Leveraging Healthcare System with Nature-Inspired Computing Techniques: An Overview and Future Perspective

Mohd Faizan Siddiqui, Aftab Alam, Roman Kalmatov, Azaroual Mouna, Ricardo Villela, Ainura Mitalipova, Yves Najm Mrad, Syed Ali Abbas Rahat, Bhupendra Kumar Magarde, Waseem Muhammad, Salieva Rana Sherbaevna, Nazgul Tashmatova, Umurzakova Gavkharoi Islamovna, Mohammad Ahmad Abuassi, and Zeenat Parween

1 Introduction

The healthcare profession has been grossly inflated by technologies. Medical informatics, without a doubt, is altering the medical industry's landscape (Wani and Barh 2021). With technological improvements, it is now possible to properly identify and treat disorders. Many lethal illnesses have been eradicated thanks to modern

M. F. Siddiqui (✉) · R. Kalmatov · A. Mitalipova · S. A. A. Rahat · B. K. Magarde · W. Muhammad · S. R. Sherbaevna · N. Tashmatova · U. G. Islamovna
International Medical Faculty, Osh State University, Osh City, Kyrgyzstan
e-mail: fzn.imf@gmail.com

A. Alam
Memorial Sloan Kettering Cancer Center, New York City, NY, USA

A. Mouna
Tambov State Medical University, Tambov City, Russia

R. Villela
National Autonomous University of Honduras, Tegucigalpa, Honduras

Y. N. Mrad
Gilbert and Rose-Marie Chagoury School of Medicine, Lebanese American University, Blat, Lebanon

M. A. Abuassi
Department of Internal Medicine, Jordan Hospital, Amman, Jordan

Z. Parween
Patliputra University, Patna, Bihar, India
e-mail: Pzeenat06@gmail.com

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immunizations and other therapeutic methods. However, a variety of chronic disorders, such as cardiovascular, respiratory, malignant, digestive, diarrheal, depression, malaria, cancer, diabetes, and others, do not seem to be going away anytime soon. If crucial human illnesses are detected correctly, they can be efficiently treated (Siddiqui 2021). Nature-inspired computing (NIC) is inspired by many features, components, and species of nature, including structures, plants, insects, flowers, waterfalls, and animals, among others. Swarm intelligence (SI), genetic algorithms (GA), artificial bee colony (ABC), particle swarm optimization (PSO), ant colony optimization (ACO), water wave algorithm (WWA), honeybee algorithm (HBA), bat algorithm (BA), cuckoo algorithm (CA), fish swarm algorithm (FSA), ray optimization (RO) are some of the important NIC techniques that have taken ideas from physics and biology (Agarwal and Mehta 2014). The size of the average data created across different activities has expanded by orders of magnitude due to advances in information and communication technology, as well as the data processing and storage capacity of computer devices in the contemporary period (Gupta and Raza 2019). This holds true for both the number of instances in the data and the number of characteristics. The various learning tasks (supervised or unsupervised) can yield better results by selecting the optimum amount and most useful features from such vast datasets. In the past, NICs were also used to choose the informative features in a high-dimensional space by removing unnecessary and duplicate characteristics (Alshamlan et al. 2016).

Swarm intelligence (SI) is a novel optimization approach inspired by the biology of animals, birds, and fish. SI approaches drew their inspiration from 'collective intelligence.' The collaboration of large numbers of homogenous agents such as wasps, bees, cuckoos, fish, ants, and so on identifies collective intelligence. It is a branch of computer science that seeks and investigates effective computing solutions inspired by the actions of actual swarms or insects (Carvalho Filho et al. 2017). SI attempts to discover an optimal solution to an NP-hard issue by leveraging the collective power and mutual collaboration of several agents. The genetic algorithm is a type of evolutionary algorithm developed by John Holland in the 1960s. It is the process of producing new children by fusing the genes of the population. It is determined by four factors: population size, generations, mutation rate, and crossover rate. This method produces efficient and accurate results when used to tackle real-world situations. Eberhart and Kennedy created particle swarm optimization, a novel evolutionary approach, in 1995. PSO investigates probabilistic algorithms driven by herding, flocking, and the behavior of swarms of fish or flocks of birds to find a suitable feeding location. This method is employed in the solution of n-dimensional problems. Furthermore, the answer is represented as a point or a surface (Aličković and Subasi 2017).

ACO investigated probabilistic techniques inspired by ant stigmergy and foraging behavior. ACO is a metaheuristic for solving a wide range of optimization issues. It gets its inspiration from the way actual ants select the quickest pathways from their colony to food sources. The pheromone, a chemical molecule that influences the behavior of other people with the same genes, allows the ants to communicate. The water wave algorithm (WWA) is an innovative metaheuristic approach. This

Table 1 Comparison of AI-based technologies and NIC capabilities

Shortcomings of AI-based technologies	Capabilities of NIC to resolve shortcomings
The accuracy of feature categorization is achieved by backward propagation techniques, that vary from over-fitting and under-fitting (Chan et al. 2020)	The randomization of parameters is used to discover the best or nearly optimum solution that optimizes classification accuracy (Hendrickson and Ward 1975)
Once networking has learned single-weight values, every further learning results in catastrophic forgetting (Le et al. 2019)	To maximize acquisition, it employs randomization to learn new parameters (Jaton et al. 1975)
Backward dissemination approaches, which suffer from over-fitting and under-fitting, are used to improve the accuracy of feature categorization (Vaikath et al. 2019)	The randomization of parameters is used to discover the best or nearly optimum solution that optimizes the accuracy of classification (Makar et al. 1975)
Forgetfulness occurs catastrophically when the network is exposed to new weights (Čartolovni et al. 2022)	New parameters are discovered via randomization (Bland et al. 1976)
Local optimization of back propagation may improve classification accuracy; however, global optimization fails (Esmaeilzadeh 2020)	Searching for the most optimum global variable via local search (Poole-Wilson and Langer 1975)

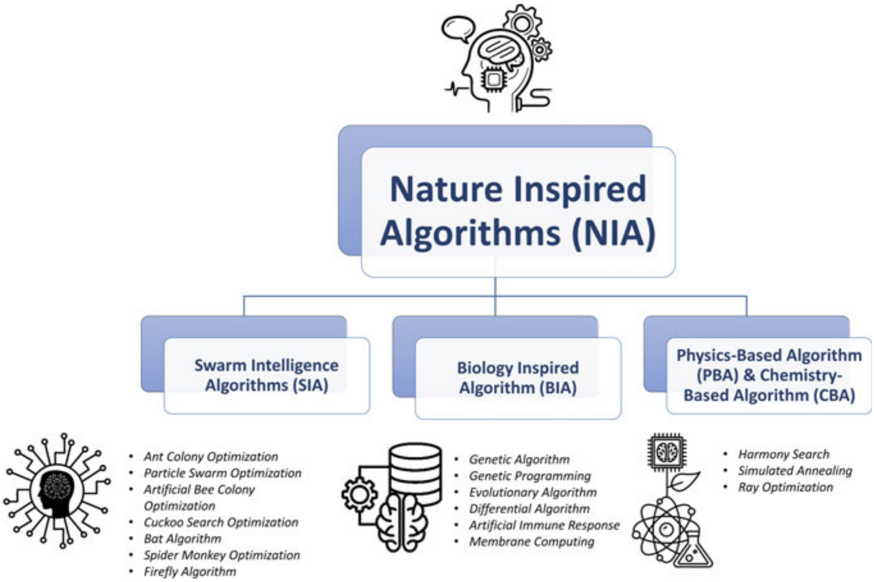

Fig. 1 Classification and important application based on nature-inspired algorithm

2.1 Swarm Intelligence

Decentralized and self-organized systems made up of relatively simple agents that interact with one another in their local environments and with the environment at large are the basis for swarm intelligence, a branch of artificial intelligence that is based on collective behavior of such systems. These algorithms have stimulated the growth of data analytics methods, which has been driven by the expansion of healthcare data availability. In the 1980s, the idea of swarm intelligence was initially put out. When it was first introduced, the scientific community began to pay more attention to it. This technique has an advantage over more traditional ones since it incorporates privacy-preserving technology by default, making it easier to compare scientific data from different sites. Research cooperation and information interchange, particularly in medicine, might benefit greatly from the use of swarm learning. Cancer diagnosis, brain tumor, diabetic retinopathy, heart disease, and medication creation and development all need the use of swarm intelligence (SI) and evolutionary algorithms (EA) in health care today. SI offers derivative-free optimization that is versatile, resilient, and inexpensive to deploy. SI with EAs are powerful global optimization strategies that are very beneficial for selecting features in medical systems. In the healthcare arena, SI and EA approaches and applications are the subject of ongoing study. Since processing healthcare data is essential for diagnosis, treatments, medicine, screening, and eventually lowering the mortality rate, there is a need to expand research advances in the areas of SI and EA approaches for processing healthcare data (Gupta et al. 2021). The SI's approach to an e-healthcare system that links and integrates patients or caregivers while protecting their privacy is really significant. This method allows patients or caregivers to converse with other patients experiencing similar challenges, to comprehend their emotions, and discuss many of their own concerns. During this procedure, however, confidential and sensitive information cannot be shared with anybody at any moment. Using common similarity metrics, the results of the proposed framework are compared to well-known privacy-preserving clustering techniques (Swathi and Sreedhar 2020). The significant SIA's applications in the healthcare domain are:

2.1.1 *Ant Colony Optimization:* Surgical case scheduling, health service data sharing.
2.1.2 *Particle Swarm Optimization:* Healthcare assistance, immediate hospitalization, emergency healthcare services.
2.1.3 *Artificial Bee Colony Optimization:* Smart healthcare system, healthcare data diagnosis, prediction of stroke, operating room scheduling problem.
2.1.4 *Cuckoo Search Optimization:* IoT-based healthcare application, big data analytics, heart disease, and diabetes prediction.
2.1.5 *Bat Algorithm*: Data classification, short-term COVID-19 forecasting.
2.1.6 *Spider Monkey Optimization:* COVID-19 prediction, attack detection in Internet of Medical Things (IoMT).
2.1.7 *Firefly Algorithms:* Sustainable and smart health care, healthcare data diagnosis.

4 Nature-Inspired Algorithms and Their Significant Use in Health Care

Using the principles of genetics as a guide, a nature-inspired algorithm (NIA) and GA attempt to develop practical answers to difficult situations. The first step is to produce a set of random people (solutions) with a variety of characteristics (chromosomes). Chromosomal crossover and mutations occur according to genetic rules and lead to the second generation of people with more varied characteristics. There are two primary techniques for diversifying individuals: crossover and mutation. Two chromosomes are selected for crossing in a zygote. The values up to the crossover point between the two chromosomes are then exchanged between the two chromosomes. Notably, GAs vary from optimization techniques based on derivatives. The first difference between GAs and classical derivative-based techniques is that GAs seek a population of points in the solution space, while classical methods only search for one point. Probabilistic transition rules and random number generators are used in GAs to pick the next population, whereas deterministic transition rules are used in derivative-based methods. Here are some examples of how GAs may be used in a range of medical fields (Tzanetos et al. 2020).

5 Healthcare Management

Health systems around the world rely heavily on the proper management of financial and human resources. The effective scheduling of patient admissions is an important element of hospital management that can improve patient service, satisfaction, and cost-effectiveness ratios. Patients at an ophthalmology facility were better served by a mathematical model that was improved using a GA. As a result of the new algorithm, the waiting list was reduced, the vacancies in hospital beds decreased, the preoperative waiting time for patients decreased, and the number of patients released from the hospital rose. There is another metaheuristic approach that may enhance patient scheduling and decrease time wastage and boost patient satisfaction: PSO (Travaglini et al. 2020).

Maintaining job skills and competence in clinical laboratories requires regular rotation of staff based on their abilities. In a clinical laboratory, staff rotation schedule has been improved by using GAs. Using GA-based software, one study found that it was possible to efficiently arrange staff rotation, assuring the preservation of methods and skills, as well as saving both time and money on the scheduling process (Tay et al. 2015).