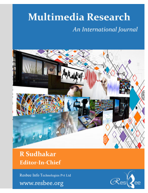
Vol.4 No.4 Oct 2021

Multimedia Research

Received 29 August, Revised 5 October, Accepted 19 October



Wireless Communication Network using Hybrid WOA and GWO Algorithm

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Abstract: In subsequent generation networks, to perform an improved communication the Orthogonal Frequency Division Multiple Access (OFDM), as well as Multiple Input-Multiple Output (MIMO) systems, are integrated which makes easy the spatial multiplexing on Resource Blocks (RBs) on the basis of time-frequency. A novel approach to interference alleviation was developed in this paper for 3D antenna array models in OFDMA as well as multi-cell MIMO wireless networks. Therefore, in the 3D MIMO-OFDM system, the Dynamic vertical beamforming is exploited to the cell degree separation user-specific down tilts user. The major contribution of this paper is to maximize the cell edge user's throughput as well as cell center users. Here, the single objective function is the specified multi-objective model that is resolved using the adoption of a novel enhanced approach. This optimization issue is solved using the fine-tuning of particular parameters like RB allocation, allocated power for RB, and cell edge user. A hybrid Whale Optimization Algorithm (WOA) and Grey Wolf Optimization (GWO) algorithm referred to as the Hybrid WOA-GWO approach is used to attain the fine-tuned parameters. At last, the superiority of the adopted technique is examined with existing techniques on the basis of throughput, etc.

Keywords: MIMO, OFDM, Resource block, SINR, Throughput, Wireless network.

Nomenclature

Abbreviations	Descriptions
MIMO	Multiple Input-Multiple Output
RBs	Resource Blocks
WOA	Whale Optimization Algorithm
OFDMA	Orthogonal Frequency Division Multiple Access
MUI	Multi-User Interference
RUs	Resource Units
RT	Remote Terminal
GA	Genetic Algorithm
ZF	Zero Forcing
SER	Symbol Error Rate
GWO	Grey Wolf Optimization
DL	Downlink
CSI	Channel State Information
UL	Uplink
SDMA	Space-Division Multiple-Access
RA	Resource Allocation
LA	Lion Algorithm
BS	Base Station
SA	Scheduled Access
TSD	Transmit Spatial Diversity

1. Introduction

In recent days, the mobile communication technology of the 5th generation endorsed considerably due to the raised in novel traffic kinds as well as the data services like smart homes, smart grid e-health care, as well as cities, and so on [1]. Hence, a novel period of information society has upcoming at any instance as well as any position devices linked to the internet will attain the personalized information service. "Things net" will be crooked to authenticity. In 2020, in the world number of devices entrée networks will

https://doi.org/10.46253/j.mr.v4i4.a3

exceed the population; therefore it will utilize maximum energy. Therefore, green energy reduction, as well as protection of the environment, is considered a significant problem in the 5G network. Also, in wireless communication, resource management is considered a significant feature. The 5G network is a tremendous issue that involves diverse contracting networks. Therefore, resource management tackles massive confronts. In some work, energy utilization issues were analyzed for diverse communication networks. Even though the minimizing transmission power of BS stores the total power utilization, the model as well as the network performance optimization minimizes the energy utilization [2].

In the current wireless application, the MIMO has come out as one of the numerous notable technologies due to its powerful capability to enhance the effectiveness of bandwidth performances. That is via maintaining its different spatial multiplexing ability as well as spatial diversity increase. With 5G the cellular networks are developed with the ascertained aspire of aiding a heterogeneous service amalgamation each one with its comprehensive requirements. mMIMO is one among them that is considered a demanding assumption, developed to improve the performance of wireless networks that combines the forthcoming 5G technology. It maintains a huge count of convenient antennas at BS and hence obtains higher improvement concerning the effectuality of spectral as well as energy [3].

The OFDMA motivation is energetically assigning subcarriers to the user with the optimal CSI. Nevertheless, in the LTE standard RA approaches are not detailed and currently, somewhat a small number of scheduling as well as RA approaches were presented for OFDMA cellular system. Intrinsically, RA is represented as a constrained optimization issue whichever increases the complete data rate or decreases the complete transfer power cause to experience particular constraints for instance the user's requirements of QoS. The optimum RA approach is an NP-complete issue and that solution can merely be seen with a comprehensive search that is infeasible for the sensible circumstance. A capable solution is presented to reduce the complete transfer power which causes to experience each user's requirement of data rate. Some research aspires to assign the power as well as subcarriers so that the least user's data rate is increased. On the other hand, to use the benefit of multiuser variety the proportional fairness scheduling was modeled when controlling similar long-term throughput for all users. To obtain a spectacular increase in power effectiveness a Lagrangian-based approach was presented. Nevertheless, the computation load is highly maximal to set it to really employ. In some work, an adaptive RA approach was presented for a spatial multi-user-access. MIMO/OFDM system to reduce complete transmits power, subject to requirements of users' QoS [4].

The major objective of this research is to set up a novel Hybrid WOA-GWO approach to maximize cell center users' and cell edge users' throughput. Here, the new optimized approach is introduced in order to fine-tune the specific parameters to assign the power for RB, cell edge user, cell center user as well as allocation of RB. The adopted technique performance is validated over traditional techniques concerning specific performance metrics.

2. Literature Review

In 2019, Wei-Chiang Wu [1], developed four resource allocation models in the downlink OFDMA network. In addition, the most important focal point of this research was on evaluating the energy effectiveness of strategies. Particularly, the highly developed multi-antenna technology in a MIMO system was employed. The initial model was on the basis of the TSD, in that vector channel with maximum increase among BS, as well as a precise antenna at the RT, was selected for transmission. Furthermore, the next strategies use multiplexing on the MIMO system to improve throughput. The SDMA method allocates a single subcarrier concurrently to RTs with pair-wise "nearly orthogonal" spatial signatures. The next strategies were to model the transfer of the beamformers on the basis of the ZF condition so that the MUI was totally evaded.

In 2021, Ibrahim Salah et al [2], worked on the development of mobile communication networks initiating from 1st-generation to 5th generation with evaluation studies. Subsequently, the evolution of 5G was considered the next generation and it was summarized by the current research schemes. In the 5G network, the most important requirements and evolving technologies were spotlighted. Further, a general idea of various technologies which may be exploited to attain the requirements of 5G such as Millimetre-waves, Massive-MIMO, and Small-Cells, beamforming, and full-duplex was described.

In 2020, Yousri Daldoul et al [3], worked on the IEEE 802.11ax describing a novel access technique named OFDMA that was exploited in both UL and DL directions. To permit the multiple stations to transfer or to obtain concurrently, the OFDMA splits the bandwidth to various RUs. Random Access RUs, as well as SA RUs, were supported by the UL OFDMA. To transmit on SA RUs merely scheduled stations were permitted when other stations must compete with RA RUs. In addition, 802.11ax describes the UL MU-MIMO and improves DL MU-MIMO. Here, by exploiting the OFDMA and MIMO the effectiveness of DL, as well as UL multi-user transmissions, was introduced and evaluated.

In 2018, Xie Chaochen et al [4], developed a technique to minimize the complete system power utilization by using the minimum power cellular with multi antennas, maximum system ability, and coverage. The experimentation outcomes exhibit that the approach can minimize the power utilization, and enhances throughput also the performance of the system. Hence multi-antenna ultra-density network resource allocation model was effective.

In 2017, Wei-Chiang Wu et al [5], developed four resources such as subcarriers-and-bits allocation techniques for the OFDMA-based multiuser MIMO system. To convene the requirement of SER, adaptive modulation was used along with the CSI. The initial strategies were on the basis of TSD, in that vector channel with maximum increase among BS and a precise antenna at the remote terminal was selected for transmission. Further strategies were to allocate the subcarrier to the optimal user. Concurrently, a single subcarrier was assigned by the SDMA to remote terminals with pair-wise "nearly orthogonal" spatial signatures. The final strategy was to model the transmit beam-formers on the basis of the ZF circumstance with the intention that the MUI was entirely evaded. In addition, the spatial multiplexing approach was in cooperation used to attain throughput multiplication.

3. System Model

In a downlink OFDMA-oriented mobile network, a synchronization cluster of $N \geq 2$ BSs is taken into consideration, wherein diverse clusters are used. Moreover, V_m represents the user's group assigned to Base Station m. $k(m,n)$ is stated as elected users on RB n served by m^{th} BS, as well as $\Re \underline{\underline{\Delta}} V_1 \cup .... \cup V_N$. Let, $k \underline{\underline{\Delta}} \left(k^{[1]},....k^{[M]}\right)$, in that $k^{[n]} \underline{\underline{\Delta}} (k(1,n),....k(N,n)),, k(m,n) \in V_m$ as well as $k \in \Re$.

The complete frequency resource is divided into a group of M orthogonal RBs. The cell-center users are served by the one BS, whereas, the cell-edge users are served by all synchronized BSs [6] exploiting partial JP CoMP transmission mode. Hence, for cell center users as well as cell edge users the RBs are divided into two areas with reprocessing factors of α as well as 1 in that order. Suppose that $M_{m,e}$ as well as $M_{m,c}$ as RBs group assigned for cell-center users as well as cell-edge users in m^{th} cell respectively, $M_m \underline{\underline{\Delta}} M_{m,c} \cup M_{m,e}$.

Consider θ_1 as a cell-edge user as well as θ_2 specifies cell-center user on the basis of the down slopes in an exacting cell, in that $\theta_1 \underline{\underline{\Delta}} \theta_{m,1}$, $\theta_2 \underline{\underline{\Delta}} \theta_{m,2}$ and $\theta_m \underline{\underline{\Delta}} (\theta_{m,1}, \theta_{m,2})$ for m^{th} BS [13].

In addition, the vertical angle amid the preferred signal radiated to the cell-edge user u and $\theta_{m,2} - \theta_{m,u}$ denotes allocation of beamforming. For that reason, the preferred signal strength needs to be computed by exploiting the $P_m^{[n]} G_{m,u}^{[n]} \cos(\theta_{m,2} - \theta_{m,u})$, in that $P_m^{[n]}$ specifies allocated power for RB n in m^{th} cell, $p^{[n]} \underline{\underline{\Delta}} \left(p_1^{[n]},.....p_1^{[M]}\right)$, in that $p = \left(p^{[1]},.....p^{[M]}\right)$. $G_{m,u}^{[n]}$ specifies channel increase of u served using m^{th} BS on RB n.

As stated in eq. (1), the corresponding SINR is formulated if u cell edge user is supplied by means of m on subcarrier n which σ^2 represents thermal noise. Conversely, on the basis of eq. (2), the SINR is devised if u is a cell-center user served by m on n.

$$SINR_{m,u}^{[n]}(\theta_{m,2}) = \sum_{m \in N} \frac{P_m^{[n]} G_{m,u}^{[n]} \cos(\theta_{m,2} - \theta_{m,u})}{\sigma^2} \tag{1}$$

$$SINR_{m,u}^{[n]}(\theta_{m,1}) = \frac{P_m^{[n]} G_{m,u}^{[n]} \cos(\theta_{m,1} - \theta_{m,u})}{\sigma^2 + \sum_{j \in N, J \neq m} P_j^{[n]} G_{j,u}^{[n]} \cos(\theta_{j,1} - \theta_{j,u})} \tag{2}$$

Rate formulation: Using "Shannon's formula" the related within reach data rate for u is defined $R_{m,u}^{[n]}(\theta_m) = \log_2 \left[1 + SINRR_{m,u}^{[n]}(\theta_m)\right]$.

4. Adopted Allocation Scheme using Hybrid WOA-GWO

Generally, using both the nearer BS the edge users will be served in a communication network. In addition, the edge users without any assignment scheme are served by the resource blocks in the BS. Moreover, the adopted model highly concentrates on the base station allocation for each user as well as it assigns that subcarriers are to be exploited using the edge user.

The major aim of the adopted technique is to plan to raise the complete throughput of transmission using the optimization model which is fed to the cell edge as well as cell center user-specific eNB power as well as down tilt parameters. Eq. (3) represents the main objective model of the proposed model wherein

$w_{k(m,n)} > 0$ represents the weighting factor for those apprehensions on choosing a user $k(m,n)$ to use a subcarrier n in m^{th} cell. C_2 and C_1 represents cell-edge user-specific down tilt as well as cell-center user constraints, respectively.

$$\max_{k,\rho,\theta} \sum_{m\in N}\sum_{n\in M_{m,c}} w_{k(m,n)} R^{[n]}_{k(m,n)}(\theta_{m,1}) + \sum_{m\in N}\sum_{n'\in M_{m,c}} w_{k(m,n')} R^{[n']}_{k(m,n')}(\theta_{m,2}) \tag{3}$$

so that

$$\begin{aligned} &C_1 : \sum_{n\in M_m} P^{[n]}_m \le P_m, P^{[n]}_m \ge 0, \ \forall m \in N \\ &C_2 : 0 \le \theta_{m,1} \le \theta_c, \ 0 \le \theta_{m,2} \le \theta_e, \ \ \forall m \in N \end{aligned} \tag{4}$$

The solutions must be ascertained concerning M_m, p,k and $\theta \triangleq (\theta_1,.....\theta_N)$ $\forall m \in N$ to solve the optimization problem. For the proposed method, the input is subjected which involves the allocated power for the cell-center user (θ_1), $RB\left(P^{[n]}_m\right)$, cell-edge user (θ_2), and RB allocation *RB*, correspondingly. In addition, $\left(P^{[n]}_m\right)$ must be optimally tuned so that sum of subcarriers' power in a BS must be equivalent to or lesser than 16 dB and the number of θ_1 and θ_2 based upon the number of base stations.

4.1 Hybrid WOA-GWO Model

On the basis of the contemporary intelligent optimization model, an outstanding approach should maintain the balance among the exploitation as well as exploration additional concentration should be remunerated to exploration in the untimely search phase as well as exploitation in the late search phase, correspondingly. Hence, the search process of the proposed model is categorized into two sub-processes equivalent to two unconnected sub-approaches [10].

In the initial search phase, the primary phase of the proposed model is developed to attain the highest global search capability. The next phase of the proposed model is exploited to improve the local search capability in the final search phase. The approach requires high exploration capability to identify the capable areas in the initial search phase. Therefore, to obtain a highly effectual global search capability in the initial phase, the proposed model augments two schemes to the proposed model arbitrarily discrepancy disturbance as well as switching parameter tuning.

(a) Arbitrary differential disturbance scheme: Initially, the proposed model chooses 2 diverse individuals Y_{ind} and Y_{index} in the population arbitrarily. By exploiting the ROL for Y_{ind}, it is updated by ROL. By exploiting an arbitrary differential perturbation scheme. For Y_{index}, it is updated by an arbitrary differential perturbation scheme. By exploiting the proposed model other individuals are updated.

Initially, an individual Y_{index} is chosen from the current population arbitrarily, as exhibited in Eq. (5), wherein Index $\neq$ Ind. Subsequently, 2 individuals Y_r and Y_n are disturbed via the weighted difference among the optimal individual Y_g and Y_{index}, as well as 2 arbitrarily chosen individuals Y_r and Y_n, as exhibited in Eq. (6):

$$\text{Index} = \text{ceil}(N \times \text{rand}) \tag{5}$$

$$Y_{index} = Y_{index} + \text{rand} \times \left(Y_g - Y_{index} + Y_r - Y_n\right) \tag{6}$$

wherein, rand indicates an arbitrary count distributed uniformly among 0 and 1.

Here, 3 individuals such as Y_{index}, Y_r and Y_n are chosen arbitrarily, the scale factor uses an arbitrary number as well as two differentials $X_g - Y_{index}$ and $X_r - Y_n$ is exploited, as a result, the approach is named arbitrary differential disturbance approach. It can enlarge the search range as well as improve global search capability while the value of random is huge. It highlights local search capability; consequently, global as well as local search capability can be enhanced and balanced while random value is less. Moreover, the dissimilarity between two individuals is high, therefore values of $X_r - Y_n$ as well as $X_g - Y_{index}$ are higher, as well as search range is higher in the early search phase. Consequently, the approach is exploited to update individuals to augment population diversity as well as recover global search capability.

(b) Switching parameter tuning: The coefficient vector $|A|$ ascertains exploitation as well as exploration in WOA. The value of a presents the approach with capability in order to balance the local exploitation as well as global exploration in the optimization approach procedure. In accordance with the calculating manner of the linear raising probability is formulated as below:

$$A = a \times (2r - 1) \quad (7)$$

$$\eta = a_{max} - (a_{max} - a_{min}) \times (t / MaxDT) \quad (8)$$

The arbitrary differential disturbance scheme is used in the proposed model to raise the population diversity.

A technique must rapidly converge to the global optimal solution in the final search phase. It necessitates enhancing the local search capability as well as accelerating the convergence speed of the technique.

While p<0.5, |A|>1, the proposed model arbitrarily chooses an individual from the past optimal population rather than the present population to show the individual in the present population to update its location, which can improve exploitation capability. The formulation of the prey search in the proposed model is shown as below:

$$D = | C \otimes pBest_{rand}(t) - pBest_i(t) | \quad (9)$$

$$Y_i(t+1) = pBest_{rand}(t) - A \otimes D \quad (10)$$

The shrinking encircling model formulation is stated as below:

$$D_\alpha = | C_1 \otimes Y_\alpha(t) - pBest_i(t) | \quad (11)$$

$$D_\beta = | C_2 \otimes Y_\beta(t) - pBest_i(t) | \quad (12)$$

$$D_\delta = | C_3 \otimes Y_\delta(t) - pBest_i(t) | \quad (13)$$

$$Y_1 = Y_\alpha(t) - A_1 \otimes D_\alpha \quad (14)$$

$$Y_2 = Y_\beta(t) - A_2 \otimes D_\beta \quad (15)$$

$$Y_3 = Y_\delta(t) - A_3 \otimes D_\delta \quad (16)$$

$$Y_i(t+1) = (Y_1 + Y_2 + Y_3)/3 \quad (17)$$

The proposed model spiral updating formulations are represented as follows:

$$D_\alpha = | Y_\alpha(t) - pBest_i(t) | \quad (18)$$

$$D_\beta = | Y_\beta(t) - pBest_i(t) | \quad (19)$$

$$D_\delta = | Y_\delta(t) - pBest_i(t) | \quad (20)$$

$$Y_1 = D_\alpha e^{b \times 1} \cos(2\pi l) + Y_\alpha(t) \quad (21)$$

$$Y_2 = D_\beta e^{b \times 1} \cos(2\pi l) + Y_\beta(t) \quad (22)$$

$$Y_3 = D_\delta e^{b \times 1} \cos(2\pi l) + Y_\delta(t) \quad (23)$$

$$Y_i(t+1) = (Y_1 + Y_2 + Y_3)/3 \quad (24)$$

wherein $pBest$ indicates the individual in the past optimal solution. The adopted model uses two diverse updating techniques as well as the first population of the proposed model is the past optimal population. The proposed model uses an individual on the basis of the updating manner founded up to the past optimal populations Eq. (16) and (17) in search of prey, Eq. (18) to (24) in the shrinking encircling model, and spiral updating model. Hence, the proposed model can attain high local search capability at a rapid running speed.

Moreover, the proposed model exploits the global optimal spiral operator to furthermore enhance exploitation. The global optimal operator creates an exploit for location information of optimal solution in population to create individuals in population be subject to an optimal solution that is named as global optimal operator. Even though the global search capability of the global optimal operator is inadequate, it is aided to obtain strong local search capability.

This work uses the global optimal spiral operator entrenched in the spiral update phase of the proposed model to additionally enhance the local search capability of the technique and accelerates the convergence speed of the method. If the arbitrary value is higher than the 0.5 or not in the global optimal spiral operator in the initial stage subsequently the dimension is chosen arbitrarily (Eq. (25)), and the present dimension value of the present individual is re-exchanged with an arbitrary dimension value of the current optimal solution. Or else, using the spiral operator it is updated. The formulation of a global-optimal spiral operator is stated as below:

$$cnum = ceil(rand \times D) \quad (25)$$

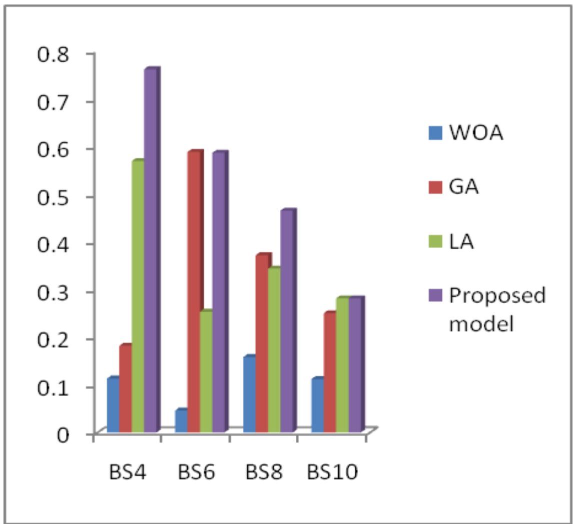
$$Y_i^d(t+1) = \begin{cases} Y_g^{cum}(t) & rand > 0.5 \\ Y_i^d(t) & otherwise \end{cases} \quad (26)$$

wherein $cnum$ indicates the arbitrary dimension index, $Y_i^d(t)$ is attained from the spiral updating model.

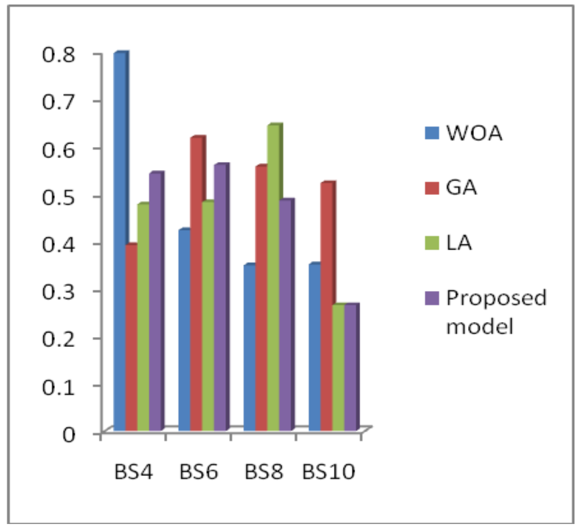
In the initial search phase, the second stage WOAG uses the optimal solutions obtained as the preliminary population, as well as optimal solutions, are diverse from the proposed model. In addition, to maintain WOA from falling into local optima, the proposed model updates all novel solutions on the basis of past optimal populations.

5. Result and Discussion

This section represents the experimentation model of the adopted 3D MIMO beam-forming and interference by exploiting the proposed Hybrid WOA-GWO algorithm, and the individual results were attained. In addition, the adopted model was evaluated and its advantage was exhibited with the exiting techniques for varied numbers of BS like 4, 6, 8, and 10. Here, the proposed model is compared with the conventional models such as WOA [11], GA [12], and LA algorithms.



(a)



(b)

Fig.1. *Performance analysis of adopted and traditional techniques (a) center user (b) edge user*

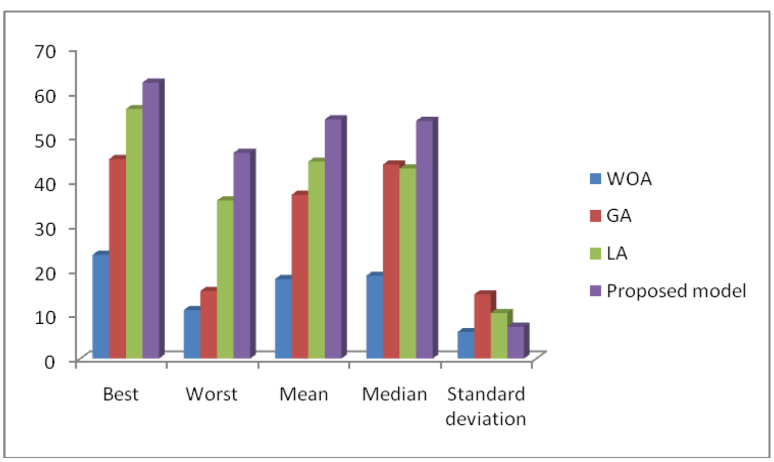


Fig.2. *Statistical analysis of adopted and traditional techniques concerning throughput*

Fig 1 represents the performance analysis of adopted and traditional approaches for center users as well as edge users. Here, the data rate attained by both the users is superior to the conventional techniques that tend to increase throughput.

Fig 2 exhibits statistical analysis of adopted and traditional approaches concerning throughput. From the results, the adopted approach has obtained optimal outcomes in all test case states. Here, the proposed model is 12% better than the WOA, 14% better than the GA, and 21% better than the LA algorithms. Therefore, the higher performance of the proposed model has been examined efficiently.

6. Conclusion

The main aim of this work was to introduce a novel method to increase cell center users' and cell edge users' throughput. In addition, a new enhanced method was introduced called hybrid WOA, and the GWO approach to fine-tune the specific parameters like allocated power for RB, cell-edge user, and allocation of RB and cell-center user. At last, the statistical analysis of the developed technique was examined with conventional models regarding the throughput analysis, as well as statistical metrics. While verifying the results, the overall analysis exhibits that the improvement of the proposed method was examined efficiently from the obtained results.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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