian system. MNRAS, 415 (1), 701–708.

13. Eglitis, I., Eglite, M., Shatokhina, S. V. et. al. (2016). Asteroids from digitised processing of photographic observations in Baldone. AstroPlate.
14. Protsyuk, Yu. I., Andruk, V. M., Relke, H. (2016). The original astrometric software package for digitized photographic plates. Astroplate.
15. Bezkrovnyj, M. M., Kozhuhov, A. M., Savanevich, V. E., Annenkov, A. B., Sokovikova, N. S. (2012). Ocenka mestopolozhenija ob'ekta na PZS-kadre pri srednem vremeni jekspozici. Sistemi obrobki informacii, 7 (105), 44–50.
16. Savanevich, V. E., Brjuhoveckij, A. B., Kozhuhov, A. M., Dikov, E. N. (2010). Ocenka jekvatorial'nyh koordinat asteroida po ocenkam ego koordinat na CCD-kadre. Sistemi obrobki informacii, 6 (87), 172–179.
17. Zacharias, N., Gaume, R., Dorland, B., Urban, S. E. Catalog Information and Recomendations, U.S. Naval Observatory. Available at: http://ad.usno.navy.mil/star/star_cats_rec.shtml
18. Savanevich, V. E., Movsesjan, Ja. S., Dihtjar, N. Ju. (2016). Metod formirovanija vnutrennego kataloga obektov, nepodvizhnyh na serii kadrov. Sistemi obrobki informacii, 8 (145), 45–49.
19. Robin, M. G. (1985). Spherical Astronomy. New York: Cambridge Univercity Press, 536.
20. Řeřábek, M., Páta, P., Koten, P. (2008). Processing of the Astronomical Image Data obtained from UWFC Optical Systems. Image Reconstruction from Incomplete Data V, 7076. doi: 10.1117/12.794858
21. Maksutov, D. D. (1984). Astronomicheskaja optika. Moscow: Nauka, gl. red. Fiz-mat. lit., 272.
22. McLean, I. S. (2008). Electronic Imaging in Astronomy. Detectors and Instrumentation. Berlin: Springe-Praxis, 552. doi: 10.1007/978-3-540-76583-7
23. Smith, G. E. (2010). Nobel Lecture: The invention and early history of the CCD. Reviews of Modern Physics, 82 (3), 2307–2312. doi: 10.1103/revmodphys.82.2307
24. Ermakov, S. M., Zhyhliavskyi, A. A. (1987). Matematycheskaia teoryia optymalnoho eksperymenta. Moscow: Nauka, 320.
25. Draper, N. R., Smith, H. (1998). Applied regression analysis. John Wiley & Sons, Inc., 716. doi: 10.1002/9781118625590
26. Bezkrovnyj, M. M., Dashkova, A. N., Sokovikova, N. S., Savanevich, V. E., Brjuhoveckij, A. B. (2015). Research methods of statistical characteristics of CCD-measurement of position and brightness of the Solar system objects. Technology audit and production reserves, 2 (2 (22)), 26–37. doi: 10.15587/2312-8372.2015.40820
27. Savanevych, V. E., Briukhovetskyi, O. B., Sokovikova, N. S., Bezkrovny, M. M., Vavilova, I. B., Ivashchenko, Y. M. et. al. (2015). A new method based on the subpixel Gaussian model for accurate estimation of asteroid coordinates. Monthly Notices of the Royal Astronomical Society, 451 (3), 3287–3298. doi: 10.1093/mnras/stv1124
28. Savanevych, V. E., Briukhovetskyi, A. B., Ivashchenko, Y. N., Vavilova, I. B., Bezkrovniy, M. M., Dikov, E. N. et. al. (2015). Comparative analysis of the positional accuracy of CCD measurements of small bodies in the solar system software CoLiTec and Astrometrica. Kinematics and Physics of Celestial Bodies, 31 (6), 302–313. doi: 10.3103/s0884591315060045
29. Savanevych, V. E., Briukhovetskyi, A. B., Kozhukhov, A. M., Dykov, E. N., Vlasenko, V. P. (2010). Program CoLiTec avtomatyzyrovannoho obnaruzhenyia nebesnykh tel so slabym bleskom. Kosmichna nauka i tekhnolohiia, 18 (1), 39–46.

REALIZATION OF THE PARADIGM OF PRESCRIBED CONTROL OF A NONLINEAR OBJECT AS THE PROBLEM ON MAXIMIZATION OF ADEQUACY (p. 50-58)

Alexander Trunov

Here we propose a new realization of the paradigm of prescribed control on the example of a vector model in the form of nonlinear non-stationary system of differential equations of the first order, for which a control system is synthesized. The estimation of efficiency is introduced as a continuous, three times differentiated, dimensionless function. Dimensionless objective function and the function of Lagrange with the inequalities constraints is formed. The problem of minimization of square deviation is posed for them as the problem of maximization of one of the criteria of adequacy – accuracy. It is written in a formalized way in the form of a system of nonlinear algebraic equations. For construction of its solution, a recurrent approximation of objective function is used, which made it possible to complement the system with new equations and to find, in a general form, expressions of auxiliary vectors independent on the number of components of the vectors of strategies and the Lagrange multipliers. Two additional equations are brought out, which realize maximization of adequacy by two additional criteria: depth and completeness. All this taken together made it possible to complement the system with new nonlinear equations, which, in turn, increased substantially the number of permissible inequalities constraints. This approach considers the properties of a non-stationary nonlinear model, which describes the object independent of the selection of the purpose of control. As a result of the solution of the problem, it was possible to connect the idea about the adequate, prescribed behavior of model and the properties of a nonlinear object, to obtain a differential equation that describes optimal controlling action, which, in this case, maximizes adequacy.

It was demonstrated that in a particular case, under condition of independence of the rate of change in controlling influence on its magnitude, the obtained results coincide with expressions of the method of speed gradient. The estimations of the norm of error in the vector of strategies are presented depending on the properties of object, error in the function of efficiency and synthesized law of controlling action for the prescribed law of the object's functioning.

The set and solved problem demonstrated possibilities to set, with the aid of cybernetic methods, a new type of problems on adequate control. The latter is especially relevant in connection with application of integrated computer technologies. The obtained solutions without artificial assumptions make it possible to synthesize controlling action for the conditions that change over time both in the properties of object and in constraints.

Keywords: prescribed control, maximization of adequacy, additional equations in the problem of optimal control.

References

1. Blekhman, Y. Y., Fradkov, A. L. (2001). Upravlenye mekhatronnymy vybratsyonnymy ustanovkamy. Sankt-Peterburg: Nauka, 85.
2. Bryllyuen, L. (1960). Nauka y teoryya ynformatsyy. Moscow: Fyzmathyz, 392.

3. Butkovskyy, A. H., Samoylenko, Yu. Y. (1984). Upravlenye kvantovo-mekhanycheskymy protsessamy. Moscow: Nauka, 256.
4. Bak, P. E., Yoshino, R. (2000). A Dynamical Model of Maxwell's Demon and Confinement Systems. Contributions to Plasma Physics, 40 (3-4), 227–232. doi: 10.1002/1521-3986(200006)40:3/4<227::aid-ctpp227>3.0.co;2-y
5. Blekhman, I. I. (Ed.) (2004). Selected Topics in Vibrational Mechanics. Series on Stability, Vibration and Control of Systems, Series A. Singapore: World Scientific, 440. doi: 10.1142/9789812794529
6. Brockett, R. W.; Martin, C., Hermann, R. (Eds.) (1977). Control theory and analytical mechanics In Geometric Control Theory. Vol. VII. Lie Groups. Brookline, MA: Mat. Sci. Press, 1–48.
7. Valyev, K. A., Kokyn, A. (2000). Kvantovyy komp'yuter: mechta yly real'nost'? Yzhevsk: RKhD, 352.
8. Gabor, D. (1953). Communication theory and physics. Transactions of the IRE Professional Group on Information Theory, 1 (1), 48–59. doi: 10.1109/tit.1953.1188558
9. Gubarenko, G. V., Ovezgel'diev, A. O., Petrov, E. G. (2013). Modeli i metody upravlenija ustojchivym razvitiem social'no-jekonomicheskih sistem. Kherson: Iz-vo Grin', 252.
10. Karu, T. (2003). Low-Power Laser Therapy. Chep. 48. Biomedical Photonics Handbook. CRC Press, 1787. doi: 10.1201/9780203008997.ch48
11. Karu, T. I. (2008). Mitochondrial Signaling in Mammalian Cells Activated by Red and Near-IR Radiation. Photochemistry and Photobiology, 84 (5), 1091–1099. doi: 10.1111/j.1751-1097.2008.00394.x
12. Kadomtsev, B. B. (1994). Dynamics and information. Physics-Uspekhi, 37 (5), 425–499. doi: 10.1070/pu1994v037n05abeh000109
13. Kadomtsev, B. B. (1999). Dynamyka y ynformatsyya. Moscow: Red. zhurn. "Uspekhy fyzycheskykh nauk", 400.
14. Kilin, S. Y. (1999). Quantum information. Physics-Uspekh, 42 (5), 435–452. doi: 10.1070/pu1999v042n05abeh000542
15. Kozeev, V. A. (1985). Povyshenye bezotkaznosty y tochnosty nelyneynykh system upravlenyya. Leningrad: Enerhoatomyzdat, 127.
16. Kondratenko, Y. P., Sidenko, Ie. V. (2012). Correction of the Knowledge Database of Fuzzy Decision Support System with Variable Structure of the Input Data. Minsk: Publ. Center of BSU, 56–61.
17. Kondratenko, Y. P., Korobko, V. V., Korobko, O. V. (2013). Distributed computer system for monitoring and control of thermoacoustic processes. IEEE 7th International Conference on Intelligent Data Acquisition and Advanced Computing Systems (IDAACS), 249–253. doi: 10.1109/idaacs.2013.6662682
18. Kondratenko, Y., Klymenko, L., Kondratenko, V., Kondratenko, G., Shvets, E. (2013). Slip Displacement Sensors for Intelligent Robots: Solutions and Models. 2013 IEEE 7th International Conference on Intelligent Data Acquisition and Advanced Computing Systems (IDAACS), 861–866. doi: 10.1109/idaacs.2013.6663050
19. Kryuchkovskiy, V. V., Petrov, E. G., Brynza, N. A. (2010). Informativnaya predpochtitelnost statisticheskoy formy predstavleniya iskhodnykh dannykh v usloviyakh intervalnoy neopredelennosti. Computer science. Telecommunications and control systems, 4 (103), 11–18.
20. Khodakov, V. E., Vezumskiy, A. K. (2013). Kharakternye osobennosti odnogo klassa sotsial'no-ekonomicheskikh system. Problemi Informatsiynikh, 2 (014), 10–14.
21. Landauer, R. (1996). Minimal Energy Requirements in Communication. Science, 272 (5270), 1914–1918. doi: 10.1126/science.272.5270.1914
22. H. S. Leff, A. F. Rex (Eds.) (1990). Maxwell's Demon: Entropy, Information, Computing. New York: Random House.
23. Neymark, Yu. Y., Landa, P. S. (1987). Stokhastycheskye y khaotycheskye kolebanyya. Moscow: Nauka, 424.
24. Ott, E., Grebogi, C., Yorke, J. A. (1990). Controlling chaos. Physical Review Letters, 64 (11), 1196–1199. doi: 10.1103/physrevlett.64.1196
25. Poplavskyy, R. P. (1981). Termodynamyka ynformatsyonnykh protsessov. Moscow: Nauka, 255.
26. Peierls, R. (1983). Postroenie fizicheskikh modeley. Uspekhi fizicheskikh nauk, 140 (6), 315. doi: 10.3367/ufnr.0140.198306d.0315
27. Petrov, E. G. Brynza, N. A. (2013). Sintez modeli prinyatiya investitsionnykh resheniy v usloviyakh mnogokriterial'nosti. Problemi Informatsiynikh tekhnologiy, 14, 6–25.
28. Stratonovych, R. L. (1975). Teoryya ynformatsyy. Moscow: Sov. radyo, 424.
29. Stratonovych, R. L., Polyakova, M. S. (1981). Elementy molekulyarnoy fyzyky, termodynamyky y statystycheskoy fyzyky. Moscow: Yzd-vo MHU, 176.
30. Solodovnikov, V. V. (1951). Sintez korrektiruyushchikh ustroystv sledyashchikh sistem pri tipovykh vozdeystviyakh. Avtomatika i telemekhanika, 5, 352–388.
31. Szilard, L. (1929). Über die Entropieverminderung in einem thermodynamischen System bei Eingriffen intelligenter Wessen. Zeitschrift for Physik, 53 (11-12), 840–856. doi: 10.1007/bf01341281
32. Trunov, A. N. (2011). Recurrence approximation in problems of modeling and design. Monografy, Mykolayiv:Petro Mohyla BSSU, 272.
33. Trunov, A. N. (2013). Intellectualization of the models' transformation process to the recurrent sequence. European Applied Sciences, Ort Publishing, 9 (1), 123–130.
34. Trunov, A. N. (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), 169–174. doi: 10.1109/elnano.2016.7493041
35. Trunov, A. N. (2014). Application of the recurrent approximation method to synthesis of neuron net for determination the hydrodynamic characteristics of underwater vehicles. Problem of Information Technology, 02 (016), 39–47.
36. Trunov, A. N. (2014). The formation of unified method of technological process effectiveness evolution. Problemi informatsiynikh tekhnologiy, 14, 104–108.
37. Trunov, O. M. (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: 10.15587/1729-4061.2015.37204
38. Trunov, A. N. (2015). Maximization of adequacy as the tool of formulation and improving of model. Problem of Information Technology, Jornal, 01 (017), 70–76.
39. Trunov, A. N. (2015). Modernization of means for analysis and solution of nonlinear programming problems. Metody Ilościowe w Badaniach Ekonomicznych, 16 (2), 133–141.
40. Turchyn, V. F. (2000). Fenomen nauky: Kybernetycheskyy podkhod k evolyutsyy. Moscow: ETS, 368.
41. Fradkov, A. L., Yakubovskyy, O. A. (Eds.) (2003). Upravlenye molekulyarnymy y kvantovymy systemamy. Moscow – Yzhevsk: Ynstytut komp'yuternykh yssledovanyy, 416.

42. Fradkov, A. L. (2003). Kybernetycheskaya fyzyka. Sankt-Peterburg: Nauka, 208.
43. Fradkov, A. L. (2005). O primenenii kiberneticheskikh metodov v fizike. Uspekhi Fizicheskih Nauk, 175 (2), 113–138. doi: 10.3367/ufnr.0175.200502a.0113
44. Fradkov, A. L., Pogromsky, A. Yu. (1998). Introduction to Control of Oscillations and Chaos. World Scientific Series on Nonlinear Science Series A. doi: 10.1142/9789812798619
45. Fradkov, A. (1999). Exploring nonlinearity by feedback. Physica D: Nonlinear Phenomena, 128 (2-4), 159–168. doi: 10.1016/s0167-2789(98)00322-4
46. Kholevo, A. S. (2002). Vvedenye v kvantovuyu teoryyu ynformatsyy. Moscow: Yzd-vo MTsNMO, 128.
47. Zaychenko, J. P. (2000). Operational Research. Kyiv, 688.
48. Naeser, M. A., Hamblin, M. R. (2015). Traumatic Brain Injury: A Major Medical Problem That Could Be Treated Using Transcranial, Red/Near-Infrared LED Photobiomodulation. Photomedicine and Laser Surgery, 33 (9), 443–446. doi: 10.1089/pho.2015.3986
49. Selivanov, A., Fradkov, A., Fridman, E. (2015). Passification-based decentralized adaptive synchronization of dynamical networks with time-varying delays. Journal of the Franklin Institute, 352 (1), 52–72. doi: 10.1016/j.jfranklin.2014.10.007
50. Fradkov, A. L. (2011). International conferences in control systems: Traditions and trends. Automation and Remote Control, 72 (1), 160–163. doi: 10.1134/s0005117911010139
51. Dzhunusov, I. A., Fradkov, A. L. (2011). Synchronization in networks of linear agents with output feedbacks. Automation and Remote Control, 72 (8), 1615–1626. doi: 10.1134/s0005117911080029