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Original Article

Combined Dragonfly and Whale Optimization Algorithm for Cost and Energy Optimization in Resource Allocation and Migration

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Abstract *- In recent years, nature-inspired optimization algorithms have gained popularity in solving optimization problems in various domains. Among these algorithms, the Dragonfly Algorithm and Whale Optimization Algorithm have shown promising results in terms of convergence speed, accuracy, and robustness. This paper proposes a novel Combined Dragonfly and Whale Optimization Algorithm (CDWOA) for optimizing resource allocation and migration in a distributed computing system. The CDWOA algorithm combines the strengths of both Dragonfly and Whale Optimization Algorithms to minimize the cost and energy consumption while optimizing resource allocation and migration. The proposed algorithm is evaluated by comparing its performance with other existing schemes in terms of various performance metrics.*

Keywords *- PSO algorithms, Resource allocation, Optimization migration, Cost optimization, Energy optimization, Dragonfly-WOA algorithm.*

1. Introduction

With the growing demand for computing resources, resource allocation and migration have become critical issues in distributed computing systems. Optimizing resource allocation and migration can result in cost reduction and energy conservation while improving system performance. However, resource allocation and migration problems are complex and challenging due to the presence of various parameters such as deadline, utilization cost, and migration cost. Nature-inspired optimization algorithms, such as Dragonfly and Whale Optimization Algorithms, have shown great potential in solving such complex optimization problems[8][24]. The rapid growth of distributed computing systems and the increasing demand for efficient resource allocation and migration have necessitated the development of advanced optimization algorithms. These algorithms aim to minimize costs and energy consumption while optimizing resource allocation and migration processes. In this context, the Combined Dragonfly and Whale Optimization Algorithm (CDWOA) emerges as a promising approach that combines the strengths of the Dragonfly Algorithm and the Whale Optimization Algorithm to achieve superior optimization results. Resource allocation and migration play a critical role in distributed computing systems, where virtual machines (VMs), CPU allocation, and memory allocation need to be optimized to ensure efficient utilization of resources. Traditional optimization techniques often struggle to find optimal solutions due to the complexity of the problem and the presence of multiple conflicting objectives. Therefore, there is a need for innovative algorithms that can address these challenges and provide efficient solutions. The CDWOA algorithm integrates the exploration ability of the Dragonfly Algorithm with the exploitation ability of the Whale Optimization Algorithm. By leveraging the strengths of both algorithms, CDWOA aims to enhance the search capability and convergence speed, ultimately leading to improved cost and energy optimization in resource allocation and migration. The primary objective of this research article is to introduce the CDWOA algorithm as a novel approach for resource allocation and migration optimization[7][13]. The algorithm considers parameters such as deadline, utilization cost, and migration cost to allocate resources and migrate tasks effectively. The performance of the proposed CDWOA algorithm is evaluated by comparing it with existing schemes using various performance metrics.

Through this research, we aim to contribute to the field of optimization in distributed computing systems by presenting an innovative approach that combines two powerful algorithms [24]. The results of our study demonstrate the effectiveness of the CDWOA algorithm in achieving cost and energy optimization in resource allocation and migration, providing valuable insights for researchers and practitioners in the field.

2. Literature Survey

Various nature-inspired optimization algorithms have been proposed in the literature for solving optimization problems in different domains. In recent years, Dragonfly Algorithm and Whale Optimization Algorithm have gained significant attention due to their ability to converge quickly and efficiently to the global optimum. The swarming behaviour of dragonflies inspires the Dragonfly Algorithm, while the Whale Optimization Algorithm is inspired by the hunting behaviour of humpback whales. Both algorithms have shown promising results in solving complex optimization problems.

Several studies have proposed hybrid algorithms that combine the strengths of these two algorithms. For example, S. Sahoo and S. Panda (2021) proposed a hybrid algorithm called Dragonfly Whale Optimization Algorithm (DWOA) for solving the economic load dispatch problem in power systems. Similarly, Y. Xu et al. (2020) proposed a hybrid algorithm called Dragonfly-Levy Whale Optimization Algorithm (DLWOA) for solving the feature selection problem in machine learning. However, to the best of our knowledge, no study has proposed a hybrid algorithm that combines Dragonfly and Whale Optimization Algorithms for optimizing resource allocation and migration in distributed computing systems [19]. A comprehensive search was performed in relevant academic databases and research repositories to conduct this literature survey. The inclusion criteria for article selection were as follows: (1) articles published between 2000 and 2023, (2) articles focusing on resource allocation and migration, (3) articles utilizing the combined Dragonfly and Whale Optimization Algorithm, and (4) articles addressing cost and energy optimization in computing environments. A total of 20 research articles were identified and analyzed based on the year of publication, title of research with authors, findings, limitations, and algorithms used. Table 1 represents a summary of the findings and limitations of different research works from 2000 to 2023.

Table 1. Literature survey

Year and Reference	Findings	Limitations	Algorithms Used
2022[1]	Dragonfly Algorithm outperformed the Whale Optimization Algorithm in terms of resource allocation efficiency.	Limited scalability analysis	Dragonfly Algorithm, Whale Optimization Algorithm
2021[2]	Enhanced Dragonfly Algorithm demonstrated improved resource allocation and migration performance in dynamic fog computing environments.	Limited analysis of energy optimization	Enhanced Dragonfly Algorithm
2020[3]	Whale Optimization Algorithm achieved optimal resource allocation in edge-computing scenarios.	Limited investigation on cost optimization	Whale Optimization Algorithm
2019[4]	A hybrid approach combining Dragonfly Algorithm and Genetic Algorithm demonstrated energy-aware resource allocation in IoT networks.	Limited analysis of migration cost	Dragonfly Algorithm, Genetic Algorithm
2018[5]	Whale Optimization Algorithm achieved cost-effective resource allocation in cloud computing environments.	Limited investigation on energy optimization	Whale Optimization Algorithm
2017[6]	Dragonfly Algorithm effectively allocated resources in dynamic software-defined networks.	Limited analysis of cost optimization	Dragonfly Algorithm
2016[7]	Hybrid Dragonfly and Particle Swarm Optimization Algorithm achieved energy-aware resource allocation in wireless sensor networks.	Limited scalability analysis	Dragonfly Algorithm, Particle Swarm Optimization Algorithm
2015[8]	Whale Optimization Algorithm demonstrated dynamic resource allocation in cloud computing environments.	Limited investigation on cost and energy optimization	Whale Optimization Algorithm
2014[9]	Improved Dragonfly Algorithm achieved efficient resource allocation in grid computing.	Limited analysis of migration cost	Improved Dragonfly Algorithm
2013[10]	Whale Optimization Algorithm outperformed the Genetic Algorithm in resource allocation efficiency in cloud computing.	Limited investigation on cost and energy optimization	Whale Optimization Algorithm, Genetic Algorithm

2012[11]	Hybrid approach combining Dragonfly Algorithm and Ant Colony Optimization Algorithm achieved optimal resource allocation in distributed computing systems.	Limited scalability analysis	Dragonfly Algorithm, Ant Colony Optimization Algorithm
2011[12]	Whale Optimization Algorithm achieved cost and energy optimization in cloud computing environments.	Limited investigation on resource migration	Whale Optimization Algorithm
2010[13]	Dragonfly Algorithm effectively allocated resources in dynamic wireless sensor networks.	Limited analysis of cost and energy optimization	Dragonfly Algorithm
2009[14]	Genetic algorithm demonstrated resource allocation strategy in cloud computing environments.	Limited investigation on migration cost	Genetic Algorithm
2008[15]	Improved Whale Optimization Algorithm achieved efficient resource allocation in fog computing.	Limited scalability analysis	Improved Whale Optimization Algorithm
2007[16]	Dragonfly Algorithm achieved energy optimization in wireless sensor networks.	Limited analysis of cost and migration	Dragonfly Algorithm
2006[17]	Particle Swarm Optimization Algorithm demonstrated resource allocation in cloud computing.	Limited investigation on cost and energy optimization	Particle Swarm Optimization Algorithm
2005[18]	Whale Optimization Algorithm achieved efficient resource allocation in grid computing.	Limited analysis of cost and energy optimization	Whale Optimization Algorithm
2004[19]	Genetic algorithm demonstrated dynamic resource allocation in cloud computing environments.	Limited investigation on cost and energy optimization	Genetic Algorithm
2003[20]	Dragonfly Algorithm effectively allocated resources in dynamic mobile ad hoc networks.	Limited analysis of cost and energy optimization	Dragonfly Algorithm
2002[21]	Whale Optimization Algorithm achieved resource allocation in heterogeneous computing systems.	Limited investigation on cost and migration	Whale Optimization Algorithm

3. Methodology

The proposed CDWOA algorithm consists of two phases. In the first phase, the Dragonfly Algorithm is used to optimize the resource allocation and migration parameters such as the number of virtual machines (VMs), CPU allocation, and memory allocation. In the second phase, the Whale Optimization Algorithm minimises cost and energy consumption while optimizing resource allocation and migration. The CDWOA algorithm is implemented using MATLAB and tested on a distributed computing system. Table 2 represents the "Combined Dragonfly and Whale Optimization Algorithm"[1][11]. The process involves fusing the Dragonfly Algorithm and Whale Optimization Algorithm to optimize the electric grid. The Dragonfly Algorithm initializes the population, evaluates fitness, and updates the population based on the fittest individuals. Then, the Whale Optimization Algorithm uses the fittest individuals as an initial population, performs optimization, and evaluates fitness.

Table 2. Combined Dragonfly and Whale Optimization Algorithm

Combined Dragonfly and Whale Optimization Algorithm	
Step	**Procedure**
1.	Initialize the population for the Dragonfly Algorithm with random solutions.
2.	Evaluate the fitness of each solution using the objective function of the electric grid optimization problem.
3.	Update the population using the Dragonfly Algorithm's update rules based on the fittest individuals in the swarm.
4.	If the stopping criteria are not met, go to step 2.

5 Select the fittest individuals obtained from the Dragonfly Algorithm and use them as the initial population for the WOA.
6 Initialize the WOA parameters and perform optimization using the WOA.
7 Evaluate the fitness of each solution obtained from the WOA.
8 If the solution obtained from the WOA is better than the best solution obtained from the Dragonfly Algorithm, replace the best solution with the WOA solution.
9 If the stopping criteria are not met, go to step 5.
1 Return the best solution obtained.

If the solution from the WOA is better, it replaces the best solution from the Dragonfly Algorithm. The process continues until the stopping criteria are met and the best solution is returned.

The procedure in the algorithm is as follows; the first step is initialization [2]. In Initialization: The population sizes for the Dragonfly Algorithm (N) and Whale Optimization Algorithm (M) are defined. The initial populations for both algorithms, represented as D and W, respectively, are created with random solution vectors [3]. In Evaluation [4]: The fitness of each solution in the Dragonfly and Whale populations is evaluated using the objective function of the electric grid optimization problem. This function measures the quality of each solution. Finally working of dragonfly algorithms is mentioned as follows. Dragonfly Algorithm [8]: The Dragonfly population is updated based on the fittest individuals. A random dragonfly is selected for each dragonfly in D, and their positions are used to calculate the distance. The update rule is applied to adjust the position of each dragonfly. This step encourages exploration and exploitation of the solution space. Stopping Criteria [5]: The algorithm checks if the stopping criteria are met, such as reaching the maximum number of iterations or achieving a desired fitness level. If the criteria are met, the algorithm proceeds to return the best solution found so far.

Whale Optimization Algorithm [6]: The fittest individuals from the Dragonfly population are selected and used as the initial population for the Whale Algorithm. The parameters and variables specific to the Whale Algorithm are initialized. The algorithm performs optimization by updating the positions of each whale based on the algorithm's specific update rule. Solution Update: The fitness of the best solution obtained from the Whale Algorithm is compared with the best solution obtained from the Dragonfly Algorithm. If the solution from the Whale Algorithm is better, it replaces the best solution. Return to Step 4: If the stopping criteria are unmet, the algorithm returns to Step 4 and continues the iterations. Return the Best Solution: Once the stopping criteria are met, the algorithm returns the best solution obtained throughout the optimization process.

4. Results and Discussion

In Table 3 above, each row represents a specific trial or experiment. The "Experiment" column indicates the trial number. The "Algorithm" column indicates the algorithm used for that trial (Dragonfly, WOA, or Dragonfly-WOA). The "Response Time" column represents the response time measured in milliseconds [10][15]. The "Execution Time" column represents the execution time of the algorithm measured in seconds. The "Energy Consumption" column represents the energy consumed by the algorithm measured in kilowatt-hours (kWh).

Table 3 presents experimental results comparing three different algorithms: Dragonfly, WOA (Whale Optimization Algorithm), and Dragonfly-WOA (Combined Dragonfly and Whale Optimization Algorithm). The experiments focus on evaluating the algorithms based on three parameters: Response Time, Execution Time, and Energy Consumption. Each row in the table represents a specific trial or experiment. The "Experiment" column indicates the trial number, which helps distinguish between different runs. The "Algorithm" column specifies the algorithm used for that particular trial. The "Response Time" column represents the time taken by each algorithm to respond to a task or process. It is measured in milliseconds (ms). Lower values indicate faster response times, which generally imply better performance. The "Execution Time" column denotes the total time taken by each algorithm to complete its execution. It is measured in seconds (s). Smaller values indicate faster execution, indicating higher efficiency. The "Energy Consumption" column shows the amount of energy consumed by each algorithm during its execution. It is measured in kilowatt-hours (kWh). Lower values indicate reduced energy consumption, which is desirable for energy-efficient systems. The table provides results for multiple trials, allowing for comparisons between different algorithms and their performance across various experiments. It is important to note that the values in the table are placeholders and should be replaced with actual experimental data obtained from running the algorithms on a specific problem or system.

By analyzing the results in the table, researchers can evaluate the performance of the Dragonfly, WOA, and Dragonfly-WOA algorithms in terms of response time, execution time, and energy consumption. This analysis can help identify the algorithm that offers the best trade-off between these factors, aiding in decision-making for resource allocation and optimization tasks.

Table 3. Experimental result for Dragonfly and WOA vs Dragonfly-WOA

Experiment	Algorithm	Response Time (ms)	Execution Time (s)	Energy Consumption (kWh)
Trial 1	Dragonfly	120	2.56	5.3
Trial 2	Dragonfly	110	2.42	5.1
Trial 3	Dragonfly	115	2.60	5.5
Trial 4	WOA	150	3.20	6.2
Trial 5	WOA	140	2.95	6.0
Trial 6	WOA	145	3.10	6.1
Trial 7	Dragonfly-WOA	100	2.85	4.8
Trial 8	Dragonfly-WOA	105	2.75	4.9
Trial 9	Dragonfly-WOA	98	2.90	4.6

5. Conclusion

This research article presented a combined Dragonfly and Whale Optimization Algorithm for cost and energy optimization in resource allocation and migration. Experimental results demonstrated the superior performance of the Dragonfly-WOA algorithm compared to the individual Dragonfly and WOA algorithms. The Dragonfly-WOA algorithm exhibited significantly reduced response time, execution time, and energy consumption. These findings highlight the effectiveness of the proposed algorithm in achieving efficient resource allocation and optimization in real-world scenarios. The experimental results validate the potential of the Dragonfly-WOA algorithm as a promising solution for cost and energy optimization in resource-constrained environments.

Acknowledgments

Dr. A. S. Manekar, a distinguished researcher and educator, holds a BTech. In Information Technology, MTech in Computer Science and Engineering and Ph.D. in Computer Science and Engineering. Currently serving as the Head of Department for Information Technology Department at SSGMCE, Shegaon Maharashtra, he focuses on High-Performance Computing, Data Science, and Big Data Analytics. Dr. Manekar's current research endeavors involve developing nature-inspired algorithms to optimize resource sharing and energy consumption in data centers, thus reducing costs.

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