Received: 07/04/2022 *Accepted: 29/04/2022*

International Journal of Advances in Biomedical Engineering
Open Access Peer-reviewed Journal
ISSN: 2822-2237
www.ijabe.online
Volume:1, Number:2, Pages:(87-93)
Year:2022

Mini Review: Nature-Inspired Algorithms in Tomography

Çağlar Cengizler*[*1]

**Corresponding Author E-mail:ccengizler@cu.edu.tr*

[1]*Electric and Energy Program, AOSB Technical Sciences Vocational School, Cukurova University, Adana, Turkey*

Abstract

Tomography is simply generation of cross-sectional images of body via any kind of penetrating wave. Today, tomography is one of the most popular medical imaging modalities that is mostly preferred for monitoring body internals to search for any kind of abnormalities. In this article, it is aimed to review some of the most successful implementations of nature-inspired algorithms used in the development of tomography technology.

Keywords: Tomography; Intelligent; Nature-inspired; Technology

1. Introduction

Tomography is one of the medical imaging modalities which is widely used for monitoring body internals by cross-sectional images. The word tomography word originating from imaging by sections. It was first introduced to the public in 1972 [1, 2]. Devices used for generating tomography images are called tomograph and images generated by these devices are called tomograms. A tomography required to be able to generate waveforms that can penetrate through body. A rotating axis moves the source of these waves during the imaging. Whereby a 2 dimensional cross-section image of body is generated with each step. One of the oldest and most popular type of tomography is x-ray tomography where a x-ray source is utilized for imaging. This non-invasive modality gives doctors ability to scan body internals for abnormal regions. It has found widespread use since it was first announced to the public. There are approximately 70 million recorded examinations in 2007 in the US alone [3]. With the widespread use of tomography technology, diagnostic problems that can be optimized have also increased. Rapidly evolving computing technologies have increased the diagnostic and imaging potential of tomography, as well as medical diagnostic capacity. At this point, mechanisms inspired by nature have been used to solve many problems that may be challenging for traditional approaches. In this article some of the most successful implementations of nature-inspired algorithms used in the development of tomography technology are reviewed.

2. Use of Nature-Inspired Algorithms in Tomography

Biomimicry is an innovative approach focused on adapting nature's mechanisms into high-tech problems. Similarly, nature-inspired algorithms have been successfully applied in the solution of many biomedical problems. The optimization of problems with nature-inspired algorithms has also increased the evolutionary acceleration of tomography technology. Study of Rattan et al. may be given as an interesting example which they have utilized BAT algorithm for optimizing segmentation problem of tomography images [4]. They have utilized a series of algorithm combinations for automated detection of lung nodules. The BAT algorithm is inspired by the bats' perception of their environment. Accordingly, the bats' echolocation-based sensing abilities were simplified and used for optimization [5]. Similarly Filho et al. have presented a study in 2017, focused on lung nodule diagnosis in computed tomography (CT). They have utilized a combination of genetic algorithm, phylogenetic diversity and support vector machines. They have utilized genetic algorithm for selecting the best individuals to generate the model that will be used in the classification [6]. Genetic algorithm is also a nature inspired meta-heuristic algorithm that allows us to find solutions for complex problems by mimicking the evolution elements of nature such as selection, mutation and reproduction [7]. Moreover they have utilized phylogenetic trees as texture descriptors.

This is also a nature inspired approach. Phylogenetic trees are used in Biology for showing the evolutionary relationships [8]. Resolution is one of the critical factors that directly affects the medical efficiency of the CT. Higher resolution means more accurate detection of abnormal regions. It is possible to enhance resolution by hardware improvements like sensor improvements [9]. However there are many studies that aims to refine the reconstruction of CT images and enhancing the images. As an example, Yu et al. proposed a deep neural network based approach as a Super-resolution (SR) technique. They have managed to take a single image as input and produce SR images by utilizing deep convolutional neural networks [9].

Single photon emission is one of the types of computed tomography. Single photon emission computed tomography (SPECT) uses gamma rays and can provide 3D images of body internals [10]. Samadiani and Moameri proposed a nature inspired mechanism for diagnosis of coronary artery disease from SPECT heart images [10]. They have innovatively utilized genetic algorithm for selecting best features. Moreover they have also implemented Cuckoo Search (CS) algorithm for search space reduction. It is one of the population based meta-heuristic algorithms [11].

Automated segmentation of CT images is also one of the challenges of latest studies. Dorgham and friends have presented a paper that tackles such problem. Their innovative approach is based on monarch butterfly optimization (MBO) algorithm. They have utilized that algorithm for finding optimal threshold for segmentation. MBO algorithm is inspired from the transmigration behavior of monarch butterflies which increases the probability of finding the optimal threshold [12]. Similarly Pleszczynski and friends inspired from animal behaviour for reconstruction of incomplete tomography data in their study [13]. They have implemented polar bear optimization algorithm which is based on hunting characteristics of polar bears [14].

Genetic algorithm is one of the widely used nature inspired algorithms for enhancing tomography technology. Mishra and friends implemented a self-guided genetic algorithm as a reconstruction algorithm for limited view or sparse data [15]. A self-guided Genetic Algorithm is kind of a Estimation of Distribution Algorithms (EDAs) that use the probabilistic model to sample new solutions without the help of conventional genetic operators [16].

3. Conclusion

When the development process of tomography is examined, it is seen that the developments in information processing technologies play a serious role on tomography technology. The rapidly accelerating computing power makes it possible to adapt more mechanisms from nature to solving numerical problems. The studies examined in this article show that the ways in which nature evaluates complex problems within its unique system have the potential to be a serious source of inspiration for human beings. In addition, the non-invasive three-dimensional visual data presented by this new imaging technique is a source for completely new and challenging problems for scientists to explore. This new data source, which has the potential to carry critical information for human life, also creates diagnostic and enhancement problems that are increasingly difficult to solve. The reviewed articles show that solutions inspired by nature play a role in increasing the depth of data that tomography can offer and in making the tomography technique much more intelligent, flexible and adaptive than it is.

Rights and permissions

References

[1] J. Ambrose, Computerized transverse axial tomography, Brit J Radiol 46 (1973) 147–150.

[2] G. N. Hounsfield, Computerized transverse axial scanning (tomography): Part 1. description of system, The British journal of radiology 46 (552) (1973) 1016–1022.

[3] D. Fleischmann, F. E. Boas, Computed tomography—old ideas and new technology, European radiology 21 (3) (2011) 510–517.

[4] S. Rattan, S. Kaur, N. Kansal, J. Kaur, An optimized lung cancer classification system for computed tomography images, in: 2017 Fourth International Conference on Image Information Processing (ICIIP), IEEE, 2017, pp. 1–6.

[5] X.-S. Yang, A. H. Gandomi, Bat algorithm: a novel approach for global engineering optimization, Engineering computations (2012).

[6] A. O. de Carvalho Filho, A. C. Silva, A. Cardoso de Paiva, R. A. Nunes, M. Gattass, Computer-aided diagnosis of lung nodules in computed tomography by using phylogenetic diversity, genetic algorithm, and svm, Journal of digital imaging 30 (6) (2017) 812–822.

[7] S. Mirjalili, Genetic algorithm, in: Evolutionary algorithms and neural networks, Springer, 2019, pp. 43–55.

[8] P. Kapli, Z. Yang, M. J. Telford, Phylogenetic tree building in the genomic age, Nature Reviews Genetics 21 (7) (2020) 428–444.

[9] H. Yu, D. Liu, H. Shi, H. Yu, Z. Wang, X. Wang, B. Cross, M. Bramler, T. S. Huang, Computed tomography super-resolution using convolutional neural networks, in: 2017 IEEE International Conference on Image Processing (ICIP), IEEE, 2017, pp. 3944–3948.

[10] N. Samadiani, S. Moameri, Diagnosis of coronary artery disease using cuckoo search and genetic algorithm in single photon emision computed tomography images, in: 2017 7th International Conference on Computer and Knowledge Engineering (ICCKE), IEEE, 2017, pp. 314–318.

[11] X.-S. Yang, S. Deb, Cuckoo search via lévy flights, in: 2009 World congress on nature & biologically inspired computing (NaBIC), Ieee, 2009, pp. 210–214.

[12] G.-G. Wang, S. Deb, Z. Cui, Monarch butterfly optimization, Neural computing and applications 31 (7) (2019) 1995–2014.

[13] M. Pleszczyński, A. Zielonka, D. Połap, M. Woźniak, J. Mańdziuk, Polar bear optimization for industrial computed tomography with incomplete data, in: 2021 IEEE Congress on Evolutionary Computation (CEC), IEEE, 2021, pp. 681–687.

[14] D. Połap, M. Woźniak, Polar bear optimization algorithm: Meta-heuristic with fast population movement and dynamic birth and death mechanism, Symmetry 9 (10) (2017) 203.

[15] R. Mishra, A. Singh, M. K. Bajpai, Self-guided genetic algorithm for limited view tomography, in: 2021 IEEE International Conference on Imaging Systems and Techniques (IST), IEEE, 2021, pp. 1–6.

[16] S.-H. Chen, P.-C. Chang, T. Cheng, Q. Zhang, A self-guided genetic algorithm for permutation flowshop scheduling problems, Computers & operations research 39 (7) (2012) 1450–1457.