Multidisciplinary

Review: the principle of algorithms in wireless communication networks

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Abstract
There are many challenges facing artificial intelligence technologies, including the availability and quality of internet service in different locations. This is where network science comes in. The importance of this science lies in its use to address the various obstacles and challenges that prevent us from achieving optimal internet service. Evolutionary algorithms are a branch of artificial intelligence that simulate the natural distribution of some living organisms. These algorithms rely on biological techniques such as reproduction, reassortment, and selection mechanisms, and utilize concepts of biological evolution, such as natural selection, to solve various problems and achieve the best results.

Keywords: Artificial intelligence, Genetic algorithms, Bird flock algorithm

Introduction

Optimization, or more precisely "optimization", is a very important matter in many engineering and economic applications, where it is clear that the main goals of optimization are to reduce resource consumption, increase profit and raise efficiency in many applications. Optimization is present everywhere, from engineering design to communications and computer science, from planning to place the least communication towers and obtain the best coverage to daily routines where companies seek to maximize profits and reduce installation costs with the least effort. When designing a specific product, the engineering designer takes care to maximize the product's performance and reduce its cost at the same time, so studying optimization helps solve many problems that the engineer faces in his daily routine work. Nowadays, computer simulations have become an indispensable tool for solving these optimization problems using effective and diverse search algorithm [1].

Intelligence can be defined as the ability of a system to adapt its behavior to a constantly changing environment. Optimization systems repeatedly improve the quality of solutions until they reach the optimal, or at least the feasible, solution. In this regard, John Holland introduced genetic algorithms inspired by nature in the early 1970s. His goal was to make computers do what they do. Nature. Holland's genetic algorithm is a sequence of procedural steps to move from one generation of artificial "chromosomes" to the next. The evolutionary approach to artificial intelligence is based on models of natural selection known as evolutionary computing. Evolutionary computing includes the genetic algorithm (GA), the bird swarm algorithm, the ant colony algorithm, and more recently the cuckoo algorithm [2]. In general, all evolutionary computing methods work as follows:

Produce a population of individuals, evaluate their fitness, produce a new improved population, and repeat this process a number of times until the optimal, or at least possible, solution is reached. Artificial intelligence is defined as a science whose goal is to make computers and what they do things that require intelligence if they are performed by a living being [3]. With the beginning of the nineties of the last century, research began towards simulating living beings that are less intelligent than humans, such as ant colonies, fish and birds, that is, the type of social intelligence of animals that appears in their behavior, and thus the result of such simulation is to transfer social or cooperative intelligence to the computer. An example of this is the modern series of algorithms of examples inspired by nature [4] which are usually based on a simple set of rules, to improve solutions repeatedly until the optimal solution is found, or at least the possible one.

Nature-Inspired Optimization Algorithms (NIO) is a branch of artificial intelligence that deals with discovering or investigating the optimal solutions to a given problem from a set of alternatives, or it can be viewed as one of the main quantitative tools in the field of decision-making, as decisions must be taken to optimize at least one of the objectives in a specific set of circumstances.

Methods for solving example problems are divided into two main types: deterministic algorithms and random or semi-random algorithms. Most traditional algorithms are deterministic algorithms such as the Simplex algorithm and the Newton-Rufson algorithm. They are often called slope-based or derivative-based algorithms, as they use the values of the objective function and its derivatives to work well in simple problems, but they face great difficulty in problems that contain discontinuity in the objective function, in addition to the fact that their solutions are fixed and do not improve, unlike random algorithms that give new solutions with each implementation [5].

Type II algorithms have elements that distinguish them from the aforementioned type I algorithms, including:

intensification, diversity, exploitation, and exploration. Thus, the use of randomness or semi-randomness to find solutions provides a new way to move away from the problems that traditional methods fall into, including moving away from local search to search on the general or comprehensive scale (Global Scale), which makes them suitable algorithms for solving global optimization problems [6].

Genetic algorithms

The genetic algorithm (Genetic Algorithms abbreviated as GA) appeared in its current form in 1975 by the scientist John Holland and is called genetic because it relies on simulating the work of genetic genes in living organisms. The most important feature of this algorithm is its adaptive nature, which makes it less in need of knowing the equation in order to solve it. This method can be classified as one of the evolutionary algorithms that rely on imitating the work of nature from a Darwinian perspective. The genetic algorithm uses a search technique to find exact or approximate solutions that achieve optimization.Genetic algorithms are classified as Global Search Heuristics. They are also a specific class of evolutionary algorithms also known as evolutionary computation that uses technology inspired by evolutionary biology such as inheritance, mutations, selection, and crossover. Genetic algorithms are considered important techniques in searching for the optimal option from a set of available solutions for a specific design. They rely on Darwin's principle of selection, as this genetic processing passes the optimal features through successive reproductive processes, and strengthens these traits [6]. These traits have the greatest ability to enter the reproductive process, and produce optimal offspring. By repeating the genetic cycle, the quality of the offspring gradually improves.

Genetic algorithms are based on generating new solutions that generate solutions from probabilities encoded in the form known as a "chromosome" or "gene". Chromosomes combine or change to produce new individuals. They are useful for finding the optimal solution to multidimensional problems in which the values of different variables can be encoded in the form of a chromosome. To apply the genetic algorithm, the appropriate representation of the problem [7] under study is found according to chromosomal operations. The most famous representation methods are using binary strings to represent the values of the variables that express a solution to the given problem in the form of chromosomes. After these chromosomes are produced, methods must be found to process them, as there are four operations, which are (copying, crossing, mutation, and vice versa).

The genetic algorithm is based on the optimal solution technique that simulates natural evolution by encoding possible solutions to represent them in the form of chains, and then applying some biological processes (copying, crossing, mutation) and artificial processes (the opposite) to produce the optimal solution. Genetic algorithms are a way to simulate what nature does in the reproduction of living organisms, and use these methods to solve complex problems to reach the best solution, or the closest possible solution to the best solution. So, there is a problem that has a very large number of solutions, most of which are wrong and some are correct, and there is always the best solution, which is often difficult to reach [8]. The idea of genetic algorithms lies in generating some solutions to the problem randomly, then examining these solutions and comparing them with some criteria set by the algorithm designer, and only the best solutions remain, while the less efficient solutions are neglected in accordance with the biological rule of "survival of the fittest".

Then the remaining solutions (the most efficient solutions) are mated or mixed to produce new solutions, similar to what happens in living organisms, by mixing their genes so that the new organism carries characteristics that are a mixture of the characteristics of its parents [9]. The solutions resulting from the mating are also subject to examination and refinement to determine their efficiency and proximity to the optimal solution. If the efficiency of the new solution is proven, it remains, otherwise it is neglected. Thus, the mating and selection processes are carried out until the process reaches either a certain number of repetitions (determined by the system user) or the resulting solutions, or one of them, reach an efficiency percentage, or a small error percentage (also determined by the user), or even the best solution.

Swarm intelligence

For more than fifty years, biologists have demonstrated the existence of various forms of intelligence emerging from the society of insects, fish, birds or mammals, within anthills, termite swarms, bee colonies, bird and fish swarms. However, the simple abstract interaction between a large number of simple creatures can lead to the emergence of an intelligence that interacts and adapts to the surrounding environment. In insect societies, the entire system is organized in a decentralized model. Many autonomous units with relatively simple probabilistic behavior are distributed in the environment [10]. Each unit is provided only with local information. These units have no clear representation or knowledge of the global structure they are supposed to produce or develop. Nor any plan at all.

In other words, the global task is not explicitly programmed by individuals but emerges after the success of a large number of unilateral interactions between individuals or between individuals and the environment. This model of collective intelligence built from many simple individual entities inspired a new discipline in computer science called swarm intelligence [11].

The principle of the ant algorithm is summarized in the beginning that the ant starts from the hive in several random directions, then the ant secretes a substance called pheromone in a certain proportion to know the path it took. When it finds food, the ant takes an amount of it and returns to the hive by choosing the path that contains the largest amount of pheromone. Upon its return, it will secrete the same amount of pheromone [12]. When it starts from the hive again, it will test the amount of pheromone in each path and choose the path that contains the largest amount of pheromone, as the amount of pheromone is updated every certain period of time. If an obstacle occurs in the shortest path, the ant will choose a new path in the same way. Figure No. (1) illustrates the principle of the ant colony algorithm.

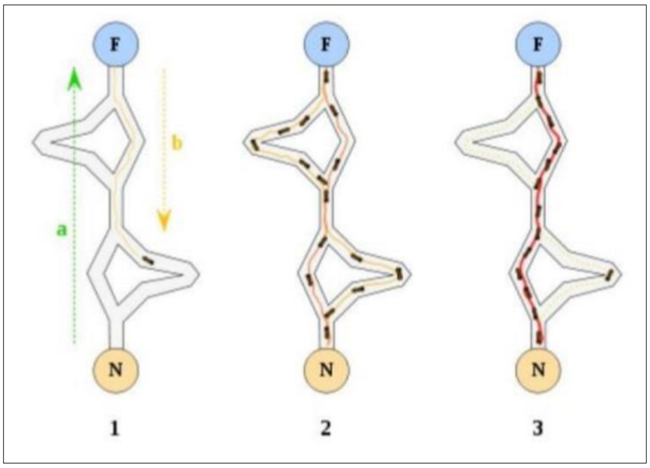

Fig 1: The principle of the ant colony algorithm

The ant colony algorithm is characterized by working in parallel with feedback of information, which gives speed in discovering good solutions, as it is effective in solving complex problems, and is suitable for dynamic applications because it adapts to sudden changes. However, it suffers from some disadvantages [13], as it is not predictive, as it depends on a series of random decisions, in addition to the fact that the probability distribution changes with each iteration, as the search for the solution is an experimental search and not a theoretical search, in addition to the difficulty of the theoretical analysis of this algorithm.

Artificial Bee Colony Algorithm (ABC)

The Artificial Bee Colony Algorithm (ABC) was proposed by Karaboga in 2005 for the true preference criteria, and is an optimization algorithm that simulates the foraging behavior of a bee colony. The minimal model of swarm intelligence in food selection in a honey bee colony simulated by the ABC algorithm consists of three types of bees: Employed Bees, Onlookers, and Scout Bees.

Half of a bee colony consists of workers, and the other half includes observer bees. Worker bees are responsible for exploiting nectar sources and providing information to observer bees waiting in the hive about the quality of the location of the food source they are trying to exploit [14]. Observer bees make decisions about which food source to exploit based on the information they share with the worker bees. Scout bees randomly search the environment to find a new food source based on internal motivation or on possible external cues.

In the ABC algorithm Karaboga proposed a location for the food source that represents a possible solution to the preference problem, and the amount of nectar from the food source corresponds to the profitability of the solution (fitness) associated with it. Each food source is exploited by only one worker bee. In other words, the number of worker bees is equal to the number of food sources around the hive (number of solutions in the community) and the worker bee that abandoned the food source becomes the scout. It is also called a learning algorithm because it is the fastest in the learning process, which has been characterized by finding the optimal solution for many applications.

Bird flock algorithm (PSO)

The algorithm model was developed by the scientists (Dr. Eberhart and Dr. Kennedy) in 1995, and this model is inspired by the social behavior of bird flocks and fish groups during their movement from one place to another. This model is based on the following:

- When one of the birds in the flock identifies the target or food, the bird immediately transmits the information to the rest of the birds.
- The rest of the birds are gradually attracted to the target or food.
- Each bird has the ability to remember the best previous location.

The goal of the algorithm is to obtain the optimal and best solution to the problem by simulating the behavior of birds in searching for the best source of food. Therefore, any system based on this algorithm will initially be formed from a random collection of random solutions, and the search is carried out within this collection for the optimal solution by following the best elements (Particles) [15].

The principle of the bird flock algorithm (PSO)

The idea of the (PSO) algorithm is based on simulating the behavior of bird flocks. To explain the idea, we will present the following example:

We have a flock of birds spread in a specific area for the purpose of searching for food, and the food is spread in this area randomly. In addition, the birds do not know the locations of the food clearly, so what is the best way to search for food? The best way is for a number of birds to spread throughout the area, with the birds telling each other about the locations of the food each time. The birds start the search journey from random areas, and with each repetition, the birds approach the food (the area full of food), which is equivalent to the optimal and most accurate solution [16].

The (PSO) algorithm simulates the previous scenario, and used it to solve the problems of the examples (Optimization Problems), within the (PSO) flock algorithm, each bird is equivalent to a solution within the space of solutions called the (Particle), and each element has a fitness value called (Fitness Value), which indicates the extent to which this part is suitable for the solution. These fitness values are evaluated through a function called the Fitness Function, and the evaluation here aims to calculate the degree of closeness of this part of the optimal solution, and the elements also have velocities and these velocities drive these flying elements. The PSO algorithm is initialized with a set of random elements (solutions), and then the best solution is searched for by updating these solutions, within each iteration (Iteration), and each element of the elements within the group is updated by following the following optimal values: the best fit value recorded by the element (PBest), in addition to the best fit value recorded within the swarm (GBest), and finally the value of the best local positioning of an element compared to the elements locally neighboring (LBest).

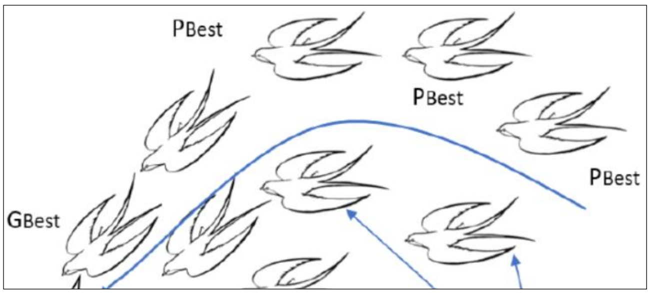

Fig 2: The mechanism of movement of elements within the swarm

Advantages of the PSO algorithm

The PSO algorithm has a set of features:

- It is based on perception and intelligence and is perfectly suited to scientific research and engineering applications.
- This algorithm does not contain any overlap or deviation in the values in its calculations, so the search speed depends on the speed of the element. When developing generations, only the values of the best element in the swarm will be sent to the other elements, which means speed in the process of searching for the target.
- The mathematical calculations in this algorithm are simple compared to other algorithms and it has the greatest ability to obtain the optimal solution and can be accomplished easily.
- The PSO algorithm adopts the real number encoding of the problem and is straightforward to solve.

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