ABSTRACT AND REFERENCES

INFORMATION AND CONTROLLING SYSTEM

DOI: 10.15587/1729-4061.2020.197095

IMPLEMENTATION OF A PARALLEL ALGORITHM OF IMAGE SEGMENTATION BASED ON REGION GROWING (p. 6–11)

Jesús Antonio Álvarez-Cedillo
Instituto Politécnico Nacional – UPIICSA,
Col. Granjas México, Iztacalco, México
ORCID: http://orcid.org/0000-0003-0823-4621

Mario Aguilar-Fernández
Instituto Politécnico Nacional – UPIICSA,
Col. Granjas México, Iztacalco, México
ORCID: http://orcid.org/0000-0003-2621-8692

Teodoro Álvarez-Sánchez
Instituto Politécnico Nacional – CITEDI,
Nueva Tijuana, Tijuana, Baja California, México
ORCID: http://orcid.org/0000-0002-2975-7125

Raúl Junior Sandoval-Gómez
Instituto Politécnico Nacional – UPIICSA,
Col. Granjas México, Iztacalco, México
ORCID: http://orcid.org/0000-0001-9335-2176

In computer vision and image processing, image segmentation remains a relevant research area that contains many partially answered research questions. One of the fields of most significant interest in Digital Image Processing corresponds to segmentation, a process that breaks down an image into its different components that make it up. However, the level of its computational complexity is high. The traditional methods of Region growing are based on the comparison of grey levels of neighbouring pixels, and usually, fail when the region to be segmented contains intensities similar to adjacent regions. However, if a broad tolerance is indicated in its thresholds, the detected limits will exceed the region to identify; on the contrary, if the threshold tolerance decreases too much, the identified region will be less than the desired one. In the analysis of textures, multiple scenes can be seen as the composition of different textures. The visual texture refers to the impression of roughness or smoothness that some surfaces created by the variations of tones or repetition of visual patterns therein. The texture analysis techniques are based on the assignment of one or several parameters indicating the characteristics of the texture present to each region of the image. This paper shows how a parallel algorithm was implemented to solve open problems in the area of image segmentation research. Region growing is an advanced approach to image segmentation in which neighbouring pixels are examined one by one and added to an appropriate region class if no border is detected. This process is iterative for each pixel within the boundary of the region. If adjacent regions are found, a region fusion algorithm is used in which weak edges dissolve, and firm edges remain intact, this requires a lot of processing time on a computer to make parallel implementation possible.

Keywords: computer vision, image processing, segmentation techniques, Region growing, parallel processing, parallel algorithms, GPU, SIMD, texture analysis, Digital Image Processing.

References

1. Keely, C. C., Hale, J. M., Heard, G. W., Parris, K. M., Sumner, J., Hamer, A. J., Melville, J. (2015). Genetic structure and diversity of the endangered growling grass frog in a rapidly urbanizing region. Royal Society Open Science, 2 (8), 140255. doi: https://doi.org/10.1098/rsos.140255
2. Ashburner, J., Friston, K. J. (2005). Unified segmentation. NeuroImage, 26 (3), 839–851. doi: https://doi.org/10.1016/j.neuroimage.2005.02.018
3. Bandler, R., Tork, I. (1987). Midbrain periaqueductal grey region in the cat has afferent and efferent connections with solitary tract nuclei. Neuroscience Letters, 74 (1), 1–6. doi: https://doi.org/10.1016/0304-3940(87)90041-3
4. Patel, N. H., Liu, P. Z. (2009). Segmentation. Encyclopedia of Insects, 909–912. doi: https://doi.org/10.1016/b978-0-12-374144-8.00240-x
5. Taylor, J. R. A., deVries, M. S., Elias, D. O. (2019). Growling from the gut: co-option of the gastric mill for acoustic communication in ghost crabs. Proceedings of the Royal Society B: Biological Sciences, 286 (1910), 20191161. doi: https://doi.org/10.1098/rspb.2019.1161
6. Chen, D. (2008). Image Segmentation. User Centered Design for Medical Visualization, 258–279. doi: https://doi.org/10.4018/978-1-59904-777-5.ch013
7. Hsiao, Y.-T., Chuang, C.-L., Jiang, J.-A., Chien, C.-C. (2005). Robust Multiple Targets Tracking Using Object Segmentation and Trajectory Estimation in Video. 2005 IEEE International Conference on Systems, Man and Cybernetics. doi: https://doi.org/10.1109/icsmc.2005.1571289
8. Tynan, A. C., Drayton, J. (1987). Market segmentation. Journal of Marketing Management, 2 (3), 301–335. doi: https://doi.org/10.1080/0267257x.1987.9964020
9. Felzenszwalb, P. F., Huttenlocher, D. P. (2004). Efficient Graph-Based Image Segmentation. International Journal of Computer Vision, 59 (2), 167–181. doi: https://doi.org/10.1023/b:visi.0000022288.19776.77
10. Hu, R., Dollar, P., He, K., Darrell, T., Girshick, R. (2018). Learning to Segment Every Thing. 2018 IEEE/CVF Conference on Computer Vision and Pattern Recognition. doi: https://doi.org/10.1109/cvpr.2018.00445
11. Owens, J. D., Houston, M., Luebke, D., Green, S., Stone, J. E., Phillips, J. C. (2008). GPU Computing. Proceedings of the IEEE, 96 (5), 879–899. doi: https://doi.org/10.1109/jproc.2008.917757
12. Stuart, J. A., Owens, J. D. (2011). Multi-GPU MapReduce on GPU Clusters. 2011 IEEE International Parallel & Distributed Processing Symposium. doi: https://doi.org/10.1109/ipdps.2011.102
13. Nickolls, J., Dally, W. J. (2010). The GPU Computing Era. IEEE Micro, 30 (2), 56–69. doi: https://doi.org/10.1109/mm.2010.41
14. Bergstra, J., Breuleux, O., Bastien, F. F., Lamblin, P., Pascanu, R., Desjardins, G. et. al. (2010). Theano: a CPU and GPU math compiler in Python. Proceedings of the Python for Scientific Computing Conference (SciPy).
15. Sanders, J., Kandrot, E. (2010). CUDA by Example: An Introduction to General-Purpose GPU Programming. NVIDIA Corporation, 311.
16. Pratx, G., Xing, L. (2011). GPU computing in medical physics: A review. Medical Physics, 38 (5), 2685–2697. doi: https://doi.org/10.1118/1.3578605
17. Sengupta, S., Harris, M., Zhang, Y., Owens, J. D. (2007). Scan primitives for GPU computing. Proceedings of the SIGGRAPH/Eurographics Workshop on Graphics Hardware, 97–106.
18. Che, S., Boyer, M., Meng, J., Tarjan, D., Sheaffer, J. W., Skadron, K. (2008). A performance study of general-purpose applications on graphics processors using CUDA. Journal of Parallel and Distributed Computing, 68 (10), 1370–1380. doi: https://doi.org/10.1016/j.jpdc.2008.05.014
19. Power, J., Hestness, J., Orr, M. S., Hill, M. D., Wood, D. A. (2015). gem5-gpu: A Heterogeneous CPU-GPU Simulator. IEEE Com-

puter Architecture Letters, 14 (1), 34–36. doi: https://doi.org/10.1109/lca.2014.2299539

20. Feng, W., Xiao, S. (2010). To GPU synchronize or not GPU synchronize? Proceedings of 2010 IEEE International Symposium on Circuits and Systems. doi: https://doi.org/10.1109/iscas.2010.5537722
21. Lee, V. W., Hammarlund, P., Singhal, R., Dubey, P., Kim, C., Chhugani, J. et. al. (2010). Debunking the 100X GPU vs. CPU myth. Proceedings of the 37th Annual International Symposium on Computer Architecture - ISCA '10. doi: https://doi.org/10.1145/1815961.1816021
22. Zhou, Y., Tan, Y. (2009). GPU-based parallel particle swarm optimization. 2009 IEEE Congress on Evolutionary Computation. doi: https://doi.org/10.1109/cec.2009.4983119
23. Shah, S., Bull, M. (2006). OpenMP---OpenMP. Proceedings of the 2006 ACM/IEEE Conference on Supercomputing - SC '06. doi: https://doi.org/10.1145/1188455.1188469
24. Hermanns, M. (2002). Parallel programming in Fortran 95 using OpenMP. School of Aeronautical Engineering.
25. Chapman, B., Jost, G., Van Der Pas, R. (2008). Using OpenMP. Cluster Computing.

DOI: 10.15587/1729-4061.2020.197079

DEVELOPMENT OF MEASURING SYSTEM FOR DETERMINING LIFE-THREATENING CARDIAC ARRHYTHMIAS IN A PATIENT'S FREE ACTIVITY (p. 12–22)

Chingiz Alimbayev
Satbayev University, Almaty, Republic of Kazakhstan
ORCID: http://orcid.org/0000-0003-0160-1943

Zhadyra Alimbayeva
Satbayev University, Almaty, Republic of Kazakhstan
ORCID: http://orcid.org/0000-0002-2628-2515

Kassymbek Ozhikenov
Satbayev University, Almaty, Republic of Kazakhstan
ORCID: http://orcid.org/0000-0003-2026-5295

Oleg Bodin
Penza State University, Penza, Russia
ORCID: http://orcid.org/0000-0001-9299-1005

Yerkat Mukazhanov
Zhetysu State University named after I. Zhansugurov, Taldykorgan, Republic of Kazakhstan
ORCID: http://orcid.org/0000-0002-9086-021X

Cardiovascular diseases continue to be the main cause of mortality. According to the official source, over the past three years in Kazakhstan, an average of 179,200 people dies from the coronary disease per year. 1,360,000 people suffer from this disease, that is, almost every twelfth Kazakhstani today suffers from coronary heart disease. An average of 272,000 people are admitted to hospitals annually with an acute heart attack [1]. To minimize damage to the population and medicine, timely diagnosis is necessary, which reduces the cost of subsequent treatment.

The paper considers the system of non-invasive cardiac diagnostics, based on a biophysical approach. The system allows to fill the existing gap between electrophysiology of the heart and the most common methods of analysis of the electromagnetic field of the heart for diagnostic purposes. The developed system of non-invasive cardiac diagnosis uses the latest advances in information technology that allows to record, collect, store and process cardiographic information.

The product allows you to monitor the state of human health around the clock with the identification of pathologies and the determination of their development trends and with the formation of alarm alerts indicating the location of the subscriber and instant analysis of the physiological parameters of the heart. Such experience can be successfully used for personal monitoring of human health, regardless of his location.

The developed sample of the measuring system increases the diagnostic efficiency of the medical services by the timely determination of dangerous cardiac arrhythmias.

Keywords: non-invasive cardiac diagnostic system, portable cardio analyzer, cardiac signal processing.

References

1. Statistical data of Medinform LLP, Kazakhstan. Available at: http://www.medinfo.kz/#/stats
2. Naranjo-Hernández, D., Roa, L. M., Reina-Tosina, J., Barbarov-Rostan, G., Galdámez-Cruz, O. (2017). Smart Device for the Determination of Heart Rate Variability in Real Time. Journal of Sensors, 2017, 1–11. doi: https://doi.org/10.1155/2017/8910470
3. Safronov, M., Kuzmin, A., Bodin, O., Baranov, V., Trofimov, A., Tychkov, A. (2019). Mobile ECG Monitoring Device with Bioimpedance Measurement and Analysis. 2019 24th Conference of Open Innovations Association (FRUCT). doi: https://doi.org/10.23919/fruct.2019.8711944
4. Kuzmin, A., Safronov, M., Bodin, O., Prokhorov, S., Stolbova, A. (2017). Mobile ECG monitoring system prototype and wavelet-based arrhythmia detection. 2017 21st Conference of Open Innovations Association (FRUCT). doi: https://doi.org/10.23919/fruct.2017.8250184
5. Türker, G. F., Tarımer, İ. (2016). Portable ECG design and application based on wireless sensor network. Pamukkale University Journal of Engineering Sciences, 22 (2), 78–84. doi: https://doi.org/10.5505/pajes.2015.08860
6. Holter Monitor. Poly-Spectrum-Radio. Available at: https://www.medicalexpo.com/prod/neurosoft/product-69506-454318.html
7. Kompleks dlya telemetricheskoy registratsii EKG «Astrokard® - Telemetriya» 3G. Available at: https://www.astrocard-meditek.ru/index.php?page=prod_10
8. Oppengeym, A., Shafer, R. (2007). Tsifrovaya obrabotka signalov. Moscow: Tehnosfera, 856.
9. Rangayan, R. M.; Nemirko, A. P. (Ed.) (2007). Analiz biomeditsinskih signalov. Prakticheskiy podhod. Moscow: FIZMATLIT, 440.
10. Noro, M., Anzai, D., Wang, J. (2017). Common-mode noise cancellation circuit for wearable ECG. Healthcare Technology Letters, 4 (2), 64–67. doi: https://doi.org/10.1049/htl.2016.0083
11. He, R., Wang, K., Li, Q., Yuan, Y., Zhao, N., Liu, Y., Zhang, H. (2017). A novel method for the detection of R-peaks in ECG based on K-Nearest Neighbors and Particle Swarm Optimization. EURASIP Journal on Advances in Signal Processing, 2017 (1). doi: https://doi.org/10.1186/s13634-017-0519-3
12. Yupapin, P., Sh Hussain, S., Hadrina, S.-H., Tan, Ting, C.-M., Noor, A. M. et. al. (2012). Acoustic cardiac signals analysis: a Kalman filter-based approach. International Journal of Nanomedicine, 2012 (7), 2873–2881. doi: https://doi.org/10.2147/ijn.s32315
13. Alimbaev, C. A., Ozhikenov, K. A., Bodin, O. N., Kramm, M. N., Rakhmatullov, F. K., Mukazhanov, Y. B. (2019). System of Non-Invasive Electrocardiac Diagnostics. 2019 20th International Conference of Young Specialists on Micro/Nanotechnologies and Electron Devices (EDM). doi: https://doi.org/10.1109/edm.2019.8823170
14. Alimbayev, C. A., Bodin, O. N., Ozhikenov, K. A., Mukazhanov, E. B., Alimbayeva, Z. N. (2018). Development of the structure of a multi-component filter based on the principle of adaptive aggregation of filters. 2018 IEEE 12th International Conference on Application of Information and Communication Technologies (AICT). doi: https://doi.org/10.1109/icaict.2018.8747119

15. Huang, N. E., Shen, Z., Long, S. R., Wu, M. C., Shih, H. H., Zheng, Q. et. al. (1998). The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. Proceedings of the Royal Society of London. Series A: Mathematical, Physical and Engineering Sciences, 454 (1971), 903–995. doi: https://doi.org/10.1098/rspa.1998.0193
16. Huang, N. E., Shen, S. S. P. (2005). The Hilbert-Huang Transform and Its Applications. World Scientific Publishing Co. Pte. Ltd., 526.
17. Krivonogov, L. Yu. (2014). Method and algorithms for accurate ECG signal processing based on empirical mode decomposition. Izvestiya Yuzhnogo federal'nogo universiteta. Tehnicheskie nauki, 10 (159), 104–114.
18. Krivonogov, L. Yu., Egorov, M. S. (2013). Podavlenie vysokochastotnyh pomeh v elektrokardiosignalah na osnove usechennoy empiricheskoy modovoy dekompozitsii. Materialy IV Mezhregion. nauchn. konf. «Aktual'nye problemy meditsinskoy nauki i obrazovaniya». Elektron. nauchn. izd. FGUP NTTS «Informregistr», 485–491.

DOI: 10.15587/1729-4061.2020.195369

DEVELOPMENT OF TECHNIQUE FOR FACE DETECTION IN IMAGE BASED ON BINARIZATION, SCALING AND SEGMENTATION METHODS (p. 23–31)

Eugene Fedorov
Cherkasy State Technological University, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0003-3841-7373

Tetyana Utkina
Cherkasy State Technological University, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0002-6614-4133

Olga Nechyporenko
Cherkasy State Technological University, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0002-3954-3796

Yaroslav Korpan
Cherkasy State Technological University, Cherkasy, Ukraine
ORCID: http://orcid.org/0000-0002-1455-5977

A technique for face detection in the image is proposed, which is based on binarization, scaling, and segmentation of the image, followed by the determination of the largest connected component that matches the image of the face.

Modern methods of binarization, scaling, and taxonomic image segmentation have one or more of the following disadvantages: they have a high computational complexity; require the determination of parameter values. Taxonomic image segmentation methods may have additional disadvantages: they do not allow noise and outliers selection; clusters can't have different shapes and sizes, and their number is fixed.

Due to this, to improve the efficiency of face detection techniques, the methods of binarization, scaling and taxonomic segmentation needs to be improved.

A binarization method is proposed, the distinction of which is the use of the image background. This allows to simplify the process of scaling and segmentation (since all the pixels in the background are represented by the same color), non-uniform brightness of the face, and not to use the threshold settings and additional parameters.

A binary image scaling method is proposed, the distinction of which is the use of an arithmetic mean filter with threshold processing and fast wavelet transform. This allows to speed up the image segmentation process by about P^2 times, where P is the scaling parameter, and not to use the time-consuming procedure for determining.

A binary scaled image segmentation method is proposed, the distinction of which is the use of density clustering. This allows to separate areas of the face of non-uniform brightness from the image background, noise and outliers. It also allows clusters to have different shapes and sizes, to not require setting the number of clusters and additional parameters.

To determine the scaling parameter, numerous studies were conducted in this work, which concluded that the dependence of the segmentation time on the scaling parameter is close to exponential. It was also found that for small P, where P is the scaling parameter, the quality of face detection deteriorates slightly.

The proposed technique for face detection in image based on binarization, scaling and segmentation can be used in intelligent computer systems for biometric identification of a person by the face image.

Keywords: face detection, image, binarization, scaling, segmentation, density clustering.

References

1. Nechyporenko, O. V., Korpan, Y. V. (2016). Biometric identification and authentication of persons for geometry face. Herald of Khmelnytskyi national university, 4, 133–138. Available at: http://journals.khnu.km.ua/vestnik/pdf/tech/pdfbase/2016/2016_4/(239)%20 2016-4-t.pdf
2. Nechyporenko, O., Korpan, Y. (2017). Analysis of methods and technologies of human face recognition. Technology Audit and Production Reserves, 5 (2 (37)), 4–10. doi: https://doi.org/10.15587/2312-8372.2017.110868
3. Lee, M.-T., Chang, H. T. (2011). On the pinned field image binarization for signature generation in image ownership verification method. EURASIP Journal on Advances in Signal Processing, 2011 (1). doi: https://doi.org/10.1186/1687-6180-2011-44
4. Wagdy, M., Faye, I., Rohaya, D. (2015). Document Image Binarization Using Retinex and Global Thresholding. ELCVIA Electronic Letters on Computer Vision and Image Analysis, 14 (1). doi: https://doi.org/10.5565/rev/elcvia.648
5. Michalak, H., Okarma, K. (2019). Improvement of Image Binarization Methods Using Image Preprocessing with Local Entropy Filtering for Alphanumerical Character Recognition Purposes. Entropy, 21 (6), 562. doi: https://doi.org/10.3390/e21060562
6. Fedorov E., Utkina T., Rudakov K., Lukashenko A., Mitsenko S., Chychuzhko M., Lukashenko V. (2019). A Method for Extracting a Breast Image from a Mammogram Based on Binarization, Scaling and Segmentation. CEUR Workshop Proceedings, 2488, 84–98. Available at: http://ceur-ws.org/Vol-2488/paper7.pdf
7. Kozei, A., Nikolov, N., Haluzynskyi, O., Burburska, S. (2019). Method of Threshold CT Image Segmentation of Skeletal Bones. Innovative Biosystems and Bioengineering, 3 (1), 4–11. doi: https://doi.org/10.20535/ibb.2019.3.1.154897
8. Meng, X., Gu, W., Chen, Y., Zhang, J. (2017). Brain MR image segmentation based on an improved active contour model. PLOS ONE, 12 (8), e0183943. doi: https://doi.org/10.1371/journal.pone.0183943
9. Pun, C.-M., An, N.-Y., Chen, C. L. P. (2012). Region-based Image Segmentation by Watershed Partition and DCT Energy Compaction. International Journal of Computational Intelligence Systems, 5 (1), 53–64. doi: https://doi.org/10.1080/18756891.2012.670521
10. Teodorescu, H., Rusu, M. (2012). Yet Another Method for Image Segmentation Based on Histograms and Heuristics. Computer Science Journal of Moldova, 20 (2 (59)), 163–177. Available at: http://www.math.md/files/csjm/v20-n2/v20-n2-(pp163-177).pdf
11. Selvaraj Assley, P. S. B., Chellakkon, H. S. (2014). A Comparative Study on Medical Image Segmentation Methods. Applied Medical Informatics, 34 (1), 31–45. Available at: https://ami.info.umfcluj.ro/index.php/ami/article/view/460
12. Ren, Z. (2014). Variational Level Set Method for Two-Stage Image Segmentation Based on Morphological Gradients. Mathematical Problems in Engineering, 2014, 1–11. doi: https://doi.org/10.1155/2014/145343

13. Ganea, E., Burdescu, D. D., Brezovan, M. (2011). New Method to Detect Salient Objects in Image Segmentation using Hypergraph Structure. Advances in Electrical and Computer Engineering, 11 (4), 111–116. doi: https://doi.org/10.4316/aece.2011.04018
14. O'Mara, A., King, A. E., Vickers, J. C., Kirkcaldie, M. T. K. (2017). ImageSURF: An ImageJ Plugin for Batch Pixel-Based Image Segmentation Using Random Forests. Journal of Open Research Software, 5. doi: https://doi.org/10.5334/jors.172
15. Linyao, X., Jianguo, W. (2017). Improved K-means Algorithm Based on optimizing Initial Cluster Centers and Its Application. International Journal of Advanced Network, Monitoring and Controls, 2 (2), 9–16. doi: https://doi.org/10.21307/ijanmc-2017-005
16. Brusco, M. J., Shireman, E., Steinley, D. (2017). A comparison of latent class, K-means, and K-median methods for clustering dichotomous data. Psychological Methods, 22 (3), 563–580. doi: https://doi.org/10.1037/met0000095
17. Zhou, N., Yang, T., Zhang, S. (2014). An Improved FCM Medical Image Segmentation Algorithm Based on MMTD. Computational and Mathematical Methods in Medicine, 2014, 1–8. doi: https://doi.org/10.1155/2014/690349
18. Kesavaraja, D., Balasubramanian, R., Rajesh, R. S., Sasireka, D. (2011). Advanced Cluster Based Image Segmentation. ICTACT Journal on Image and Video Processing, 02 (02), 307–318. doi: https://doi.org/10.21917/ijivp.2011.0045
19. Fu, Z., Wang, L. (2012). Color Image Segmentation Using Gaussian Mixture Model and EM Algorithm. Communications in Computer and Information Science, 61–66. doi: https://doi.org/10.1007/978-3-642-35286-7_9
20. Giacoumidis, E., Lin, Y., Jarajreh, M., O'Duill, S., McGuinness, K., Whelan, P. F., Barry, L. P. (2019). A Blind Nonlinearity Compensator Using DBSCAN Clustering for Coherent Optical Transmission Systems. Applied Sciences, 9 (20), 4398. doi: https://doi.org/10.3390/app9204398
21. Olugbara, O. O., Adetiba, E., Oyewole, S. A. (2015). Pixel Intensity Clustering Algorithm for Multilevel Image Segmentation. Mathematical Problems in Engineering, 2015, 1–19. doi: https://doi.org/10.1155/2015/649802
22. Cahyono, C., Prasetyo, G., Yoza, A., Hani, R. (2014). Multithresholding in Grayscale Image Using Pea Finding Approach and Hierarchical Cluster Analysis. Jurnal Ilmu Komputer Dan Informasi, 7 (2), 83. doi: https://doi.org/10.21609/jiki.v7i2.261
23. Wang, X., Du, J., Wu, S., Li, X., Li, F. (2013). Cluster Ensemble-Based Image Segmentation. International Journal of Advanced Robotic Systems, 10 (7), 297. doi: https://doi.org/10.5772/56769
24. Ghahraman, B., Davary, K. (2014). Adopting Hierarchial Cluster Analysis to Improve the Performance of K-mean Algorithm. Journal of Water and Soil, 28 (3), 471–480. Available at: https://www.sid.ir/en/journal/ViewPaper.aspx?id=443469
25. Fedorov, E., Lukashenko, V., Utkina, T., Lukashenko, A., Rudakov, K. (2019). Method for Parametric Identification of Gaussian Mixture Model Based on Clonal Selection Algorithm. CEUR Workshop Proceedings, 2353, 41–55. Available at: http://ceur-ws.org/Vol-2353/paper4.pdf
26. Fedorov, E., Lukashenko, V., Patrushev, V., Lukashenko, A., Rudakov, K., Mitsenko, S. (2018). The Method of Intelligent Image Processing Based on a Three-Channel Purely Convolutional Neural. CEUR Workshop Proceedings, 2255, 336–351. Available at: http://ceur-ws.org/Vol-2255/paper30.pdf
27. Yu, C., Dai, F. (2016). Mobile Camera based Motion Segmentation by Image Resizing. Journal of Robotics, Networking and Artificial Life, 3 (2), 96. doi: https://doi.org/10.2991/jrnal.2016.3.2.7
28. Lemke, O., Keller, B. (2018). Common Nearest Neighbor Clustering – A Benchmark. Algorithms, 11 (2), 19. doi: https://doi.org/10.3390/a11020019
29. Xu, L., Yan, Y., Cheng, J. (2017). Guided Filtering For Solar Image/Video Processing. Solar-Terrestrial Physics, 3 (2), 9–15. doi: https://doi.org/10.12737/stp-3220172
30. Konsti, J., Lundin, M., Linder, N., Haglund, C., Blomqvist, C., Nevanlinna, H. et. al. (2012). Effect of image compression and scaling on automated scoring of immunohistochemical stainings and segmentation of tumor epithelium. Diagnostic Pathology, 7 (1). doi: https://doi.org/10.1186/1746-1596-7-29
31. Jeyaram, B. S., Raghavan, R. (2014). New CA Based Image Encryption-Scaling Scheme Using Wavelet Transform. Journal of Systemics, Cybernetics and Informatics, 12 (3), 66–71. Available at: https://pdfs.semanticscholar.org/4d20/2d302da9e63a34570fb34bdac3c7e43739df.pdf?_ga=2.263733902.320808902.1581593117-1908018850.1550590803

DOI: 10.15587/1729-4061.2020.195253

METHODS OF COMPUTER TOOLS DEVELOPMENT FOR MEASURING AND ANALYSIS OF ELECTRICAL PROPERTIES OF SEMICONDUCTOR FILMS (p. 32–38)

Roman Dunets
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-3325-7908

Bogdan Dzundza
Lviv Polytechnic National University, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-6657-5347

Mykhailo Deichakivskyi
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-7574-7772

Volodymyr Mandzyuk
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-6020-7722

Andrii Terletsky
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0003-2091-0362

Omelian Poplavskyi
Vasyl Stefanyk Precarpathian National University, Ivano-Frankivsk, Ukraine
ORCID: http://orcid.org/0000-0001-7711-0855

The method is presented and computer tools of automated measurement of electrical parameters and experimental data processing are developed, taking into account models for describing physical processes that determine the operating characteristics of semiconductor material. The possibility of automated investigation of the quality and ohmicity of contacts is realized, which significantly improves the reliability of the data obtained.

Methods and features of software processing of automated research results are considered using the models that allow taking into account the effect of surface, structure and thickness of the sample on the electrical properties of semiconductor films.

Experimental studies of a series of n-PbTe thin films are carried out and the efficiency of the developed tools and methods of processing scientific data using the described methods of experimental data analysis is shown. Based on the simulation, the electrical parameters of the surface layers were determined and the effect of the surface and grain boundary mechanisms of charge carrier scattering on the electrical parameters of the films was separated. The surface mobility of the charge carriers is approximately 3 times less than the mobility in the bulk material,

which indicates the dominance of the diffuse scattering of charge carriers on the surface of the thin-film samples despite the high reflectance coefficient (0.4). Taking into account the effect of the surface and the boundaries of the grains, it is possible to choose the technological modes and duration of spraying to obtain a semiconductor material with the desired properties.

As a result of using the developed tools, it was possible to significantly reduce the complexity of the process of measuring the basic electrical parameters of semiconductor materials, processing the experimental results, to improve the accuracy of the results obtained.

Keywords: computer tools, automation, minimization algorithms, contacts, electrical properties.

References

1. Jones, R. O., Gunnarsson, O. (1989). The density functional formalism, its applications and prospects. Reviews of Modern Physics, 61 (3), 689–746. doi: https://doi.org/10.1103/revmodphys.61.689
2. Naidych, B. P. (2018). Calculation of the Stability and Rebuilding of the Crystal Surface Within DFT-Calculations. Physics and Chemistry of Solid State, 19 (3), 254–257. doi: https://doi.org/10.15330/pcss.19.3.254-257
3. Novosyadlyj, S., Dzundza, B., Gryga, V., Novosyadlyj, S., Kotyk, M., Mandzyuk, V. (2017). Research into constructive and technological features of epitaxial gallium-arsenide structures formation on silicon substrates. Eastern-European Journal of Enterprise Technologies, 3 (5 (87)), 54–61. doi: https://doi.org/10.15587/1729-4061.2017.104563
4. Ruvinskii, M. A., Kostyuk, O. B., Dzundza, B. S., Yaremiy, I. P., Mokhnatskyi, M. L. (2017). Kinetic Phenomena and Thermoelectric Properties of Polycrystalline Thin Films Based on PbSnAgTe Compounds. Journal of Nano- and Electronic Physics, 9 (5), 05004-1–05004-6. doi: https://doi.org/10.21272/jnep.9(5).05004
5. De Boor, J., Müller, E. (2013). Data analysis for Seebeck coefficient measurements. Review of Scientific Instruments, 84 (6), 065102. doi: https://doi.org/10.1063/1.4807697
6. Glinchenko, A. S., Komarov, V. A., Tronin, O. A. (2012 Computer spectral measurements and their applications. Uspehi sovremennoy radioelektroniki, 9, 025–028.
7. Iermolenko, Ie. O. (2014). Classification of methods for measuring current-voltage characteristics of semiconductor devices. Tehnologiya i konstruirovanie v elektronnoy apparature, 2-3, 3–11. doi: https://doi.org/10.15222/tkea2014.2-3.03
8. Sondheimer, E. H. (1950). The Influence of a Transverse Magnetic Field on the Conductivity of Thin Metallic Films. Physical Review, 80 (3), 401–406. doi: https://doi.org/10.1103/physrev.80.401
9. Saliy, Ya. P., Freik, I. M. (2004). Elektrotekhnichna model elektroprovidnosti tonkykh polikrystalichnykh plivok PbTe. Fizyka i khimiya tverdoho tila, 5 (1), 94–95.
10. Petritz, R. L. (1958). Theory of an Experiment for Measuring the Mobility and Density of Carriers in the Space-Charge Region of a Semiconductor Surface. Physical Review, 110 (6), 1254–1262. doi: https://doi.org/10.1103/physrev.110.1254
11. Kogut, I. T., Holota, V. I., Druzhinin, A., Dovhij, V. V. (2016). The Device-Technological Simulation of Local 3D SOI-Structures. Journal of Nano Research, 39, 228–234. doi: https://doi.org/10.4028/www.scientific.net/jnanor.39.228
12. Tsibanov, V. V. Programma minimizatsii funktsii mnogih peremennyh metodom deformiruemogo mnogogrannika (po Nelderu i Midu). doi: http://doi.org/10.13140/RG.2.2.31221.88803
13. Ruvinskii, M. A., Kostyuk, O. B., Dzundza, B. S., Makovyshyn, V. I. (2017). The Influence of Surface on Scattering of Carriers and Kinetic Effects in n-PBTE Films. Nanosistemi, Nanomateriali, Nanotehnologii, 15 (2), 277–288. doi: https://doi.org/10.15407/nnn.15.02.0277
14. Tellier, C. R., Rabel, M., Tosser, A. J. (1978). Hall coefficient of thin films in a mean free path model. Journal of Physics F: Metal Physics, 8 (11), 2357–2365. doi: https://doi.org/10.1088/0305-4608/8/11/019
15. Khokhlov, D. (2003). Lead Chalcogenides: Physics and Applications. Taylor & Frencis.
16. Dzundza, B. S. (2018). Automated Hardware-Softw are System for Measurement of Thermoelectric Parameters of Semiconductor Materials. Journal of Thermoelectricity, 5, 5–12.

DOI: 10.15587/1729-4061.2020.196086

DEVISING AND INTRODUCING A PROCEDURE FOR MEASURING A DYNAMIC STABILIZATION ERROR IN WEAPON STABILIZERS (p. 39–45)

Olena Bezvesilna
National Technical University of Ukraine
“Igor Sikorsky Kyiv Polytechnic Institute”, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-6951-1242

Oleksii Petrenko
Pablic Joint Stock Company «Research-and-Production association «Kyiv avtomatics plant», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-0435-0211

Viacheslav Halytskyi
National Aviation University, Kyiv, Ukraine
Pablic Joint Stock Company «Research-and-Production association «Kyiv avtomatics plant», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-9310-1529

Mukola Ilchenko
Pablic Joint Stock Company «Research-and-Production association «Kyiv avtomatics plant», Kyiv, Ukraine

This paper reports variants for checking the median error of the 2E36 weapon stabilizer under conditions of a standard path by means of video recording with a film camera followed by film processing and performing all operations in a manual mode. A procedure of measuring the median error of the SVU-500 weapon digital stabilizer has been given. To ensure the possibility of determining the errors of stabilization in each set of stabilizers, the enterprise-manufacturer has devised and implemented for the customer’s main product, without using a standard path, a new procedure for measuring a dynamic stabilization error. This work involved methods of mathematical modeling, which has made it possible to determine the point of sending a sinusoidal signal to the control circuit of the stabilizer. The experimental confirmation of the results obtained during modeling involved the test of a stabilizer kit at the technological bench and at the actual training turret, which made it possible to refine the parameters of the sinusoidal signal. To conduct such tests, special algorithmic software was developed, which was installed, in addition to the main program at the time of testing, in the stabilizer control unit. Subsequent tests confirmed correctness of results obtained during mathematical modeling, which made it possible to introduce verification of one of the main parameters of stabilization of dynamic error to the acceptance tests of each stabilizer kit.

Keywords: stabilizer, gyro tachometer, vibration gyroscope, median stabilization error, dynamic stabilization error.

References

1. Boevaya mashina pehoty BMP-2. Tehnicheskoe opisanie i instruktsiya po ekspluatatsii. Chast’ 1 (1988). Moscow: Voennoe izdatel’stvo, 250.
2. Kudryavtsev, A. M., Ulasevich, O. K., Zheglov, V. N., Gumilev, V. Yu. (2013). Stabilizatory vooruzheniya 2E36: ustroystvo i obsluzhivanie. Ryazan’, 145. Available at: http://portalnp.ru/wp-content/uploads/2014/04/KUDRYAVTSEV-GUMELEV-SV-2E36.pdf

3. Stabilizator 2E26M. Tehnicheskoe opisanie i instruktsiya po ekspluatatsii. Al'bom risunkov (1985). Moscow: Voenizdat, 84.
4. BMP-3. Tehnicheskoe opisanie boevoy mashiny pehoty (1988). Moscow: Voenizdat, 55. Available at: https://eknigi.org/voennaja_istorija/181170-bmp-3-tehnicheskoe-opisanie-boevoy-mashiny-pehoty.html
5. Berezin, S. M., Kononchuk, V. P., Lun'kov, A. P., Nikonov, A. I. (1991). Kompleks vooruzheniya BMP-3. Vestnik bronetankovoy tehniki, 5.
6. Stepanchenko, I. V., Sal'nikov, S. S., Matveev, I. A., Bogdanova, L. A., Vlasov, E. V., Shiryaev, G. S., Popov, V. V. (2009). Pat. No. RU2360208C2. Kompleks vooruzheniya boevoy mashiny i stabilizator vooruzheniya. No. 2007124064/02; declareted: 10.01.2009; published: 27.06.2009, Bul. No. 18. Available at: https://patentimages.storage.googleapis.com/50/95/ed/33b95b367d15c7/RU2360208C2.pdf
7. Lepeshinskiy, I. Yu., Varlakov, P. M., Zaharov, D. N., Chikirev, O. I. (2010). Avtomaticheskie sistemy upravleniya vooruzheniem. Omsk, 200.
8. Bezvesilna, O. M., Tsiruk, V. H., Kvasnikov, V. P., Chepiuk, L. O. (2014). Analiz zakordonnykh system navedennia ta stabilizatsiyi. Bulletin of Engineering Academy of Ukraine, 2, 155–159.
9. Besekerskiy, V. A., Popov, E. P. (2003). Teoriya sistem avtomaticheskogo upravleniya. Sankt-Peterburg, 752.
10. Ornatskiy, P. P. (1983). Teoreticheskie osnovy informatsionno-izmeritel'noy tehniki. Kyiv, 455.
11. Simulation and Model-Based Design. Available at: https://www.mathworks.com/products/simulink.html
12. Vasil'ev, V. V., Simak, L. A., Rybnikova, A. M. (2008). Matematicheskoe i komp'yuternoe modelirovanie protsessov i sistem v srede MATLAB/SIMULINK. Kyiv: Natsional'niy aviatsionnyy universitet, 91.
13. Liu, J., Shen, Q., Qin, W. (2015). Signal Processing Technique for Combining Numerous MEMS Gyroscopes Based on Dynamic Conditional Correlation. Micromachines, 6 (6), 684–698. doi: https://doi.org/10.3390/mi6060684
14. Ting, T. O., Man, K. L., Lei, C.-U., Lu, C. (2014). State-of-Charge for Battery Management System via Kalman Filter. Engineering Letters, 22 (2), 75–82.
15. Ji, X. (2015). Research on Signal Processing of MEMS Gyro Array. Mathematical Problems in Engineering, 2015, 1–6. doi: https://doi.org/10.1155/2015/120954
16. IEEE Standard Specification Format Guide and Test Procedure for Coriolis Vibratory Gyros (2004). doi: https://doi.org/10.1109/ieeestd.2004.95744

DOI: 10.15587/1729-4061.2020.192711

DEVELOPMENT OF AN ALGORITHM TO TRAIN ARTIFICIAL NEURAL NETWORKS FOR INTELLIGENT DECISION SUPPORT SYSTEMS (p. 46–55)

Oleg Sova
Military Institute of Telecommunications and Informatization named after Heroes of Kruty, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-7200-8955

Oleksandr Turinskyi
Ivan Kozhedub Kharkiv University of Air Force, Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-6888-6045

Andrii Shyshatskyi
Central Scientifically-Research Institute of Arming and Military Equipment of the Armed Forces of Ukraine, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-6731-6390

Volodymyr Dudnyk
Hetman Petro Sahaidachnyi National Army Academy, Lviv, Ukraine
ORCID: http://orcid.org/0000-0002-9792-0000

Ruslan Zhyvotovskyi
Central Scientifically-Research Institute of Arming and Military Equipment of the Armed Forces of Ukraine, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-2717-0603

Yevgen Prokopenko
Ivan Chernyakhovsky National Defense University of Ukraine, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-2003-5035

Taras Hurskyi
Military Institute of Telecommunications and Informatization named after Heroes of Kruty, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-7646-853X

Valerii Hordiichuk
Institute of Naval Forces National University "Odessa Maritime Academy", Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-3665-4201

Anton Nikitenko
Ivan Chernyakhovsky National Defense University of Ukraine, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0002-0659-3201

Artem Remez
Ivan Chernyakhovsky National Defense University of Ukraine, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-4970-1097

The algorithm to train artificial neural networks for intelligent decision support systems has been constructed. A distinctive feature of the proposed algorithm is that it conducts training not only for synaptic weights of an artificial neural network, but also for the type and parameters of membership function. In case of inability to ensure the assigned quality of functioning of artificial neural networks due to training of parameters of artificial neural network, the architecture of artificial neural networks is trained. The choice of the architecture, type and parameters of membership function occurs taking into consideration the computation resources of the facility and taking into consideration the type and the amount of information entering the input of an artificial neural network. In addition, when using the proposed algorithm, there is no accumulation of an error of artificial neural networks training as a result of processing the information entering the input of artificial neural networks.

Development of the proposed algorithm was predetermined by the need to train artificial neural networks for intelligent decision support systems in order to process more information given the unambiguity of decisions being made. The research results revealed that the specified training algorithm provides on average 16–23 % higher the efficiency of training artificial neural networks training that is on average by 16–23 % higher and does not accumulate errors in the course of training. The specified algorithm will make it possible to conduct training of artificial neural networks; to determine effective measures to enhance the efficiency of functioning of artificial neural networks. The developed algorithm will also enable the improvement of the efficiency of functioning of artificial neural networks due to training the parameters and the architecture of artificial neural networks. The proposed algorithm reduces the use of computational resources of decision support systems. The application of the developed algorithm makes it possible to work out the measures aimed at improving the effectiveness of training artificial neural networks and to increase the efficiency of information processing.

Keywords: artificial neural networks, synaptic weights, membership function, information processing, intelligent decision support systems.

References

1. Kalantaievska, S., Pievtsov, H., Kuvshynov, O., Shyshatskyi, A., Yarosh, S., Gatsenko, S. et. al. (2018). Method of integral estimation of channel state in the multiantenna radio communication systems. Eastern-European Journal of Enterprise Technologies, 5(9 (95)), 60–76. doi: https://doi.org/10.15587/1729-4061.2018.144085
2. Kuchuk, N., Mohammed, A. S., Shyshatskyi, A., Nalapko, O. (2019). The method of improving the efficiency of routes selection in networks of connection with the possibility of self-organization. International Journal of Advanced Trends in Computer Science and Engineering, 8 (1.2), 1–6. Available at: http://www.warse.org/IJATCSE/static/pdf/file/ijatcse01812sl2019.pdf
3. Zhang, J., Ding, W. (2017). Prediction of Air Pollutants Concentration Based on an Extreme Learning Machine: The Case of Hong Kong. International Journal of Environmental Research and Public Health, 14 (2), 114. doi: https://doi.org/10.3390/ijerph14020114
4. Katranzhy, L., Podskrebko, O., Krasko, V. (2018). Modelling the dynamics of the adequacy of bank's regulatory capital. Baltic Journal of Economic Studies, 4 (1), 188–194. doi: https://doi.org/10.30525/2256-0742/2018-4-1-188-194
5. Manea, E., Di Carlo, D., Depellegrin, D., Agardy, T., Gissi, E. (2019). Multidimensional assessment of supporting ecosystem services for marine spatial planning of the Adriatic Sea. Ecological Indicators, 101, 821–837. doi: https://doi.org/10.1016/j.ecolind.2018.12.017
6. Çavdar, A. B., Ferhatosmanoğlu, N. (2018). Airline customer lifetime value estimation using data analytics supported by social network information. Journal of Air Transport Management, 67, 19–33. doi: https://doi.org/10.1016/j.jairtraman.2017.10.007
7. Kachayeva, G. I., Mustafayev, A. G. (2018). The use of neural networks for the automatic analysis of electrocardiograms in diagnosis of cardiovascular diseases. Herald of Dagestan State Technical University. Technical Sciences, 45 (2), 114–124. doi: https://doi.org/10.21822/2073-6185-2018-45-2-114-124
8. Zhdanov, V. V. (2016). Experimental method to predict avalanches based on neural networks. Ice and Snow, 56 (4), 502–510. doi: https://doi.org/10.15356/2076-6734-2016-4-502-510
9. Kanev, A., Nasteka, A., Bessonova, C., Nevmerzhitsky, D., Silaev, A., Efremov, A., Nikiforova, K. (2017). Anomaly detection in wireless sensor network of the "smart home" system. 2017 20th Conference of Open Innovations Association (FRUCT). doi: https://doi.org/10.23919/fruct.2017.8071301
10. Sreeshakthy, M., Preethi, J. (2016). Classification of human emotion from deap EEG signal using hybrid improved neural networks with Cuckoo search. Brain: Broad Research in Artificial Intelligence and Neuroscience, 6 (3-4), 60–73.
11. Chica, J., Zaputt, S., Encalada, J., Salamea, C., Montalvo, M. (2019). Objective assessment of skin repigmentation using a multilayer perceptron. Journal of Medical Signals & Sensors, 9 (2), 88. doi: https://doi.org/10.4103/jmss.jmss_52_18
12. Massel, L. V., Gerget, O. M., Massel, A. G., Mamedov, T. G. (2019). The Use of Machine Learning in Situational Management in Relation to the Tasks of the Power Industry. EPJ Web of Conferences, 217, 01010. doi: https://doi.org/10.1051/epjconf/201921701010
13. Abaci, K., Yamacli, V. (2019). Hybrid Artificial Neural Network by Using Differential Search Algorithm for Solving Power Flow Problem. Advances in Electrical and Computer Engineering, 19 (4), 57–64. doi: https://doi.org/10.4316/aece.2019.04007
14. Mishchuk, O. S., Vitynskyi, P. B. (2018). Neural Network with Combined Approximation of the Surface of the Response. Research Bulletin of the National Technical University of Ukraine "Kyiv Politechnic Institute", 2, 18–24. doi: https://doi.org/10.20535/1810-0546.2018.2.129022
15. Kazemi, M., Faezirad, M. (2018). Efficiency Estimation using Nonlinear Influences of Time Lags in DEA Using Artificial Neural Networks. Industrial Management Journal, 10 (1), 17–34. doi: http://doi.org/10.22059/imj.2018.129192.1006898
16. Parapuram, G., Mokhtari, M., Ben Hmida, J. (2018). An Artificially Intelligent Technique to Generate Synthetic Geomechanical Well Logs for the Bakken Formation. Energies, 11 (3), 680. doi: https://doi.org/10.3390/en11030680
17. Prokoptsev, N. G., Alekseenko, A. E., Kholodov, Y. A. (2018). Traffic flow speed prediction on transportation graph with convolutional neural networks. Computer Research and Modeling, 10 (3), 359–367. doi: https://doi.org/10.20537/2076-7633-2018-10-3-359-367
18. Bodyanskiy, Y., Pliss, I., Vynokurova, O. (2013). Flexible Neo-fuzzy Neuron and Neuro-fuzzy Network for Monitoring Time Series Properties. Information Technology and Management Science, 16 (1). doi: https://doi.org/10.2478/itms-2013-0007
19. Bodyanskiy, Ye., Pliss, I., Vynokurova, O. (2013). Flexible wavelet-neuro-fuzzy neuron in dynamic data mining tasks. Oil and Gas Power Engineering, 2 (20), 158–162.
20. Haykin, S. (1999). Neural Networks: A Comprehensive Foundation. Prentice Hall, 842.
21. Nelles, O. (2001). Nonlinear System Identification. Springer. doi: https://doi.org/10.1007/978-3-662-04323-3
22. Wang, L.-X., Mendel, J. M. (1992). Fuzzy basis functions, universal approximation, and orthogonal least-squares learning. IEEE Transactions on Neural Networks, 3 (5), 807–814. doi: https://doi.org/10.1109/72.159070
23. Kohonen, T. (1995). Self-Organizing Maps. Springer. doi: https://doi.org/10.1007/978-3-642-97610-0
24. Kasabov, N. (2003). Evolving Connectionist Systems. Springer. doi: https://doi.org/10.1007/978-1-4471-3740-5
25. Sugeno, M., Kang, G. T. (1988). Structure identification of fuzzy model. Fuzzy Sets and Systems, 28 (1), 15–33. doi: https://doi.org/10.1016/0165-0114(88)90113-3
26. Ljung, L. (1987). System Identification: Theory for the User. Prentice Hall, 432.
27. Otto, P., Bodyanskiy, Y., Kolodyazhniy, V. (2003). A new learning algorithm for a forecasting neuro-fuzzy network. Integrated Computer-Aided Engineering, 10 (4), 399–409. doi: https://doi.org/10.3233/ica-2003-10409
28. Narendra, K. S., Parthasarathy, K. (1990). Identification and control of dynamical systems using neural networks. IEEE Transactions on Neural Networks, 1 (1), 4–27. doi: https://doi.org/10.1109/72.80202
29. I. Alieinykov, K. A. Thamer, Y. Zhuravskyi, O. Sova, N. Smirnova, R. Zhyvotovskyi et. al. (2019). Development of a method of fuzzy evaluation of information and analytical support of strategic management. Eastern-European Journal of Enterprise Technologies, 6 (2 (102), 16–27. doi: https://doi.org/10.15587/1729-4061.2019.184394
30. Koshlan, A., Salnikova, O., Chekhovska, M., Zhyvotovskyi, R., Prokopenko, Y., Hurskyi, T. et. al. (2019). Development of an algorithm for complex processing of geospatial data in the special-purpose geoinformation system in conditions of diversity and uncertainty of data. Eastern-European Journal of Enterprise Technologies, 5 (9 (101)), 35–45. doi: https://doi.org/10.15587/1729-4061.2019.180197

DOI: 10.15587/1729-4061.2020.197358

CONSTRUCTION OF A MATHEMATICAL MODEL TO DESCRIBE THE DYNAMICS OF MARINE TECHNICAL SYSTEMS WITH ELASTIC LINKS IN ORDER TO IMPROVE THE PROCESS OF THEIR DESIGN (p. 56–66)

Volodymyr Blintsov
Admiral Makarov National University of Shipbuilding, Mykolayiv, Ukraine
ORCID: http://orcid.org/0000-0002-3912-2174

Kostiantyn Trunin
Admiral Makarov National University of Shipbuilding, Mykolayiv, Ukraine
ORCID: http://orcid.org/0000-0001-6345-6257

A mathematical model (MM) has been developed to describe the dynamics of the MTS EL element using an underwater towed system (UTS) as an example, as well as the MM of MTS with EL.

The MM of the EL element dynamics makes it possible to take into consideration:

1) the movement of a carrier vessel (CV);

2) features of the EL design, which affect the functional characteristics MTS;

3) the movement of an underwater vehicle (UV);

4) the impact of obstacles along the path of UV and EL;

5) large movements of EL as part of MTS.

The mathematical model of MTS with EL makes it possible to solve the following tasks:

1) to determine a change in the shape of EL and the forces of its tension in the process of maneuvering of CV and UV taking into consideration sea waves, wind loads on CV, the sea depth and its change in the assigned water area, the mass and elastic properties of EL;

2) to determine the relative position of CV and UV in the process of their maneuvering;

3) to determine the maximum loads on EL necessary to assess its strength during the maneuvering of CV and UV.

Analysis of design tasks in the construction of marine tethered systems (MTdS) as a variety of MTS reveals that the calculation of MtdS EL is associated with significant theoretical complexity and is science-intensive. The proposed procedure for improving the design of MTS with EL, based on the MM that describes the dynamics of MTS EL (as well as MTS with EL), makes it possible to investigate the different modes of operation of almost all classes of MTdS. Using it could improve existing methods of calculating and designing MTdSs with EL thereby bringing them to the level of an engineering application.

Keywords: elastic link, marine technical system, mathematical model that describes the dynamics of an elastic link, improving the design of MTS with EL.

References

1. Blintsov, V., Klochkov, O. (2019). Generalized method of designing unmanned remotely operated complexes based on the system approach. EUREKA: Physics and Engineering, 2, 43–51. doi: https://doi.org/10.21303/2461-4262.2019.00878
2. Blintsov, V., Kucenko, P. (2019). Application of systems approach at early stages of designinng unmanned towed underwater systems for shallow water areas. Eastern-European Journal of Enterprise Technologies, 5 (9 (101)), 15–24. doi: https://doi.org/10.15587/1729-4061.2019.179486
3. Feng, D. K., Zhao, W. W., Pei, W. B., Ma, Y. C. (2011). A New Method of Designing Underwater Towed System. Applied Mechanics and Materials, 66-68, 1251–1255. doi: https://doi.org/10.4028/www.scientific.net/amm.66-68.1251
4. Minowa, A., Toda, M. (2019). A High-Gain Observer-Based Approach to Robust Motion Control of Towed Underwater Vehicles. IEEE Journal of Oceanic Engineering, 44 (4), 997–1010. doi: https://doi.org/10.1109/joe.2018.2859458
5. Blintsov, O. (2017). Development of the mathematical modeling method for dynamics of the flexible tether as an element of the underwater complex. Eastern-European Journal of Enterprise Technologies, 1 (7 (85)), 4–14. doi: https://doi.org/10.15587/1729-4061.2017.90291
6. Liu, G., Xu, G., Wang, G., Yuan, G., Liu, J. (2019). Modeling and Speed Control of the Underwater Wheeled Vehicle Flexible Towing System. Mathematical Problems in Engineering, 2019, 1–11. doi: https://doi.org/10.1155/2019/3943472
7. Nedelcu, A., Tărăbuţă, O., Clinci, C., Ichimoaiei, G. (2018). CFD approach used for modelling hydrodynamic analysis and motion characteristics of a remotely operated vehicle. IOP Conference Series: Earth and Environmental Science, 172, 012029. doi: https://doi.org/10.1088/1755-1315/172/1/012029
8. Xu, X., Wang, S., Lian, L. (2013). Dynamic motion and tension of marine cables being laid during velocity change of mother vessels. China Ocean Engineering, 27 (5), 629–644. doi: https://doi.org/10.1007/s13344-013-0053-5
9. Drąg, Ł. (2016). Application of dynamic optimisation to the trajectory of a cable-suspended load. Nonlinear Dynamics, 84 (3), 1637–1653. doi: https://doi.org/10.1007/s11071-015-2593-0
10. Drąg, Ł. (2017). Application of dynamic optimisation to stabilise bending moments and top tension forces in risers. Nonlinear Dynamics, 88 (3), 2225–2239. doi: https://doi.org/10.1007/s11071-017-3372-x
11. Trunin, K. S. (2017). Equations of dynamics of the flexible connection element of the marine tethered system. Collection of Scientific Publications NUS, 1, 18–25. doi: https://doi.org/10.15589/jnn20170104
12. Trunin, K. S. (2017). Mathematical model of two connected elements of the flexible links of the marine lash system. Collection of Scientific Publications NUS, 2, 3–10. doi: https://doi.org/10.15589/jnn20170201
13. Trunin, K. S. (2017). Dynamics of a marine lash system with a flexible link. Collection of Scientific Publications NUS, 3, 3–10. doi: https://doi.org/10.15589/jnn20170301
14. Rouch, P. (1980). Vychislitel'naya gidrodinamika. Moscow: Mir, 618.
15. Bugaenko, B. A. (2004). Dinamika sudovyh spuskopodemnyh operatsiy. Kyiv: Naukova dumka, 320.
16. Nuzhniy, S. N. (1998). Osobennosti proektirovaniya kabel'-trosov dlya samohodnyh privyaznyh podvodnyh apparatov. Respublikanskyi mizhvidomchyi naukovo-tekhnichnyi zbirnyk elektrychnoho mashynobuduvannia ta elektroobladnannia. Odessa, 224.
17. Babkin, G. V. (1998). Otsenka energeticheskih harakteristik dvuhzvennoy privyaznoy podvodnoy sistemy s buem-otvoditelem. II Mizhnarodna NTK «Problemy enerhozberezhennia i ekolohiyi sudnobuduvannia. Mykolaiv, UDMTU.