INFORMATION TECHNOLOGIES

DOI: 10.15587/2312-8372.2019.172157

DATA MINING OF SUSTAINABLE DEVELOPMENT PROCESS WITH USING NIGHTLIGHT INDICATORS

page 4–8

Putrenko Viktor, *PhD, Senior Researcher, Education and Scientific Complex «World Data Center for Geoinformatics and Sustainable Development», National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Ukraine, e-mail: putrenko@wdc.org.ua, ORCID: http://orcid.org/0000-0002-0239-9241*

Pashynska Nataliia, *PhD, Senior Researcher, Department of Intellectual and Information Systems, Taras Shevchenko National University of Kyiv, Ukraine, e-mail: n_pashynska@ukr.net, ORCID: http://orcid.org/0000-0002-0133-688X*

The object of research is the process of sustainable development of territorial units on the example of the regions of Ukraine. The concept of sustainable development has become a leading development strategy for most countries in the world. One of the biggest challenges is the availability of complete and verified data for sustainable development assessment models. The method used to calculate the index of sustainable development, developed in the World Data Center for Geoinformatics and Sustainable Development of the National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute». This methodology is based on calculating the metric of the index of sustainable development based on measurements of the quality of life of the population and the components of the safety of living for individual countries and regions. For the application of the methodology at the regional level, it was suggested to use information on the night lighting of the territory received by means of remote sensing of the Earth from satellites. The character and cohesiveness of the connection between the brightness of night lighting and indicators of sustainable development are studied. It is established that the most significant link exists between indicators of the economic development index, the index of influence on climate change and night lighting of the regions of Ukraine. Based on geographic information analysis of ArcGIS software, ESRI has applied statistical zoning tools that provide opportunities for statistical processing of satellite images within the regionally or regionally allocated areas.

On the basis of the mathematical apparatus of the intellectual data analysis, a global and local regression analysis of the relationships between the revealed indicators was carried out. Consideration of the cramped nature of this connection in the territorial section revealed areas with varying degrees of close ties, which is explained by the peculiarities of the socio-economic development of the territories. Due to this, it is possible to obtain the calculation of similar indicators at more detailed territorial levels, corresponding to separate regions or cities of regional significance.

Keywords: data mining, sustainable development, nightlight luminocity, spatial regression, geospatial analysis.

References

1. *Revised list of global Sustainable Development Goal indicators.* Available at: https://unstats.un.org/sdgs/indicators/Official %20Revised %20List %20of %20global %20SDG %20indicators.pdf Last accessed: 26.06.2019
2. The Sustainable Development Goals Report 2016 (2016). *UN.* Available at: http://ggim.un.org/documents/The%20Sustainable%20Development%20Goals %20Report%202016.pdf
3. Prototype Global Sustainable Development Report – Executive Summary (2013). *UN-DESA.* Available at: https://sustainabledevelopment.un.org/content/documents/975GSDR %20 Executive %20Summary.pdf
4. Global Sustainable Development Report – 2016 (2016). *UN.* Available at: https://sustainabledevelopment.un.org/content/documents/2328Global %20Sustainable %20development %20report %202016 %20(final).pdf
5. The Applied Remote Sensing Training (ARSET) program (2017). *NASA.* Available at: https://arset.gsfc.nasa.gov/
6. Satellite Derived Annual PM2.5 Data Sets in Support of United Nations Sustainable Development Goals (2017). *NASA.* Available at: https://arset.gsfc.nasa.gov/airquality/webinars/AQ-SDG-17
7. Putrenko, V. V., Pashynska, N. M. (2017). The use of remote sensing data for modeling air quality in the cities. *ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences, IV-5/W1,* 57–62. doi: http://doi.org/10.5194/isprs-annals-iv-5-w1-57-2017
8. Putrenko, V. (2017). Data mining of relationship in crowdsourcing projects and social activities of citizens. *Proceedings IEEE 1st Ukraine Conference on Electrical and Computer Engineering (UKRCON),* 1060–1065. doi: http://doi.org/10.1109/ukrcon.2017.8100413
9. Remote Sensing of Land Indicators for Sustainable Development Goal 15. *NASA.* Available at: https://arset.gsfc.nasa.gov/land/webinars/sdg15
10. Lieskovsky, A. J. (2014). *Electricity Use as an Indicator of U.S. Economic Activity.* Washington: Energy Information Administration, 87.
11. Henderson, J. V., Storeygard, A., Weil, D. N. (2012). Measuring Economic Growth from Outer Space. *American Economic Review, 102 (2),* 994–1028. doi: http://doi.org/10.1257/aer.102.2.994
12. Coupe, T., Myck, M., Najsztub, M. (2016). And the Lights Went Out — Measuring the Economic Situation in Eastern Ukraine. *VoxUkraine.* Available at: https://voxukraine.org/en/and-the-lights-went-out-measuring-the-economic-situation-in-eastern-ukraine-en/
13. Lyalko, V. I., Sakhatsky, O. I., Elistratova, L. O., Apostolov, A. A. (2017). Use of space images of NPP / VIIRS at night to assess the economic crisis in the East of Ukraine (Donetsk and Luhansk regions). *Bulletin of the National Academy of Sciences of Ukraine, 2,* 48–53. doi: http://doi.org/10.15407/visn2017.02.048
14. Zgurovsky, M., Yefremov, K., Putrenko, V. (2014). Sustainable Development Analysis: Global and Regional Contexts. *Int. Science Council (ICSU). Part 2. «Ukraine in the Indicators of Sustainable Development».* Kyiv: NTUU «KPI», 172.
15. Zgurovsky, M. Z., Boldak, A. A., Yefremov, K. V. (2013). Intelligent analysis and the systemic adjustment of scientific data in interdisciplinary research. *Cybernetics and Systems Analysis, 49 (4),* 541–552. doi: http://doi.org/10.1007/s10559-013-9539-7

DOI: 10.15587/2312-8372.2019.173122

DEVELOPMENT OF A COMBINED IMAGE RECOGNITION MODEL

page 9–14

Voloshyn Mykola, *Postgraduate Student, Department of Hybrid Modeling and Control Systems in Power Engineering, Pukhov Institute for Modelling in Energy Engineering of National Academy of Sciences of Ukraine, Kyiv, Ukraine, ORCID: http://orcid.org/0000-0003-1290-6152, e-mail: info@dreams.global*

The object of research is the processes of identification and classification of objects in computer vision tasks. Currently, for the recognition of images, the best results are demonstrated by artificial neural networks. However, learning neural networks is a poorly conditioned task. Poor conditioning means that even a large data set can carry a small amount of information about

a problem that is being solved. Therefore, a key role in the synthesis of parameters of a specific mathematical model of a neural network belongs to educational data. Selection of a representative training set is one of the most difficult tasks in machine learning and is not always possible in practice.

The new combined model of image recognition using the non-force interaction theory proposed in the paper has the following key features:

– designed to handle large amounts of data;

– selects useful information from an arbitrary stream;

– allows to naturally add new objects;

– tolerant of errors and allows to quickly reprogram the behavior of the system.

Compared to existing analogues, the recognition accuracy of the proposed model in all experimental studies was higher than the known recognition methods. The average recognition accuracy of the proposed model was 71.3 %; using local binary patterns – 59.9 %; the method of analysis of the main components – 65.2 %; by the method of linear discriminant analysis – 65.6 %. Such recognition accuracy in combination with computational complexity makes this method acceptable for use in systems operating in conditions close to real time. Also, this approach allows to manage the recognition accuracy. This is achieved by adjusting the number of sectors of the histograms of local binary patterns that are used in the description of images and the number of image fragments used in the classification stage by the introformation approach. To a large extent, the number of image fragments affects the time of classification, since in this case, it is necessary to calculate the matching of the system actions in each of the possible directions in pairs.

Keywords: computer vision systems, image analysis, object recognition and identification.

References

1. Wagner, P. (2011). *Principal Component Analysis and Linear Discriminant Analysis with GNU Octave*. Available at: https://www.bytefish.de/blog/pca_lda_with_gnu_octave/
2. Samal, A., Iyengar, P. A. (1992). Automatic recognition and analysis of human faces and facial expressions. *Pattern Recognition, 25 (1),* 65–77. doi: http://doi.org/10.1016/0031-3203(92)90007-6
3. Ojala, T., Pietikainen, M., Maenpaa, T. (2002). Multiresolution gray-scale and rotation invariant texture classification with local binary patterns. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 24 (7),* 971–987. doi: http://doi.org/10.1109/tpami.2002.1017623
4. Tomashevich, N. S. (2007). Statisticheskie metody vydeleniia priznakov. *Neirokompiutery v prikladnykh zadachakh obrabotki izobrazhenii,* 121–128.
5. Volchenkov, M. P., Samonenko, I. Iu. (2005). Ob avtomaticheskom raspoznavanii lits. *Intellektualnye sistemy, 9 (1-4),* 135–156.
6. Simard, P. Y., Steinkraus, D., Platt, J. C. (2003). Best practices for convolutional neural networks applied to visual document analysis. *12th International Conference on Document Analysis and Recognition, 2,* 958. doi: http://doi.org/10.1109/icdar.2003.1227801
7. LeCun, Y., Huang, F.-J., Bottou, L. (2004). Learning methods for generic objects recognition with invariance to pose and lighting. Los Alamitos. *Proceedings of the Computer Vision and Pattern Recognition Conference (CVPR'04), 2,* 97–104. doi: http://doi.org/10.1109/cvpr.2004.1315150
8. Mitrofanov, C. A. (2015). Sravnenie effektivnosti razlichnykh metodov intellektualnogo analiza dannykh v zadachakh raspoznavaniia izobrazhenii. *Innovatsionnaia nauka, 12 (2),* 96–98.
9. Mamontov, D. Iu., Karaseva, T. S. (2015). Reshenie zadach finansovogo analiza s pomoshchiu intellektualnykh informatsionnykh tekhnologii. *ITSiT*. Available at: https://studfiles.net/preview/5966499/
10. Krizhevsky, A., Sutskever, I., Hinton, G. E. (2012). ImageNet classification with deep convolutional neural networks. *Advances in Neural Information Processing Systems, 25,* 1106–1114.
11. *Amsterdam Library of Object Images (ALOI)*. Available at: http://aloi.science.uva.nl/
12. *The Chars74K dataset*. Available at: http://www.ee.surrey.ac.uk/CVSSP/demos/chars74k/
13. *The Database of Faces*. Available at: http://www.cl.cam.ac.uk/research/dtg/attarchive/facedatabase.html
14. *Celebrities Data Images Set for Computer Vision*. Available at: http://cdiset.blogspot.com/

DOI: 10.15587/2312-8372.2019.176121

DEVELOPMENT OF CLASSIFICATION MODEL BASED ON NEURAL NETWORKS FOR THE PROCESS OF IRON ORE BENEFICIATION

page 15–19

Senko Anton, *Assistant, Department of Computer Systems and Networks, Kryvyi Rih National University, Ukraine, e-mail: antonysenko@gmail.com, ORCID: http://orcid.org/0000-0002-4104-8372*

Kupin Andrey, *Doctor of Technical Sciences, Professor, Head of Department of Computer Systems and Networks, Kryvyi Rih National University, Ukraine, e-mail: kupin.andrew@gmail.com, ORCID: http://orcid.org/0000-0001-7569-1721*

Mysko Bohdan, *Postgraduate Student, Department of Computer Systems and Networks, Kryvyi Rih National University, Ukraine, e-mail: b.misko@outlook.com, ORCID: http://orcid.org/0000-0002-2801-3052*

The object of research is the processes of beneficiation of iron ore in the conditions of a mining and processing plant. Iron ore beneficiation factory near parallel to existing production lines or concentration sections. One of the key characteristics that determine the operating mode of the grinding apparatus is the crushing of ore, directly related to its strength. But unlike other parameters, the problem is with constant monitoring of the strength value. The determination of this parameter requires a laboratory study of the technological ore sample from the conveyor of the beneficiation section. The specifics of the working conditions of the beneficiation section complicate the monitoring of the strength parameter by installing a hardware sensor directly on the conveyor. Therefore, it is proposed to determine it by forecasting. Based on Big Data information technologies, using the accumulated statistical data, it is possible to forecast data between the technological samples.

The technological process of ore beneficiation in the conditions of a mining and processing plant is systematically analyzed. The generalized structure of the classification model is presented, which, based on the accumulated statistical data of the beneficiation section based on the current parameters of the section, is able to determine the parameters of incoming raw materials. The unknown parameter is determined using the counterpropagation neural network, which combines the following algorithms: a self-organizing Kohonen map and a Grossberg star. Their combination leads to an increase in the generalizing properties of the network. The training sample is formed as a result of clustering the statistical data of the beneficiation section and selecting the cluster to which the current status of the section works.

The presented forecasting algorithm, based on a combination of clustering methods and the use of a predictive neural network, allows the specialist to more quickly receive recommendations for making decisions regarding the behavior of the object compared to obtaining laboratory test data.

Keywords: classification model, computer support system for solutions, neural network, ore beneficiation, clustering of statistical data.

References

1. Kupin, A. I. (2009). *Uzghodzhene intelektualne keruvannia stadiyamy tekhnolohichnoho protsesu zbahachennia mahnetytovykh kvartsytiv v umovakh nevyznachenosti*. Kryvyi Rih: Kryvorizkyi natsionalnyi universytet, 926.
2. Goncharov, Yu. G., Davidkovich, Yu. G., Geyzenblazen, B. E. (1968). *Avtomaticheskiy kontrol' i regulirovanie tehnologicheskih protsessov na zhelezorudnyh obogatitel'nyh fabrikah*. Moscow: Nedra, 277.
3. Skorohodov, V. F., Hohulya, M. S., Biryukov, V. V. (2010). Sozdanie ehffektivnyh tehnologiy i tehniki obogashcheniya mineral'nogo syr'ya s primeneniem metodov vychislitel'noy gidrodinamiki. *Gorniy zhurnal, 12,* 79–84.
4. Ding, J., Chai, T., Wang, H. (2011). Offline Modeling for Product Quality Prediction of Mineral Processing Using Modeling Error PDF Shaping and Entropy Minimization. *IEEE Transactions on Neural Networks, 22 (3),* 408–419. doi: https://doi.org/10.1109/tnn.2010.2102362
5. Jäschke, J., Skogestad, S. (2011). NCO tracking and self-optimizing control in the context of real-time optimization. *Journal of Process Control, 21 (10),* 1407–1416. doi: https://doi.org/10.1016/j.jprocont.2011.07.001
6. Würth, L., Hannemann, R., Marquardt, W. (2011). A two-layer architecture for economically optimal process control and operation. *Journal of Process Control, 21 (3),* 311–321. doi: https://doi.org/10.1016/j.jprocont.2010.12.008
7. Lu, L. (2015). *Iron Ore. Mineralogy, Processing and Environmental Sustainability*. Elsevier, 666. doi: https://doi.org/10.1016/c2013-0-16476-8
8. Wills, B. A., Napier-Munn, T. (2006). *Wills' Mineral Processing Technology*. Elsevier, 456. doi: https://doi.org/10.1016/b978-0-7506-4450-1.x5000-0
9. Ghosh, A., Sharma, A. K., Nayak, B., Sagar, S. P. (2014). Infrared thermography: An approach for iron ore gradation. *Minerals Engineering, 62,* 85–90. doi: https://doi.org/10.1016/j.mineng.2013.12.002
10. Nevedrov, A. S., Oleynik, A. G. (2011). Ob instrumental'nyh sredstvah opredeleniya ehffektivnyh rezhimov obogashcheniya mineral'nyh rud. *Informatsionnye resursy Rossii, 5,* 35–38.
11. Morkun, V., Tron, V. (2014). Automation of iron ore raw materials beneficiation with the operational recognition of its varieties in process streams. *Metallurgical and Mining Industry, 6,* 4–7.
12. Hart, J. R., Zhu, Y., Pirard, E. (2011). Particle size and shape characterization: current technology and practice. *Advances in the Characterization of Industrial Minerals,* 77–127. doi: https://doi.org/10.1180/emu-notes.2010.emu9-4
13. Andreev, S. E., Perov, V. A., Zverevich, V. V. (1980). *Droblenie, izmel'chenie i grohochenie poleznyh iskopaemyh*. Moscow: Nedra, 415.
14. Werbos, P. J. (1989). Backpropagation and neurocontrol: a review and prospectus. *International Joint Conference on Neural Networks*. doi: https://doi.org/10.1109/ijcnn.1989.118583
15. Haykin, S. (1994). *Neural Networks. A comprehensive foundation*. New York: Macmillan, 696.
16. Zhang, B., Muhlenbein, H. (1993). Evolving optimal neural networks using genetic algorithms with Occam's razor. *Complex systems, 7 (3),* 199–220.
17. Goldberg, D. E. (1989). *Genetic Algorithms in Search, Optimization, and Machine Learning*. Massachusetts, 432.

MATHEMATICAL MODELING

DOI: 10.15587/2312-8372.2019.175020

SEARCH FOR IMPACT FACTOR CHARACTERISTICS IN CONSTRUCTION OF LINEAR REGRESSION MODELS

page 20–25

Geche Fedir, *Doctor of Technical Sciences, Professor, Head of Department of Cybernetics and Applied Mathematics, Uzhhorod National University, Ukraine, e-mail: fgeche@hotmail.com, ORCID: http://orcid.org/0000-0002-4757-9828*

Mulesa Oksana, *PhD, Associate Professor, Department of Cybernetics and Applied Mathematics, Uzhhorod National University, Ukraine, e-mail: mulesa.oksana@gmail.com, ORCID: http://orcid.org/0000-0002-6117-5846*

Hrynenko Viktor, *Postgraduate Student, Department of Cybernetics and Applied Mathematics, Uzhhorod National University, Ukraine, ORCID: http://orcid.org/0000-0002-4606-0792*

Smolanka Veronika, *Postgraduate Student, Department of Cybernetics and Applied Mathematics, Uzhhorod National University, Ukraine, e-mail: veronika.smolanka@uzhnu.edu.ua, ORCID: http://orcid.org/0000-0002-8380-1967*

The object of research is the task of constructing a linear regression model that arises in the process of solving the problem of predicting the values of a dependent variable on a set of independent factor characteristics. This task often arises in the process of analyzing indicators of economic activity of enterprises. The process of constructing a regression equation adequately reflects the relationship between factor attributes and the resultant attributes, is a multi-stage and time-consuming procedure. Important in this case is the stage of choosing the most influential factor characteristics. The adequacy of the regression model and the effectiveness of the analysis of the activities of enterprises depend on the effectiveness of this stage and the correct choice of a system of attributes. A number of methods and algorithms are proposed in scientific sources for choosing the most influential factor attributes. Some of them are based on correlation and regression analysis, but there are a number of heuristic methods. Studies have shown that the use of various methods for selecting the most influential factor attributes for solving specific problems, in the general case, leads to different results. Moreover, a feature of most methods is their computational complexity or instability about the conditions of use. The main criterion for the effectiveness of factor selection algorithms is the adequacy of the constructed regression model.

The study analyzes the process of constructing multiple linear regression models. Its main steps are determined and basic concepts and calculation formulas are given. The authors propose an algorithm for selecting the most influential factor attributes in constructing linear regression models. A feature of the proposed approach is that it is based on the properties of particular correlation coefficients. The application of the developed algorithm allows to reduce the computational complexity of the process of selecting factor attributes in comparison with known algorithms.

An experimental verification of the developed algorithm for the task of building dependencies between different performance indicators of two enterprises in the form of multiple linear regression is performed. As a result of the calculations, one or two influential features are selected from a system of 17 factor attributes for each indicator. The equations of multiple linear regression constructed in this way have a reliability that exceeds 90 %.

Keywords: multiple linear regression, partial correlation coefficients, factor attributes, model adequacy.

References

1. Smeekes, S., Wijler, E. (2018). Macroeconomic forecasting using penalized regression methods. *International Journal of Forecasting, 34 (3),* 408–430. doi: https://doi.org/10.1016/j.ijforecast.2018.01.001
2. Alvarez-Diaz, M., Alvarez, A. (2010). Forecasting exchange rates using local regression. *Applied Economics Letters, 17 (5),* 509–514. doi: https://doi.org/10.1080/13504850801987217
3. Cleland, A. C., Earle, M. D., Boag, I. F. (2007). Application of multiple linear regression to analysis of data from factory energy

surveys. *International Journal of Food Science & Technology, 16 (5),* 481–492. doi: https://doi.org/10.1111/j.1365-2621.1981.tb01841.x
4. Heche, F. E. (2019). *Teoriya ymovirnostei i matematychna statystyka*. Uzhhorod: AUTDOR-ShARK, 235.
5. Baltagi, B. (2008). *Econometric analysis of panel data*. John Wiley & Sons, 388.
6. Shojima, K., Usami, S., Hashimoto, T., Todo, N., Takano, K. (2018). Understanding Differences in Statistical Models. *The Annual Report of Educational Psychology in Japan, 57,* 302–308. doi: https://doi.org/10.5926/arepj.57.302
7. Depczynski, U., Frost, V. J., Molt, K. (2000). Genetic algorithms applied to the selection of factors in principal component regression. *Analytica Chimica Acta, 420 (2),* 217–227. doi: https://doi.org/10.1016/s0003-2670(00)00893-x
8. Tibshirani, R. (1996). Regression Shrinkage and Selection Via the Lasso. *Journal of the Royal Statistical Society: Series B (Methodological), 58 (1),* 267–288. doi: https://doi.org/10.1111/j.2517-6161.1996.tb02080.x
9. Mulesa, O. (2016). Development of evolutionary methods of the structural and parametric identification for tabular dependencies. *Technology audit and production reserves, 4 (2 (30)),* 13–19. doi: https://doi.org/10.15587/2312-8372.2016.74482
10. Azadeh, A., Ziaei, B., Moghaddam, M. (2012). A hybrid fuzzy regression-fuzzy cognitive map algorithm for forecasting and optimization of housing market fluctuations. *Expert Systems with Applications, 39 (1),* 298–315. doi: https://doi.org/10.1016/j.eswa.2011.07.020
11. *Ahentstvo z rozvytku infrastruktury fondovoho rynku Ukrainy*. Available at: https://smida.gov.ua/

SYSTEMS AND CONTROL PROCESSES

DOI: 10.15587/2312-8372.2019.173640

DEVELOPMENT OF MATHEMATICAL MODEL OF LOCALIZATION OF A SMALL EXPLOSIVE OBJECT WITH THE HELP OF A SPECIALIZED PROTECTIVE DEVICE

page 26–30

Stetsiuk Yevgen, *Department of Pyrotechnic and Special Training, National University of Civil Defence of Ukraine, Kharkiv, Ukraine, e-mail: stecyuke@gmail.com, ORCID: http://orcid.org/0000-0002-5204-9194*

In the work, as a research object, a protective device of a domed form is used which is used by pyrotechnic units to localize an emergency situation in the event of an explosion inside a small hazardous object. It is noted that one of the most problematic places of its application is the development of recommendations, implementation of which should ensure the prevention of the development of an emergency event up to a level of emergency on such priority effects as the number of victims and the number of victims. It is shown that the definition of such recommendations, providing localization of the consequences of an emergency in the case of an explosion of a small explosive object inside a specialized protective device, requires the obtaining of a mathematical model of localization of the focal point of an emergency. This model should provide an assessment of the strength of the technical means of localization of fragments and become the basis for the correction of existing operational procedures in the case of its application by pyrotechnic units. In the course of the study, the Eulerian-Lagrangian approach is used, which would allow obtaining a mathematical model of localization with the help of a dome-shaped form of the consequences of emergency situations in the event of an explosion inside a small-sized dangerous object. In practice, a mathematical model is implemented in a finite element packet using the library of the ANSYS/AUTODYN computer system. This allows not to create an actual new package of applications every time, as was done before to describe similar models. Due to this, an assessment of the strength of the technical means of localization of fragments is provided. In comparison with similar well-known models, the developed mathematical model allows to estimate the size of the minimum thickness of the protective device. It allows to withstand the explosion of a small-sized explosive object and to determine the minimum mass of the protective equipment taking into account the operational capabilities of the combat calculation of the pyrotechnic unit.

Keywords: protective device, mathematical model of explosion localization, strength of technical means, ANSYS package.

References

1. *Pro skhvalennia Stratehii reformuvannia systemy DSNS Ukrainy* (2017). Rozporiadzhennia Kabinetu Ministriv Ukrainy No. 61. 25.01.2017. Baza danykh «Zakonodavstvo Ukrainy». VR Ukrainy. Available at: https://zakon.rada.gov.ua/laws/show/61-2017-%D1%80
2. Xiao, T., Horberry, T., Cliff, D. (2015). Analysing mine emergency management needs: a cognitive work analysis approach. *International Journal of Emergency Management, 11 (3),* 191–208. doi: http://doi.org/10.1504/ijem.2015.071705
3. Toan, D. Q. (2015). Train-the-Trainer Trauma Care Programin Vietnam. *Journal of Conventional Weapons Destruction, 19 (1).* Available at: http://commons.lib.jmu.edu/cisr-journal/vol19/iss1/9
4. Smith, A. (2017). An APT Demining Machine. *Journal of Conventional Weapons Destruction, 21 (2).* Available at: http://commons.lib.jmu.edu/cisr-journal/vol21/iss2/15
5. Hadjadj, A., Sadot, O. (2013). Shock and blast waves mitigation. *Shock Waves, 23 (1),* 1–4. doi: http://doi.org/10.1007/s00193-012-0429-0
6. Tyas, A., Rigby, S. E., Clarke, S. D. (2016). Preface to special edition on blast load characterisation. *International Journal of Protective Structures, 7 (3),* 303–304. doi: http://doi.org/10.1177/2041419616666340
7. Blakeman, S. T., Gibbs, A. R., Jeyasingham, J. (2008). A study of mine resistant ambush protected (MRAP) vehicle as a model for rapid defence acquisitions. *MBA Professional Report Monterey Naval School.* Available at: http://www.dtic.mil/dtic/tr/fulltext/u2/a493891.pdf
8. Sherkar, P., Whittaker, A. S., Aref, A. J. (2010). Modeling the effects of detonations of high explosives to inform blast-resistant design. *Technical Report MCEER-10–0009.* Available at: https://ubir.buffalo.edu/xmlui/bitstream/handle/10477/25356/10-0009.pdf?sequence=3
9. *Armor Thane Reduces the Impact from Bombs and Bullets.* Available at: https://www.armorthane.com/protective-coating-applications/blast-mitigation-protection.htm
10. Togashi, F., Baum, J. D., Mestreau, E., Löhner, R., Sunshine, D. (2010). Numerical simulation of long-duration blast wave evolution in confined facilities. *Shock Waves, 20 (5),* 409–424. doi: http://doi.org/10.1007/s00193-010-0278-7
11. Snyman, I. M., Mostert, F. J., Olivier, M. (2013). Measuring pressure in a confined space. *27th international symposium on ballistics, 1,* 829–837.
12. Woodley, C., Feng, C., Li, B. (2018). Defence Technology. *1st International Conference on Defence Technology.* Beijing, 14 (5), 357–642. doi: http://doi.org/10.1016/s2214-9147(18)30442-2
13. Van den Berg, A. C. (2009). «BLAST»: A compilation of codes for the numerical simulation of the gas dynamics of explosions. *Journal of Loss Prevention in the Process Industries, 22 (3),* 271–278. doi: http://doi.org/10.1016/j.jlp.2008.07.004
14. Cullis, I. G., Nikiforakis, N., Frankl, P., Blakely, P., Bennett, P., Greenwood, P. (2016). Simulating geometrically complex blast scenarios. *Defence Technology, 12 (2),* 134–146. doi: http://doi.org/10.1016/j.dt.2016.01.005

15. Chaudhuri, A., Hadjadj, A., Sadot, O., Ben-Dor, G. (2012). Numerical study of shock-wave mitigation through matrices of solid obstacles. *Shock Waves, 23 (1),* 91–101. doi: http://doi.org/10.1007/s00193-012-0362-2
16. Remennikov, A. M., Mendis, P. A. (2006). Prediction of airblast in complex environments using artificial neural networks. *WIT transactions on the build environment, structures under shock and impact IX,* 269. doi: http://doi.org/10.2495/su060271
17. *Programmnyi paket ANSYS*. Available at: https://sites.google.com/site/komputernoemodelirovanie/home/stati/programmnyj-paket-ansys
18. Andreev, S. G., Babkin, Iu. A., Baum, F. A. et. al.; Orlenko, L. P. (Ed.) (2002). *Fizika vzryva*. Vol. 1. Moscow: FIZMATLIT, 832.

DOI: 10.15587/2312-8372.2019.174529

ANALYSIS OF FOREIGN EXPERIENCE OF IMPLEMENTATION OF THE DUAL FORM OF EDUCATION AND ACCESSIBILITY OF ITS IMPLEMENTATION IN UKRAINE

page 31–38

Lechachenko Taras, *Postgraduate Student, Department of Cybersecurity, Ternopil Ivan Puluj National Technical University, Ukraine, e-mail: Taras5a@ukr.net, ORCID: http://orcid.org/0000-0003-1185-6448*

The object of research is the foreign experience of the dual form of education. One of the most problematic places is the effective transfer of the dual form of education to countries with a lack of experience in the implementation and functioning of this type of education. The difficulty of transferring dual education lies in the long-term formation of a model in the countries of origin. Characteristic features of dual learning models were obtained as a result of the influence of local factors and conditions of the countries of origin. The complexity of the transfer also lies in the formalization of the assessment data of the potential of the country of implementation. To solve this problem, fuzzy logic methods are best suited. The advantage of using a fuzzy logic apparatus is the ability to formalize the data of complex systems, converting qualitative indicators into quantitative ones and vice versa. Method of fuzzy inference of the Matlab software environment is used.

In this paper, an analysis of the prerequisites for the introduction of dual education in Ukraine is carried out. The analysis of the foreign experience of dual education is carried out. As a result, factors are identified and grouped into three subsystems (economic, political, cultural and educational) to assess the potential for introducing dual education in Ukraine.

The simulation results shown in the study provide an answer to the question of the feasibility of implementing the dual form of education and assessing this potential of Ukraine. The data obtained as a result of modeling indicate the feasibility of introducing dual education in Ukraine. This is due to the fact that the fuzzy modeling method showed that the integral estimate belongs to the mean of the output term. Among the positive factors that influenced this result, it is worth noting the level of government spending on GDP and the level of prestige of vocational education.

The advantage of research is a quantitative assessment of the potential of transfer of the dual form of education in Ukraine, which is also important from the point of view of the international discourse of transfer of the dual form of education. The paper formalizes the model of the country's potential for the introduction of dual education.

Keywords: dual education, vocational education, fuzzy logic, integrated assessment, fuzzy inference system.

References

1. Rojko, A. (2017). Industry 4.0 Concept: Background and Overview. *International Journal of Interactive Mobile Technologies, 11 (5),* 77–90. doi: http://doi.org/10.3991/ijim.v11i5.7072
2. *Approval of the Concept for the Development of the Digital Economy and Society of Ukraine for 2018–2020 and approval of the plan of measures for its implementation* (2018). Order of the Cabinet of Ministers of Ukraine No. 67-p. 17.01.2018. Available at: http://zakon2.rada.gov.ua/laws/show/67-2018- %D1 %80
3. Gessler, M. (2017). The lack of collaboration between companies and schools in the German dual apprenticeship system: Historical background and recent data. *International Journal for Research in Vocational Education and Training (IJRVET), 4 (2),* 164–195. doi: http://doi.org/10.13152/IJRVET.4.2.4
4. Thelen, K. A., Busemeyer, M. R. (2008). *From collectivism towards segmentalism: Institutional change in German vocational training (No. 08/13). MPIfG discussion paper*. Available at: https://www.mpifg.de/pu/mpifg_dp/dp08-13.pdf
5. Deissinger, T., Hellwig, S. (2005). Apprenticeships in Germany: modernising the Dual System. *Education + Training, 47 (4/5),* 312–324. doi: http://doi.org/10.1108/00400910510601896
6. Gonon, P. (2005). Challenges in the Swiss vocational education and training system. *Berufs-und Wirtschaftspädagogik online, 7*.
7. Eichhorst, W., Rodríguez-Planas, N., Schmidl, R., Zimmermann, K. F. (2012). *A roadmap to vocational education and training systems around the world*. Available at: http://repec.iza.org/dp7110.pdf
8. Euler, D. (2013). *Germany's dual vocational training system: a model for other countries?* doi: http://doi.org/10.11586/2017022
9. Langthaler, M. (2015). *The transfer of the Austrian dual system of vocational education to transition and developing countries: An analysis from a developmental perspective (No. 53). Working Paper, Austrian Foundation for Development Research (ÖFSE)*. Available at: https://www.oefse.at/fileadmin/content/Downloads/Publikationen/Workingpaper/WP53_dual_system.pdf
10. Modláné, I. G. (2015). *With Dual Training in the World of Work*. Budapest: Hungarian Chamber of Commerce and Industry, 56.
11. *On Approval of the Concept of Training of Specialists in the Dual Form of Education Regulation* (2018). Cabinet of Ministers of Ukraine; Concept No. 660-p. 09.09.2018. Available at: https://zakon.rada.gov.ua/laws/show/660-2018-r
12. Lerman, R. I. (2017). Why Firms Do and Don't Offer Apprenticeships. *Vocational Education and Training in Times of Economic Crisis*, 305–320. doi: http://doi.org/10.1007/978-3-319-47856-2_16
13. Acemoglu, D., Pischke, J. (1999). Beyond Becker: Training in Imperfect Labour Markets. *The Economic Journal, 109 (453),* 112–142. doi: http://doi.org/10.1111/1468-0297.00405
14. Koudahl, P. D. (2010). Vocational education and training: dual education and economic crises. *Procedia – Social and Behavioral Sciences, 9,* 1900–1905. doi: http://doi.org/10.1016/j.sbspro.2010.12.421
15. Zadeh, L. A. (1965). Fuzzy sets. *Information and Control, 8 (3),* 338–353. doi: http://doi.org/10.1016/s0019-9958(65)90241-x
16. Zade, L. (1976). *The concept of a linguistic variable and its application to making approximate decisions*. Moscow: World, 167.
17. Leonenkov, A. V. (2005). *Fuzzy Modeling in MATLAB and fuzzy TECH*. Saint Petersburg: BHV-Petersburg, 736.
18. Rogatinsky, R. M, Garmatiy, N. M. (2015). *Mathematical Methods of Market Economy for Cybernetics Specialists*. Ternopil: Aston, 206.
19. *Official site of the State Statistics Service of Ukraine*. Available at: http://www.ukrstat.gov.ua/
20. *Official site of Eurostat*. Available at: https://ec.europa.eu/eurostat/data/database
21. *Official site of Organisation for Economic Co-operation and Development OECD*. Available at: https://data.oecd.org
22. *BDO international business compass* (2018). Available at: https://www.bdo.global/en-gb/insights/bdo-germany/bdo-international-business-compass-2018

23. *Paying Taxes* (2018). PwC Global. Available at: https://www.pwc.com/gx/en/paying-taxes/pdf/pwc_paying_taxes_2018_full_report.pdf
24. *WEF Global Competitiveness Report* (2018). Available at: http://reports.weforum.org/global-competitiveness-report-2018/competitiveness-rankings/#series=GCI4.C.07.01
25. *Transparency International. Corruption perception index* (2018). Available at: https://www.transparency.org/cpi2018
26. Gutman, P. (2016). *Tackling trends in turnover*. Mercer Consulting. Available at: https://www.mercer.com/content/dam/mercer/attachments/global/webcasts/gl-2016-webcast-talent-tackling-trends-in-turnover-mercer.pdf
27. Carpio, D. X., Kupets, O., Muller, N., Olefir, A. (2017). *Skills for a Modern Ukraine. Washington: Overview booklet*. World Bank, License: Creative Commons Attribution CC BY 3.0 IGO. Available at: http://wbgfiles.worldbank.org/documents/hdn/ed/saber/supporting_doc/Background/WFD/SABER_WFD_Background_Skills_for_a_modern_Ukraine.pdf
28. *Official Website of the State Employment Service*. Available at: https://www.dcz.gov.ua

REPORTS ON RESEARCH PROJECTS

DOI: 10.15587/2312-8372.2019.173913

ELABORATION OF THE HIERARCHICAL APPROACH TO SEGMENTATION OF SCANNED DOCUMENTS IMAGES

page 39–42

Ishchenko Alesya, *Senior Lecturer, Department of Applied Mathematics and Information Technologies, Odessa National Polytechnic University, Ukraine, e-mail: alesya.ishchenko@gmail.com, ORCID: http://orcid.org/0000-0002-7882-4718*

Zhuchkovskyi Vladyslav, *Department of Applied Mathematics and Information Technologies, Odessa National Polytechnic University, Ukraine, e-mail: pzmaus45@gmail.com, ORCID: http://orcid.org/0000-0001-7364-784X*

The object of research is the process of recognizing the areas of scanned documents images. The paper proposes a hierarchical approach to the segmentation of scanned documents images. This approach is an image of a scanned document in the form of a multi-level structure. At each level of the structure, images containing structural regions are highlighted. Objects of the lower level strictly correlate with a certain area of the image of the upper level: areas of the photo and graphics correspond to the image containing the illustrations, and areas of text and background to the image containing both the text and the background at the same time. Using a hierarchical approach, it is possible to perform processing separately for each image area, namely: first, the areas of illustrations are highlighted on the original image of the scanned document using the analysis of connected components. Thus, the first level of the hierarchy consists of an image containing illustrations and an image containing text with a background. Then the areas of illustrations are divided into photos and graphics by splitting the areas of illustrations into blocks, and text areas are separated from the background using processing in the neighborhood of each pixel. Thus, the second level of the hierarchy is represented by images containing homogeneous areas: photos, graphics, text and background. The hierarchical approach to segmentation has reduced the processing time by an average of 80 times. The reduction in image processing time was due to the fact that at each level and in turn, in a separate part of the hierarchical structure, it was possible to take into account the structural features of a uniform image area corresponding to this level. And also choose the signs of identification of these areas with high computational efficiency, the use of which also reduced the processing time of the scanned document.

Keywords: hierarchical approach, scanned documents, image.

References

1. Shafait, F., Keysers, D., Breuel, T. M. (2008). Performance Evaluation and Benchmarking of Six-Page Segmentation Algorithms. *IEEE Transactions on Pattern Analysis and Machine Intelligence, 30 (6)*, 941–954. doi: http://doi.org/10.1109/tpami.2007.70837
2. Kumar, S., Gupta, R., Khanna, N., Chaudhury, S., Joshi, S. D. (2007). Text Extraction and Document Image Segmentation Using Matched Wavelets and MRF Model. *IEEE Transactions on Image Processing, 16 (8)*, 2117–2128. doi: http://doi.org/10.1109/tip.2007.900098
3. Acharyya, M., Kundu, M. K. (2001). Multiscale Segmentation of Document Images Using M-Band Wavelets. *Lecture Notes in Computer Science*, 510–517. doi: http://doi.org/10.1007/3-540-44692-3_62
4. Cesarini, F., Gori, M., Marinai, S., Soda, G. (1999). Structured document segmentation and representation by the modified X-Y tree. *Proceedings of the Fifth International Conference on Document Analysis and Recognition. ICDAR'99 (Cat. No.PR00318)*, 563. doi: http://doi.org/10.1109/icdar.1999.791850
5. Baird, H. S., Moll, M. A., An, C., Casey, M. R. (2007). Document image content inventories. *Document Recognition and Retrieval XIV*. doi: http://doi.org/10.1117/12.705094
6. Vilkin, A., Egorova, M. (2010). Segmentatsiia otskanirovannykh dokumentov. *GrafiKon'2010*, 339–341.
7. Moiseev, N. N. (1981). *Matematicheskie zadachi sistemnogo analiza*. Moscow: Nauka, 487.
8. de Queiroz, R. L., Buckley, R. R., Xu, M. (1999). Mixed Raster Content (MRC) Model for Compound Image Compression. *Visual Communications and Image Processing*. San Jose, 3653, 1106–1117. doi: http://doi.org/10.1117/12.334618
9. Ishchenko, A., Polyakova, M., Kuvaieva, V., Nesteryuk, A. (2018). Elaboration of structural representation of regions of scanned document images for MRC model. *Eastern-European Journal of Enterprise Technologies, 6 (2 (96))*, 32–38. doi: http://doi.org/10.15587/1729-4061.2018.147671
10. Polyakova, M., Ishchenko, A., Huliaieva, N. (2018). Document image segmentation using averaging filtering and mathematical morphology. *Telecommunications and Computer Engineering (TCSET)*. Lviv-Slavske. doi: http://doi.org/10.1109/tcset.2018.8336354
11. Polyakova, M., Ishchenko, A., Volkova, N., Pavlov, O. (2018). Combined method for scanned documents images segmentation using sequential extraction of regions. *Eastern-European Journal of Enterprise Technologies, 5 (2 (95))*, 6–15. doi: http://doi.org/10.15587/1729-4061.2018.142735
12. Magnier, B., Montesinos, P., Diep, D. (2011). Ridges and Valleys Detection in Images Using Difference of Rotating Half Smoothing Filters. *Lecture Notes in Computer Science*. Ghent, 261–272. doi: http://doi.org/10.1007/978-3-642-23687-7_24
13. Gusak, D. E., Ishhenko, A. V. (2019).Vydelenie tekstovykh fragmentov na izobrazhenii otskanirovannogo dokumenta. *Suchasni informatsiini tekhnologii*. Odessa.
14. Sauvola, J., Kauniskangas, H. (1999) *MediaTeam Document Database II, a CD-ROM collection of document images*. University of Oulu.

DOI: 10.15587/2312-8372.2019.176906

DEVELOPMENT OF AN ONTOLOGICAL MODEL FOR THE DOMAIN OF IT ENTERPRISE SUSTAINABLE DEVELOPMENT

page 43–45

Popereshnyak Svitlana, *PhD, Associate Professor, Department of Software Systems and Technologies, Taras Shevchenko National University of Kyiv, Ukraine, e-mail: spopereshnyak@gmail.com, ORCID: http://orcid.org/0000-0002-0531-9809*

Grinenko Sergiy, *Assistant, Department of Software Engineering, National Aviation University, Kyiv, Ukraine, e-mail: serggrin@ukr.net, ORCID: http://orcid.org/0000-0001-5544-2605*

The object of research is the sustainable development of IT enterprises. One of the most problematic places is the specification of the subject area, taking into account the specific activity of the IT enterprise. Today, there is a certain amount of research in the field of sustainable development, however, given the specific nature of the IT enterprise, namely that its main asset is software development, there are no researches related to the analysis of the sustainable development of IT enterprises. That is why, above all, the question arises in the representation of knowledge about the subject area. As a result, it is important to develop a model that displays the domain objects and the links between them. Such a tool is ontologies, which are a formalized representation of domain knowledge. The paper discusses the problem of building an ontology for a subject area of sustainable development of an IT enterprise, which includes the following steps:

– justification of the use of ontologies for domain modelling;

– a brief description of the basic steps of building an ontology in accordance with the IDEF5 standard.

The collection and source analysis for the formation of verbal subject domain specifications. It should be noted that the developed ontology includes three types of representation: verbal, graphic and analytical. Within this paper, only two representations (graphical and analytical) are given. The IDEF5 Schematic Language (SL) was used to graphically represent the ontology, which includes several types of ontology diagrams. In the framework of our study, we used the Composition Schematics, which is a mechanism for graphically representing the composition of ontology classes. For analytic representation, predicate calculations were used, because with increasing and refining the ontology of the subject area, this mathematical apparatus ensures the reliability of the results. The developed ontology involves refinement and expansion in accordance with the requirements of projects where this ontology will be used, for example, to develop an expert system for solving problems of the subject area.

Keywords: sustainable development, subject area ontology, IDEF5 standard, predicate calculus.

References

1. Konys, A. (2018). An Ontology-Based Knowledge Modelling for a Sustainability Assessment Domain. *Sustainability, 10 (2),* 300. doi: http://doi.org/10.3390/su10020300
2. Khomiachenkova, N. A. (2011). Monitoring ustoichivogo razvitiia promyshlennogo predpriiatiia. *Rossiiskoe predprinimatelstvo, 1 (2 (176)),* 63–67.
3. Grishakov, K. R. (2013). Poniatie ustoichivogo razvitiia promyshlennogo predpriiatiia. *SCIARTICLE.RU, 3,* 126–134.
4. Kolocheva, V. V., Titova, V. A. (2010). Ustoichivoe razvitie predpriiatii na osnove processnogo pokhoda. *Vestnik IUUrGU, 7,* 20–25.
5. *IDEF5 Method Report*. Available at: http://or-rsv.narod.ru/Docs/idef5.pdf
6. *Standart ontologicheskogo issledovaniia IDEF5*. Available at: http://citforum.ck.ua/cfin/idef/idef5.shtml
7. Poriadok dennyi v haluzi staloho rozvytku na period do 2030 roku. Rezoliutsiia, pryiniata Heneralnoiu Asambleieiu OON 25 veresnia 2015 roku.
8. Proekt «Kontseptsiia perekhodu Ukrainy do staloho rozvytku do 2030 roku». *Portal Verkhovnoi Rady Ukrainy.* Available at: http://w1.c1.rada.gov.ua/pls/zweb2/webproc34?id=&pf3511=64508&pf35401=462260
9. Sidorov, N. A. (2011). Zelenye informacionnye sistemy i tekhnologi. *Inzheneriia programnogo obespecheniia, 3 (7),* 5–12.
10. Khomenko, V. A. (2011). Ekosystemy prohramnoho zabezpechennia. *Visnyk Natsionalnoho tekhnichnoho universytetu «KhPI», 23,* 114–118.
11. Grinenko, S. A. (2016). Systematic Mapping Studies in Sustainable IT. *Inzheneriia prohramnoho zabezpechennia, 4 (28),* 5–14.
12. Kharchenko, V. S. (Ed.) (2014). *Zelenaia IT-inzheneriia. Tom 1. Principy, modeli, komponenty.* Kharkiv: Nacionalnii aerokosmicheskii universitet im. N. E. Zhukovskogo «KHAI», 594.
13. Kharchenko, V. S. (Ed.) (2014). *Zelenaia IT-inzheneriia. Tom 2. Sistemy, industriia, socium*. Kharkiv: Nacionalnii aerokosmicheskii universitet im. N. E. Zhukovskogo «KHAI», 688.
14. ISO 14001. Environmental Management Systems – Requirements with guidance for use.
15. BS 8900-1:2013. Managing sustainable development of organizations.
16. BS 8900-2:2013. Managing sustainable development of organizations. Framework for assessment against BS 8900-1. Specification.
17. Kryvyi, S. L. (2010). *Kurs dyskretnoi matematyky.* Kyiv: NAU-druk, 352.