COMPUTATIONAL RESEARCH PROGRESS IN APPLIED SCIENCE & ENGINEERING (CRPASE)

CRPASE: TRANSACTIONS OF INDUSTRIAL ENGINEERING

Journal homepage: http://www.crpase.com

CRPASE: Transactions of Industrial Engineering, Vol. 06(03), 210-215, September 2020 ISSN 2423-4591

Review Article

A Review on Multidisciplinary Design Optimization of Dynamic Engineering Systems

Batukan Cem Tarhan, Mostafa Ranjbar*

Ankara Yildirim Beyazit University, Department of Mechanical Engineering, Ankara, Turkey

Keywords

Optimization, Design, Multidisciplinary, Dynamic Systems, Engineering, Automotive.

Abstract

Dynamical system is explained as a particle movement which depend on time and predicts its future behavior. Dynamical systems are always used for some engineering problems. These problems include movements, vibrations and technology. It has several applications in automotive engineering as well. It includes the vehicle dynamic design and control systems. Although it develops the systems that helps the human life, but it also brings plenty of necessaries which one of them is optimization. Multidisciplinary design optimization (MDO) should be used in the solving of dynamic engineering problems. Lacking MDO can lead to less efficiency or mismatch of system. MDO play important role in the improvement of the systems. In this article a review on the application of MDO in dynamic system is presented.

1. Introduction

Dynamic engineering systems have an essential role in active and autonomous dynamic systems. Multidisciplinary analysis and design techniques are also important for well-designed complex systems. When multidisciplinary design optimization is used on dynamic systems, they improve their performance. MDO in dynamic systems are significant for engineers. A phenomenal amount of work has been performed around dynamic system design. Physical system design is integral to the dynamic system design problem and must be addressed as well. Unfortunately, dynamic properties are often simplified or neglected when performing plant design. There are many solutions for these problems. Each has different mathematical representation [1].

Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet the stated [2]. System is a complete thing which has a goal. It includes units that are depending and affecting each other. Also, it has certain plans [3]. Multidisciplinary design's the engineering design of systems that have at least two interdependent disciplines. It obtains that performance of one discipline which is influenced by design requirements in other disciplines and decide the design with using this performance data [1]. Multidisciplinary Design Optimization (MDO) is engineering process that uses optimization methods to make optimal design between related disciplines [4].

2. Lecture Review

In 1970, S. De Julio in [5] studied on new technique about approximate computation of optimal controls. This technique can be applied particular linear systems which is governed by partial differential equations when the cost functionals are quadratic. The technique tried on both systems with distributed and boundary control. The results are consistent for both.it seems if we accept to obtain weak convergence of the optimal solution. the technique looks practical [5].

Controllability and observability criteria are important parameters for linear dynamical systems. These parameters don't affect the systems directly, but they give the information about measuring of the quality. There are three physical measures which are about the qualities of controllability and observability of dynamical systems. For

* Corresponding Author: Mostafa Ranjbar
E-mail address: mranjbar@ybu.edu.tr

Received: 22 June 2020; Revised: 12 August 2020; Accepted: 15 August 2020

Please cite this article as: B.C. Tarhan, M. Ranjbar, A Review on Multidisciplinary Design Optimization of Dynamic Engineering Systems, Computational Research Progress in Applied Science & Engineering CRPASE: Transactions of Industrial Engineering 6 (2020) 210–215.

example, there are some works in satellite attitude control problems [6].

In 1978, problem of Titli and Singh was priority, because they didn't have enough equipment and there were two optimization problems which can solve with multi-processor system with hierarchical structure. First case is distributed parameter system and second case is traffic control problem. They tried to which one can be [7].

In 1980, Large scale systems were problem to solved and required more calculation power. They tried new method which was iterative to obtain some information about optimization of large scale systems [8].

In another work BY Manon et al. [9], a class of hybrid dynamical system. These systems operate in multiple phases. There are two different methods to minimize the operating time during process. First method contains of criterion minimization with respect to constraints. Second method contains of Pontragin's maximum principle. For example, Improving the design data and properties of wind turbines, scaling trends such as loading, mass, and cost etc. [10].

In the other work by Laudini et el., [11] the swarm/flock optimization algorithms is used in continuous dynamic systems, generally, optimization algorithms originated to classic swarm intelligence. Numerical swarm/flack-based algorithms turn to differential equations in time domain and closed-forms. Thanks to using circulant matrices for the representation of connection between molecules by via of time approach. The benefit of this integration that it provides functions of time, and these can be update the position and the velocity of each particle in time window. For instance, the leader agent manages topology of the network in its neighbourhood and increases flocking velocity [12].

Particle swarm optimization (PSO) is also using dynamic economic dispatch of power systems. The optimization model of this system is required to obtain some variables about the systems which is power system to improve. This paper's aim is how PSO effected power systems' optimization [13].

Different work by Jung and Park [14] indicates that optimization methods aim to improve design of structural and control systems. If there are more than two systems which may be including structural and control system. The integrated systems should examine together and all of them try to get better performance. Example of this system, which is generally in mechatronic field, the multidisciplinary optimization method is applied to the design of mechatronic vehicles with active suspensions [15].

In another work by Adami et al. [16], several examples were presented. For the optimizing of these systems, structural analysis, heat transfer, aerodynamics and control were done. In the practice of this system [17], paper explained the methodology of optimization of these systems. Also, it explains how to get better performance.

In this paper, there are several starting priors of solution that are useful for estimate the initial points. Methods include warm start from a prior solution, linearization, structural decomposition, and an incremental unbounding of decision variables that leads up to solving the originally intended problem. Several optimization problems are expanding some topics which are many benchmark tests, energy storage, aerial vehicle etc. [18].

In the paper from [19], the multi-functional optimization algorithm is used for dynamical systems. The problem is defined for control problem which is updated by using the gradient estimation. In Pareto Optimality, there are some inputs which is developed along to Pareto descent direction. This is succeeded by solving the linear programming problem. As an example, development of air foils shows these properties [20].

Also, there are some practice in topology optimization. One of them is in the motion systems which aim to better accuracy, higher speed and larger scale and high-performance design. The goal of topology optimization is that decide the best material quantity and quality with a design volume [21]. This approach is significant for aerodynamic design issues. There are some parameters are about limitations of system. Physical behavior is explored using a case study for aero-structural optimization along with other physical quantities and quality with established behavior [22].

Cities population is also dynamical system, so they have some problems which may solve. When solving these problems, optimization methods can be useful. This work explained mathematical model of cities and solve this function using optimization models. Results show that this approach is useful for people dynamics [23].

Ordinary differential equation systems use to find optimal solutions of the dynamical system problems. Especially, they use for low dimensional problems and for larger system which is unable to estimate bounds. In the paper, interval contractors are used for bounded optima. Upper and lower bounds on the dynamic parameters using on objective function is related to first order sensitivity equation. The method solves the tight limits [24].

The air and water exchanges are limited in recirculation aquaculture system (RAS),so the facility ventilation is crucial component for the preventing toxicity. The facility ventilation systems consume elevated energy and this paper deals with decreasing that energy consuming by dynamic facility ventilation [25].

There are challenges for optimization in dynamic environments. In a work by Ye et al. [26] suggested a novel multi-swarm particle swarm optimization with dynamic learning strategy to improve the performance of PSO in 2017.Among all sub-swarms, each sub-swarm must be classified into ordinary particles and communication particle with separated task for each iteration due to provide information exchange between subswarms. There two types of particles; ordinary particles and communication particles. The method leans on setting dynamic control mechanism with an increasing parameter "p" for implementing the classification operation provides ordinary particles an increasing sense of evolution into communication particles during the searching process.

The study of Lorenz T. Biegler on advanced optimization strategies for integrated dynamic process operations in 2017 discusses the effectiveness of dynamic optimization on three case studies on real-world chemical processes This study discusses and demonstrates the effectiveness of dynamic optimization on three case studies on real-world chemical processes. In the first case, we consider the optimal design of runaway reactors, where simulation models may lead to unbounded profiles for many choices of design and operating conditions. As a result, optimization based on repeated simulations typically fails, and a simultaneous, equation-based approach must be applied. Second, we consider optimal operating policies for grade transitions in polymer processes. Modelled as an optimal control problem, we demonstrate how incorporation of product specification bands leads to multistage formulations that greatly improve process performance and significantly reduce off-grade product. Third, we consider an optimization strategy for the integration of scheduling and dynamic process operation for general continuous/batch processes. The method introduces a discrete time formulation for simultaneous optimization of scheduling and operating decisions. Finally, we provide a concise summary of directions and challenges for future extension of these optimization formulations and solution strategies [27].

Concepts of electrical vehicles include hybrid batteries. This study concerned utilization, dimensioning and operation of hybrid battery systems. Main purpose of this paper is elaborate the energy optimization on hybrid battery system. Two optimization methods are used for given system and control problem.by working on stochastic modelling, control laws obtained and that laws applied given system which include vehicle drivetrain and vehicle chassis. After that performance of controllers are compared [28].

The fundamental mechanical engineering challenge of mechanism design is the subject which this paper deals with. Since there are few, if any, approaches that consider kinematic synthesis and optimization of dynamic performance in an integrated manner, while there is a significant body of research associated with mechanism design. To address this gap, this paper presents a multi-level, also called layered, design optimization approach that enables kinematic and dynamic optimization combined with velocity profiling of the motor/drive system. The approach is presented for both new design and redesign tasks, and is based on the use of inverse kinematic and inverse dynamic analysis, and a novel strategy for generating instantiations of spatial mechanisms that satisfy kinematic quality indicators but with improved dynamic performance. The experimental results validate not only the separated stages of the approach and the models but the overall improvements achievable through the application of the method as well. In this regard, the experimental mechanism which is also called practical, exhibited performance improvements in the peak-to-peak torque of 63%, which correlate closely with those calculated theoretically after kinematic and dynamic optimization. The introduction of a velocity cam function is shown for improving the dynamic quality indicators further and an overall reduction in peak-to-peak torque demand of 85% is resulted 29.

The matter of the paper based on adapting the particle swarm optimization (PSO) to the dynamic economic emission dispatch (DEED) problem. The paper focuses on to evaluate the performance of different variants of the PSO with Avoidance of Worst Locations (PSO AWL) against the variants of the standard particle swarm optimization (SPSO). The results showed that the compatibility of the PSO to the DEED problem [30].

In a series of publications by Ranjbar et al. [31-58], the concept of multidisciplinary engineering design optimization of various dynamical systems in cars were investigated and reported. They showed the effect of optimization in the improvement of the quality of results.

3. Conclusions

Optimization problems are created for improving the systems. We examined the dynamical systems and related topics in many fields. Also, optimization methods are compatible, so we can obtain objective function in every fields. We can solve these function with lots of technics and methods. These optimization methods are useful for improving efficiency and reducing cost of systems. We discuss some of technics and methods about multidisciplinary design optimization. These technics generally include mathematical colorations and experiments results. We try to solve these colorations and we want to obtain exact values, but we cannot always reach exact values and then we try to reach the near values. For these values, we can also investigate experimental results. During, approach the result, system can reach the optimized conditions. These papers' goal is optimizing the systems. Each paper has different way to solve the functions of the optimization problems. Some papers focus on for example time and cost. The others concentrate another parameter. The result of optimizing process advise the further improvements. As a direction for future study, we will deal with some methods such as but not limited to [59-76].

References

[1] B. A. Steinfeldt, The Multidisciplinary Design Problem as A Dynamical System, Ph.D. thesis, Georgia Institute of Technology, USA, (2013).

[2] Accreditation Board for Engineering and Technology, Baltimore, Maryland, Criteria for Accrediting Engineering Programs: Effective for Evaluations During the 2009-2010 Accreditation Cycle, (2008).

[3] R. L. Acko, Redesigning the Future: A Systems Approach to Societal Problems, John Wiley & Sons, Inc., New York, NY, (1974).

[4] F. Hui, L. Weiji, An Efficient Method for Reliability-based Multidisciplinary Design Optimization, Chinese Journal of Aeronautics 21 (2008) 335–340.

[5] De Julio, S. The Optimization of Dynamical Systems", Automatica 6 (1970) 401–408.

[6] P. Müller, H. Weber, Analysis and Optimization of Certain Qualities of Controllability and Observability for Linear Dynamical Systems, Automatica 8 (1972) 237–246.

[7] A. Titli, M. Singh, M. Hassan, Hierarchical Optimisation of Dynamical Systems Using Multiprocessors, Computers & Electrical Engineering 5 (1978) 3–14.

[8] L. Baptistella, A. Titli, Large Scale Multicriteria Optimization - An Interactive Method, IEEE Transactions on Systems, Man, and Cybernetics 10 (1980) 355–365.

[9] P. Manon, C. Valentin-Roubinet, G. Gilles, Optimal Control of Hybrid Dynamical Systems: Application in Process Engineering, Control Engineering Practice 10 (2002) 133–149.

[10] T. Ashuri, M. Zaaijer, J. Martins, J. Zhang, Multidisciplinary design optimization of large wind turbines - Technical, economic, and design challenges, Energy Conversion and Management 123 (2016) 56–70.

[11] A. Laudani, F. Fulginei, G. Lozito, A. Salvini, Swarm/Flock Optimization Algorithms as Continuous Dynamic Systems, Applied Mathematics and Computation 243 (2014) 670–683.

[12] S. Etemadia, R. Vatankhahb, A. Alasty, G. R. Vossoughib, M. Boroushakic, Leader Connectivity Management and Flocking Velocity Optimization Using the Particle Swarm Optimization Method, Scientia Iranica 19 (2012) 1251–1257.

[13] Y. Sun, Z. Wang, Improved Particle Swarm Optimization Based Dynamic Economic Dispatch of Power System, Procedia Manufacturing 7 (2016) 297–302.

[14] U. Jung, G. Park, A New Method for Simultaneous Optimum Design of Structural and Control Systems, Computers & Structures 160(2015) 90–99.

[15] C. Chen, Multidisciplinary Design Optimization of Mechanisms, Advances in Engineering Software, 36 (2004) 301–311.

[16] A. Adami, M. Mortazavi, M. Nosratollahi, A New Approach in Multidisciplinary Design Optimization of Upper-Stages Using Combined Framework, Acta Astronautica 114 (2015) 174–183.

[17] A. Okninskia, Multidisciplinary Optimisation Of Single-Stage Sounding Rockets Using Solid Propulsion, Aerospace Science and Technology 71 (2017) 412–419.

[18] S. M. Safdarnejada, J. D. Hedengrena, N. R. Lewisa, E. L. Haseltine, “Initialization Strategies for Optimization Of Dynamic Systems, Computers & Chemical Engineering 78 (2015) 39–50.

[19] M. Toyoda, T. Shen, Gradient Estimation Based Multi-Functional Optimization of Dynamical Systems, IFAC-PapersOnLine 49 (2016) 696–701.

[20] URL1: Vehicle Design, http://mail.tku.edu.tw/095980/airfoil%20design.pdf,28.11.2017

[21] S. K. Singh, A Novel Concept for Non-Linear Multidisciplinary Aerodynamic Design Optimization, Aerospace Science and Technology 70(2017) 626–635.

[22] G. Veen, M. Langelaar, S. Meulen, D. Laro, W. Aangenent, F. Keulen, Integrating Topology Optimization in Precision Motion System Design for Optimal Closed-Loop Control Performance, Mechatronics 47 (2017) 1–13.

[23] J. E. Santibanez-Aguilar, A. Flores-Tlacuahuac, M. Rivera-Toledo, J. M. Ponce-Ortega, Dynamic Optimization for the Planning of a Waste Management System Involving Multiple Cities, Journal of Cleaner Production 165 (2017) 190–203.

[24] C. Perez-Galvan, I. Bogle, Global Optimisation for Dynamic Systems Using Interval Analysis, Computers & Chemical Engineering 107(2017) 343–356.

[25] G. Gehlerta, M. Griese, M. Schlachter, C. Schulz, “Analysis and optimisation of dynamic facility ventilation in recirculation aquacultural systems, Aquacultural Engineering 80(2017) 1–10.

[26] W. Ye, W. Feng, S. Fan, A Novel Multi-Swarm Particle Swarm Optimization with Dynamic Learning Strategy, Applied Soft Computing 61(2017) 832–843.

[27] L. T. Biegler, Advanced Optimization Strategies for Integrated Dynamic Process Operations, Computers & Chemical Engineering (2017).

[28] R. Wegmann, V. Döge, J. Becker, D. Sauer, Optimized Operation of Hybrid Battery Systems for Electric Vehicles Using Deterministic and Stochastic Dynamic Programming, Journal of Energy Storage 14 (2017) 22–38.

[29] R. Rayner, M. Sahinkaya, B. Hicks, Improving the Design of High Speed Mechanisms Through Multi-Level Kinematic Synthesis, Dynamic Optimization and Velocity Profiling”, Mechanism and Machine Theory 118(2017) 100–114.

[30] K. Mason, J. Duggan, E. Howley, Multi-Objective Dynamic Economic Emission Dispatch using Particle Swarm Optimisation Variants, Neurocomputing 270(2017)188-197.

[31] S. Mazloomi, M. Ranjbar, L. Boldrin, F. Scarpa, S. Patsias, N. Ozada, Vibroacoustics of 2D Gradient Auxetic Hexagonal Honeycomb Sandwich Panels, Composite Structures, Available online 28 October 2017, https://doi.org/10.1016/j.compstruct.2017.10.077 (2017).

[32] M. Ranjbar, L. Boldrin, F. Scarpa, S. Niels, S. Patsias, Vibroacoustic optimization of anti-tetrachiral and auxetic hexagonal sandwich panels with gradient geometry, Smart Materials and Structures 25 (2016).

[33] G. Hussain, M. Ranjbar, S. Hassanzadeh, Trade-off among Mechanical Properties and Energy Consumption in Multi-Pass Friction Stir Processing of Al 7075-T651 Alloy Employing Hybrid Approach of Artificial Neural Network and Genetic Algorithm, Proc IMechE Part B: J Eng. Manufacture 231 (2015) 129–139.

[34] M. Ranjbar, St. Marburg, H-J. Hardtke, “Structural-Acoustic Optimization of a Rectangular Plate: A Tabu Search Approach, Journal of Finite Elements in Analysis and Design 50(2012)142–146.

[35] M. Ranjbar, H-J. Hardtke, D. Fritze, St. Marburg, Finding the Best Design within Limited Time: A Comparative Case Study on Methods for Optimization in Structural Acoustics, Journal of Computational Acoustics 18 (2010) 149–164.

[36] M. Ranjbar, St. Marburg, H-J. Hardtke, A New Hybrid Design of Experiments Approach for Optimization in Structural Acoustics Applications, Applied Mechanics and Materials (2012) 110–116.

[37] M. Ranjbar, A. Tadayon, Vibration Analysis of Multi Degree of Freedom Self-Excited Systems, Journal of Robotic and Mechatronic Systems 2(2017) 1–8.

[38] M. Ranjbar, M. Nahid, A. Renawi, Z. Sadeqi, Development of an Educational Noise Reduction Measurement Test Bench, Journal of Robotic and Mechatronic Systems 2 (2017) 27–32.

[39] M. Ranjbar, M. Alinaghi, Effect of Liner Layer Properties on Noise Transmission Loss in Absorptive Mufflers, Mathematical Modelling and Applications 1(2016) 46–54.

[40] M. Ranjbar, M. Gharooni Saffar, A Sensitivity Analysis on Application of Artificial Neural Networks in Structural Acoustics, Journal of Robotic and Mechatronic Systems, 1, (2016) 23–26.

[41] M. Ranjbar, M. Kemani, A Comparative Study on Design Optimization of Mufflers by Genetic Algorithm and Random Search Method, Journal of Robotic and Mechatronic Systems 1(2016) 7–12.

[42] M. Ranjbar, St. Marburg, Fast Vibroacoustic optimization of mechanical structures using artificial neural networks, International Journal of Mechanical Engineering and Applications 1 (2013) 64–68.

[43] M. Ranjbar, St. Marburg, Vibroacoustic Optimization of Mechanical Structures: A Controlled Random Search Approach, Advanced Material Research (2013) pp. 158–161.

[44] M. Ranjbar, St. Marburg, Vibroacoustical Optimization of Mechanical Structures Using Geometry Modification Concept and Genetic Algorithm Method, Journal of Mechanical Engineering, Tarbiat Modares University 12 (2012) 134–143.

[45] M. Ranjbar, A Comparative Study on Optimization in Structural Acoustics, Ph.D. Thesis, Technische Universität Dresden, Germany (2011).

[46] M. Ranjbar, Development of Hybrid Robust Optimization Strategies for Structural-Acoustic Applications," In the annual report of the Pan-European Research Infrastructure on High Performance Computing (HPC-Europa), University of Bologna, Italy, (2007).

[47] M. Ranjbar, S. E. Khadem, Development of vibration analysis using Gabor transformation for machinery fault diagnosis , Journal of Amirkabir University 12 (2001).

[48] M. Ranjbar, O. Keskin, S. Demirtaş, Y. E. Karakoca, H. Arslan, Designing and Manufacturing of a Modal Analysis Test Bench – Part one: Harmonic Shaker Development, International Symposium on Multidisciplinary Studies and Innovative Technologies Gaziosmanpaşa University Tokat / Turkey, (2017).

[49] M. Ranjbar, B. Dalkılıç, E. Çalık, M. C. Arslan, H. Arslan, On Muffler Design for Transmitted Noise Reduction, International Symposium on Multidisciplinary Studies and Innovative Technologies Gaziosmanpaşa University Tokat / Turkey (2017).

[50] S. Mazloomi, M. Ranjbar, F. Sarpa, N. Ozada, Vibroacoustic Optimization of 2-dimensional gradient auxetics sandwich panels, Medyna 2017: 2nd Euro-Mediterranean Conference on Structural Dynamics and Vibroacoustics, Sevilla, Spain (2017).

[51] M. Ranjbar, S. Orhan, Self-Excited Vibration of the Three-Degrees of Freedom System, the 25th Annual International Conference on Mechanical Engineering (ISME 2017), Tehran, Iran, (2017).

[52] M. Ranjbar, M. Kermani, Muffler Design by Noise Transmission Loss Maximization on Narrow Band Frequency Range, the 7th Automotive Technologies Congress (OTEKON 2014), Bursa, Turkey, 26–27 May (2014).

[53] M. Ranjbar, M. Kermani, On Maximization of Noise Transmission Loss in Mufflers by Geometry Modification Concept, ASME District F - 2013 Early Career Technical Conference, University of Alabama, Birmingham, Alabama, USA, 2–3 November (2013).

[54] M. Ranjbar, St. Marburg, H.-J. Hardtke, Development of a Hybrid Neural Networks Algorithm for Structural-Acoustics Optimization Applications, In Proceedings of the First International Conference of Acoustics and Vibration, Tehran, Iran, 21–22 December (2011).

[55] M. Ranjbar, St. Marburg, H.-J. Hardtke, Schnelle Optimierung in der Struktur Akustik, the 37-annual meeting for Acoustics, Düsseldorf, Germany, 21–24 March (2011).

[56] M. Ranjbar, St. Marburg, H.-J. Hardtke, Ein Vergleich von Optimierungsverfahren fuer Anwendungen in der Strukturakustik," Proceedings of the 33-annual meeting for Acoustics, Stuttgart, Germany, 19–22 March (2007).

[57] M. Ranjbar, St. Marburg, H.-J. Hardtke, Study of Optimization Methods for Structural-Acoustic Applications, In: Proceedings of 77th Annual Meeting of the Gesellschaft für Angewandte Mathematik und Mechanik e.V., Technische Universität Berlin, Germany, 27–31 March (2006).

[58] M. Ranjbar, M. Mirsalim, A Feasibility Study Phase on the Hybrid Electric Vehicles For Iran, The First International Conference on HEV's, Iran Science and Technology University, Tehran, Iran, in Persian, (2001).

[59] R. Khan, X. Zhang, R. Kumar, A. Sharif, N. A. Golilarz, M. Alazab, An Adaptive Multi-Layer Botnet Detection Technique Using Machine Learning Classifiers, Applied Sciences 9 (2019).

[60] L. Ali, C. Zhu, N. A. Golilarz**,** A. Javeed, M. Zhou, Y Liu, Reliable Parkinson's Disease Detection by Analyzing Handwritten Drawings: Construction of an Unbiased Cascaded Learning System based on Feature Selection and Adaptive Boosting Model, IEEE Access 7 (2019) 116480–116489.

[61] L. Ali, A. Niamat, J. A. Khan, N. A. Golilarz, X. Xingzhong, A. Noor, R. Nour, S. A. Chan Bukhari, An Optimized Stacked Support Vector Machines Based Expert System for the Effective Prediction of Heart Disease IEEE Access 7 (2019) 54007–54014.

[62] N. A. Golilarz, H. Gao, H. Demirel, Satellite Image De-noising with Harris Hawks Meta Heuristic Optimization Algorithm and Improved Adaptive Generalized Gaussian Distribution Threshold Function, IEEE Access 7 (2019) 57459 –57468.

[63] N. A. Golilarz, N. Robert, J. Addeh, A. Salehpour, Translation invariant wavelet based noise reduction using a new smooth nonlinear improved thresholding function, Computational Research Progress in Applied Science & Engineering 3 (2017) 104–108.

[64] N. A. Golilarz, N. Robert, J. Addeh, Survey of image de-noising using wavelet transform combined with thresholding functions, Computational Research Progress in Applied Science & Engineering 3 (2017) 132–135.

[65] N. A. Golilarz, H. Demirel, Thresholding neural network (TNN) based noise reduction with a new improved thresholding function, Computational Research Progress in Applied Science & Engineering 3 (2017) 81–84.

[66] S. S. Mirjavadi, M. Forsat, M. Nikookar, M. R. Barati, AMS Hamouda, Nonlinear forced vibrations of sandwich smart nanobeams with two-phase piezo-magnetic face sheets, European Physical Journal Plus 134 (2019).

[67] A. Addeh, A. Khormali, N. A. Golilarz, Control chart pattern recognition using RBF neural network with new training algorithm and pracrical features, ISA Transactions 79 (2018) 202–216.

[68] N. A. Golilarz, A. Addeh, H. Gao, L. Ali, A. M. Roshandeh, H. M. Munir, R. Khan, A new automatic method for control chart patterns recognition based on ConvNet and harris hawks meta heuristic optimization algorithm, IEEE Access 7 (2019) 149398–149405.

[69] H. Chen, A. A. Heidari, X. Zhao, L. Zhang, H. Chen, Advanced orthogonal learning-driven multi-swarm sine cosine optimization: Framework and case studies, Expert Systems with Applications 144 (2020) 113113.

[70] Z. Xu, Z. Hu, A. A. Heidari, M. Wang, X. Zhao, H. Chen, X. Cai, Orthogonally-designed adapted grasshopper optimization: A comprehensive analysis, Expert Systems with Applications 150 (2020) 113282.

[71] H. M. Ridha, A. A. Heidari, M. Wang, H. Chen, Boosted mutation-based Harris hawks optimizer for parameters identification of single-diode solar cell models, Energy Conversion and Management 209 (2020) 112660.

[72] H. Zhang, A. A. Heidari, M. Wang, L. Zhang, H. Chen, C. Li, Orthogonal Nelder-Mead moth flame method for parameters identification of photovoltaic modules, Energy Conversion and Management 211 (2020) 112764.

[73] N. A. Golilarz, H. Demirel, Image de-noising using un-decimated wavelet transform (UWT) with soft thresholding technique. In: Proceedings of the IEEE 9th International Conference on Computational Intelligence and Communication Networks (CICN), Girne, Cyprus, September 16–17 (2017).

[74] N. A. Golilarz, H. Demirel, Thresholding neural network (TNN) with smooth sigmoid based shrinkage (SSBS) function for image de-noising. In: Proceedings of the IEEE 9th International Conference on Computational Intelligence and Communication Networks (CICN), Girne, Cyprus, September 16–17 (2017).

[75] N. A. Golilarz, H. Gao, W. Ali, M. Shahid, Hyper-spectral remote sensing image de-noising with three dimensional wavelet transform utilizing smooth nonlinear soft thresholding function. In: Proceedings of the IEEE15th International Computer Conference on Wavelet Active Media Technology and Information Processing (ICCWAMTIP), Chengdu, China, December 14–16 (2018).

[76] N. A. Golilarz, H. Demirel, H. Gao, Adaptive generalized Gaussian distribution oriented thresholding function for image de-noising, International Journal of Advanced Computer Science and Applications(IJACSA) 10 (2019) 10–15.