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Suggest Method to Improve Reptile Search Algorithm (RSA) by Using the Dingo Optimization Algorithm (DOA)

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Abstract: This research studied two intelligent algorithms for swarms: the Reptile Search Algorithm (RSA) and the Dingo Optimization Algorithm (DOA). These algorithms have distinct characteristics and depend on mathematical models inspired by nature. The DOA algorithm, a proposed hybrid algorithm called RSA-DOA, improved the RSA algorithm.

This algorithm was applied to 10 optimization functions and compared with the SRA and DOA algorithms, each separately. The numerical results proved the superiority of the improved algorithm over other algorithms by reaching the optimal solution and avoiding falling into local solutions, as well as the speed of reaching the optimal solution in record time, meaning that it addresses the issue of time by reaching the solution, in addition to the possibility of solving problems with the least number of swarm elements for the algorithm above, in addition to the fact that it does not require a large number of iterations during the application of the program. This was explained from a practical aspect and from the results. This algorithm can also be applied to other mathematical, engineering, and computer models.

Keywords: Optimization, Swarm Intelligence, heuristic Algorithm, Development, Intelligent Technologies.

1. Introduction

The optimal case or solution is one of the most essential principles in our current world, i.e. choosing the best options from a set of decisions available in life. Since many issues in nature need a solution, we strive to choose the best of them, and it is based on the least loss or the best profit in issues that compare to the percentage of profit or loss or reducing the percentage of consumption or increasing the percentage of production according to the issues raised. For this reason, scientists have presented mathematical models that help make decisions. When studying these mathematical models, it was found that natural swarms have an excellent and organized model that facilitates the selection process for the best. Scientists have employed these models with mathematical issues that simulate natural swarms and called them intelligent swarm algorithms [2], heuristic and meta-heuristic algorithms [5].

Choosing the optimal solution is based on optimization issues [3], one of the branches of computational sciences that search for the best solution and find the minimum or maximum values of the states used.

Since no specific methods always find the optimal solution, many methods have been developed to solve different types of issues, such as engineering and mathematical programming issues and issues related to the branches of operations research.

With the advancement of programming processes and models, mathematics has had to keep pace with this great development. Accordingly, many algorithms inspired by nature were proposed, and many have developed, merged and hybridized them to suit this significant development. Examples of this include what (Mirjalili,2016)[9] presented with various algorithms that were developed using others, including the AOA algorithm, which was developed by (A.h etl.) such as SCA-AOA[7] and SCA-BA[6] and CG-SCA[4], which contributed to finding optimal solutions through the development of these algorithms. Studies indicate that algorithms have revolutionized scientific research, but their accuracy is questionable. The challenge facing research is finding a developed method that can solve many problems, which was indicated through this study. We will also shed light on a fact that previous studies have not yet highlighted, which is the introduction of a hybrid algorithm that is highly computationally advanced to be an essential source in processing many engineering and computational models in various fields of science.

2. Materials and Methods

2.1. Reptile Search Algorithm (RSA)

The encirclement, hunting, and social behavior of crocodiles in the wild—where they encircle and hunt prey—serve as the inspiration for this algorithm. The algorithm's mathematical model is given as follows:

A . Solution Initialization

The optimization process begins with a set of candidate solutions X that are generated randomly, and the best solution obtained is the approximately optimal solution in each iteration, where X is a set of candidate solutions that are generated randomly using equation (1.1) and x refers to the position of the solution, N is the number of candidate solutions

$$x_{i,j} = rand \times \left(ub_j - lb_j\right) + lb_j \qquad (1.1)$$

B . Encirclement phase (exploration)

Under two situations, this phase relies on two primary search strategies: the belly walking approach and the high walking strategy. The belly walking approach is conditional on $t > \frac{T}{4}$and $\leq 2\frac{T}{4}$, whereas the high walking strategy is conditional on $t \leq$. Consequently, the exploration phase's location update equation

$$x_{i,j}(t) = \left\{ \begin{array}{ll} Best_j(t) - \eta_{i,j}(t) \times \alpha - R_{i,j}(t) \times rand & t \leq \frac{T}{4} \\ Best_j(t) \times x_{(r1,j)} \times ES(t) \times rand & t \leq 2\frac{T}{4} \ and \ t > \frac{T}{4} \end{array} \right\} \qquad (1.2)$$

Where $Best_j(t)$ is the best solution thus far, η_(i,j) indicates the hunting factor and is computed from Equation (1.3), α is a sensitive parameter that regulates the accuracy of exploration (i.e., high walking) of the encirclement phase over the iterations and is constant and equal to 0.1, R_(i,j) is a value used to reduce the search and is computed using Equation (1.4), $r1$ is a random number between [1, N], and ES is computed using Equation (1.5).

$$\eta_{i,j} = Best_j(t) \times p_{i,j} \qquad (1.3)$$

$$R_{i,j} = \frac{Best_j(t) - x_{(r2,j)}}{Best_j(t) + \epsilon} \qquad (1.4)$$

$$ES(t) = 2 \times r3 \times (1 - \frac{1}{T}) \qquad (1.5)$$

Where ϵ is a small value and r2 is a random number between [1,N] and refers to a random integer -1 and 1 and $p_{i,j}$ is the percentage between the current position and the best solution and is calculated by the following equation

$$p_{i,j} = \alpha + \frac{x(i,j) - M(x_i)}{Best_j(t) \times (ub - lb) + c} \quad (1.6)$$

and $M(x_i)$ It is the average location and is calculated as follows:

$$M(x_i) = \frac{1}{n} \sum_{j=1}^{n} x(i,j) \quad (1.7)$$

C . Fishing stage (exploitation)

This stage also depends on two strategies, fishing coordination and cooperation, and is conditional on two conditions. The fishing coordination strategy is conditional on $t \le 3\frac{T}{4}$ and $t > 2\frac{T}{4}$, and the fishing cooperation strategy is conditional on $t \le T$ and $t > 3\frac{T}{4}$. Accordingly, the equation for updating the site for exploitation is:

$$x_{i,j}(t) = \begin{cases} Best_j(t) \times p_{i,j}(t) \times rand & t \le 3\frac{T}{4} \ \ and\ t > 2\frac{T}{4} \\ Best_j(t) - \eta_{i,j}(t) \times \epsilon - R_{i,j}(t) \times rand & t \le T \ and \ \ t > 3\frac{T}{4} \end{cases} \quad (1.8)$$

The encirclement phase (exploration) occurs if $t \le \frac{T}{2}$ and if $t < \frac{T}{2}$the hunting phase (exploitation) occurs.[1][8]

2. 1.1. Steps of the Reptile Search Algorithm (RSA Algorithm) .[1][8]

The steps of the algorithm can be summarized as follows:

Step (1) Initialize the required parameters

Step (2) Initialize the initial solutions

Step (3) Calculate the fitness function for the solutions

Step (4) Search for the best solution so far

Step (5) Update η, p, ES, R using equations (1.3), (1.4), (1.5), and (1.6)

Step (6) Update the location using equation (1.2)

Step (7) End the steps when the stopping metric is achieved, and the optimal solution is found

2.2. Dingo Optimization Algorithm (DOA)

The dingo is one of the largest carnivores; its scientific name is Lupus lutea. It uses its fangs when it preys on several types of mammals. They stalk and attack their prey from behind. Group attacks are the most commonly used. The following strategies illustrate the mathematical model of the algorithm:

The first strategy (group attacks) Predators often use clever hunting techniques. Dingoes hunt small prey, such as rabbits alone, but they gather in groups when hunting large prey, such as kangaroos. The following equation can represent this behaviour

$$x_k(t+1) = \alpha_1 \sum_{k=1}^{na} \frac{[\emptyset_i(t) - x_k(t)]}{na} - x_*(t) \quad (1.9)$$

Where $x_k(t+1)$ is the new location (referring to the dingo movement), na is a random integer in the interval $[2, 2/sizepop]$, $\emptyset_i(t)$ is a population of dingoes, X is a random population of dingoes, $x_k(t)$ is the current location, $x_*(t)$ is the best location found, α_1 is a random number.

Strategy 2: When a dingo hunts a small prey, it is pursued until it is captured individually, and the following equation represents this behaviour

$$x_k(t+1) = x_*(t) + \alpha_1 * e^{\alpha_2} * (x_{r_1}(t) - x_k(t)) \quad (1.10)$$

Where α_2 is a random number and r_1 is the search factor that has been determined. The third strategy: When the dingo walks randomly, if it finds carcasses, it eats them. The following equation represents this behaviour:

$$x_k(t+1) = \frac{1}{2}[e^{\alpha_2} * x_{r_1}(t) - (-1)^{\sigma} x_k(t)) \quad (1.11)$$

σ is a binary number whose value is zero if $rand \leq 0.5$ or equals one.

Strategy 4: Dingo Survival Rate The Australian dingo is at risk of extinction due to poaching, and the following equation can represent the survival rate

$$survival = \frac{fitness_{max} - fitness_{(k)}}{fitness_{max} - fitness_{min}} \quad (1.12)$$

Where $fitness_{max}$ and $fitness_{min}$ are the best and worst fitness values in the current generation, and $fitness_{(k)}$ is the current fitness value. If the survival rate values are low, equal to or less than 0.3, they are calculated using the following equation:

$$x_k(t) = x_*(t) + \frac{1}{2}[x_{r_1}(t) - (-1)^{\sigma} x_{r_2}(t)).$$ [10][8]. (1.13)

2.2.1. Steps of the Dingo Optimization Algorithm (DOA Algorithm) [10][8].

The steps of the algorithm can be summarized as follows:

Step (1): Initialize the parameters and initialize the initial community

Step (2): While the number of steps is less than the maximum number of iterations, go to

Step (3): The first strategy in equation (1.9) and the second strategy in equation (1.10)

The third strategy in equation (1.11)

Step (4): Update the site if the survival rates are low in equation (1.12)

Step (5): Calculate x_{new}

Step (6): If $x_{new} < x_*$

Step (7): $x_* = x_{new}$

Step (8): End the steps when the stopping metric is achieved and find the optimal solution.

3. The proposed method RSA-DOA

This developed method included using the RSA reptile search algorithm inspired by nature, which simulates the social behaviour of crocodiles and uses its mathematical model as a solution stage, encirclement stage (exploration) and hunting stage. This algorithm was developed using the Dingo DOA optimization algorithm, which has a fantastic mathematical model: group attack, chasing and hunting prey, and walking randomly to find dead prey. Accordingly, we have a highly effective developed RSA-DOA algorithm that uses two types of mathematical strategy, so it is a strong mathematical model with intelligent specifications that uses two kinds of multi-swarm intelligence. The solution was improved using the Dango DOA optimization algorithm, evaluated, and the best among them was chosen. Then, these solutions are used by the RSA reptile search algorithm as an improved initial community. After that, these solutions are evaluated, and the mathematical model of the algorithm is used to choose the best among them. Then, these solutions are evaluated. Thus, the algorithms work together to choose and improve the best solutions to reach the optimal global solution. Thus, we have a developed, high-performance algorithm, which is the algorithm RSA-DOA.

3.1. Mathematical and programming steps for this algorithm RSA DOA

1- Prepare random initial solutions

2- Calculate the fitness function for these solutions

3- Find the best solution using DOA algorithm and calculate the fitness function for these solutions

4- Use the best solutions as an initial population for RSA algorithm

5- Calculate the fitness for these solutions and arrange them

6- Choose the best solutions

7- Compare the best solution with these solutions and choose the best among them

8- Use the stopping condition using the number of iterations if it is less, execute steps 3-7 otherwise stop. As in Figure 1

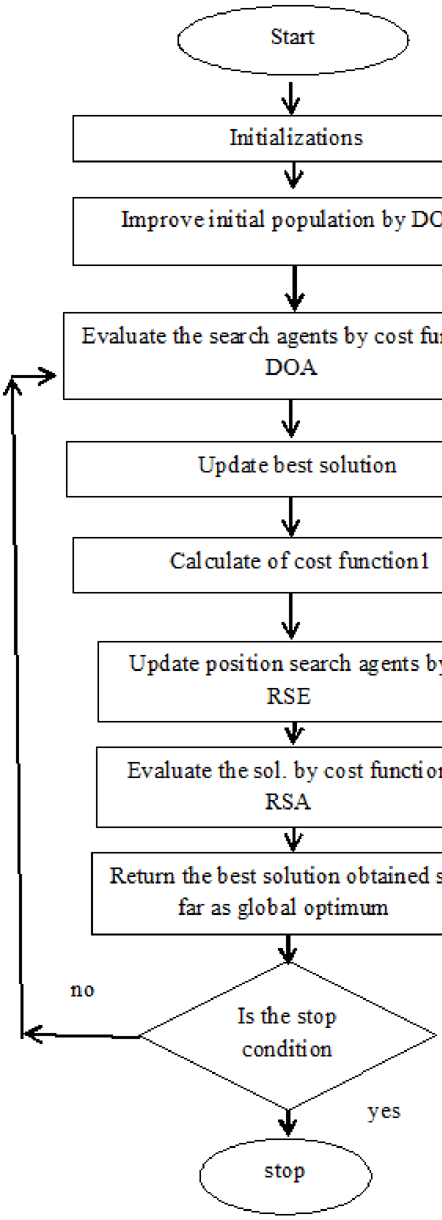

Figure (1): flow chart Proposed method (RSA-DOA) Algorithm

4. The aim of developing the RSA-DOA algorithm

Using algorithms specific to swarm intelligence produces many local solutions and often does not reach the optimal global solution. This is what prompted us to develop an improved algorithm that we called RSA-DOA. Suppose each of the RSA and DOA algorithms has certain characteristics. In that case, if we combine these characteristics and benefit from the mathematical model of them together, we will have an amazing model with computational power, characteristics and accuracy in finding the best solutions and reaching the global solution. It can avoid falling into local solutions, i.e. making the two algorithms work together. This will raise the potential of this algorithm. Using two algorithms with different characteristics creates this model's broad and comprehensive multiple potential.

5. Results:

The numerical results are shown in Table 1, where 10 functions[9] were used for optimization measurement, with 30 elements of a swarm and 500 repetitions. As in Table 1

Table (1). Comparison of the proposed algorithm RSA-DOA with the algorithms RSE and DOA at the number of elements N=30 and the number of iterations T=500

Func.	RSA	DOA	RSE-DOA
f1	0.00E+00	6.57E-142	0
f2	0.00E+00	2.51E-31	0
f3	0.00E+00	1.51E-72	0
f4	0.00E+00	3.51E-78	0
f5	2.76E-28	28.8672	4.46E-78
f7	6.89E-05	8.11E-05	1.42E-126
f9	0.00E+00	0.00E+00	0
f11	5.08E-31	1.52E-28	0
f12	1.93E-29	0.19674	0
f13	1.49E-31	1.4729	0

6. Discussion

The use of the developed algorithm RSA-DOA and its application to the optimality measurement functions and its comparison with the reptile search algorithm RSA and the dingo optimization algorithm DOA, the results were clear with the superiority of the developed algorithm RSA-DOA over the others through the numerical results, as it has proven its ability to avoid falling into local solutions and reach the global optimal solution in most functions. This algorithm has also proven its speed in reaching solutions with the least number of iterations and the least time to execute the computer program.

7. Conclusions

Through the numerical results of applying the developed algorithm RSA-DOA on the set of functions for measuring optimality, several conclusions were reached, which are:

1-The superiority of the developed algorithm RSA-DOA over others.

2-The ability of the developed algorithm RSA-DOA to avoid falling into local problems.

3-The optimal solution for a function is considered to be reaching the global optimal solution for most countries or reaching the least minimization of the function.

4-The speed of reaching the optimal solution in the shortest time by measuring the time taken to execute the program.

5- Using the least number of iterations to reach the optimal solution.

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