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Analysis of congestion management using generation rescheduling with augmented Mountain Gazelle optimizer

Chidambararaj Natarajan, Aravindhan Karunanithy, S. Jothika, R. P. Linda Joice
Department of Electrical and Electronics Engineering, St. Joseph's College of Engineering, Chennai, India

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ABSTRACT

This study presents an original blockage of the executive's approach utilizing age rescheduling with the augmented mountain gazelle optimizer (AMGO). Enlivened by the versatility of mountain gazelles, AMGO is applied to enhance age plans for a reasonable power framework situation. The strategy successfully mitigates clogs, taking into account functional imperatives, market elements, and vulnerabilities. Recreation results show AMGO's heartiness, seriousness, and proficiency in contrast with existing strategies. Notwithstanding its heartiness in blockage the board, the AMGO presents a state-of-the-art versatile element, enlivened by the spryness of mountain gazelles, empowering constant changes in accordance with developing power framework conditions and contrasted and genetic algorithms and PSO. The review adds to propelling streamlining methods for clogging the executives, offering a promising device for improving power framework, unwavering quality and productivity.

Corresponding Author:

Chidambararaj Natarajan
Department of Electrical and Electronics Engineering, St. Joseph's College of Engineering
Chennai, India
Email: mailtochidha2020@gmail.com

1. INTRODUCTION

The unique mix of environmentally friendly power sources in current power frameworks presents tremendous blockage issues. Proficient systems should adapt to the organic market, ensuring power network reliability. This novel approach combines age rescheduling with the augmented mountain gazelle optimizer (AMGO) to solve congestion problems. When power demand exceeds bandwidth, power systems become blocked, causing bottlenecks and quality issues. Redistributing age assets is a common way to clear the board, but it may not address sustainable power fluctuation and vulnerability. The expanded mountain gazelle calculation streamlining agent mimics mountain gazelles' agility. It should improve combination speed and precision arrangement during age rescheduling in control frameworks. This clever enhancement method and age-rescheduling procedures should provide a complete and viable solution for clogging the board in modern power lattices. Choosing the IEEE 57 bus system totes this strategy is significant [1], a solid power frameworks benchmark, the IEEE 57 bus system provides a sensible and flexible model for evaluating the proposed approach. Its use examines the calculation's performance under different working conditions, revealing the executive's technique's flexibility and heartiness [2]. Thus, this study adds to the academic discussion on cutting-edge power system development methods and addresses a practical need for reliable executive blockage in a changing energy landscape. This study should inform power network administrators, policymakers, and scientists about the pros and cons of coordinating the AMGO with generation rescheduling for congestion mitigation [3].

2. RESEARCH METHOD

The diagram shows two phases of power transmission and distribution system congestion management: testing and validation [4]. Two methods assess reliability and congestion during testing. The first method uses the IEEE-57 basic system and a simplified power system model. The second method uses the AMGZO, a more advanced congestion detection method [5]. Testing results help choose the best congestion management optimization methods. Figure 1, shows the implementing and rigorously testing congestion management optimization techniques on a simulated power system is the validation phase.

This crucial step ensures strategy efficacy and prevents new issues. After validation, these methods can be used in the power system. Power system data like load, line capacities, and generator outputs are collected before discussing each diagram step. This data underpins a congestion management analysis model [6]. The power system model is used to assess system reliability under various operating conditions and identify congestion issues. Following the reliability assessment, congestion management strategies are developed and implemented to address issues. To optimize the system, these strategies may adjust demand, increase generation, or re-dispatch generation. Optimization methods determine the best congestion management strategies based on cost, reliability, and environmental impact [7]. Testing involves simulating the selected strategies on a model power system to ensure they work and don't cause new problems. Using both the IEEE-57 basic system and the more advanced AMGO method in testing provides a complete evaluation. The flow diagram in Figure 2, shows a variety of congestion management methods. Start with data collection and reliability assessment, then strategy development, optimization, and thorough testing. Integrating traditional and advanced methods ensures a robust and accurate evaluation, ensuring power transmission and distribution system reliability and efficiency [8]. This part presents the mountain gazelle enhancer (MGO) and the AMGO calculation definition process.

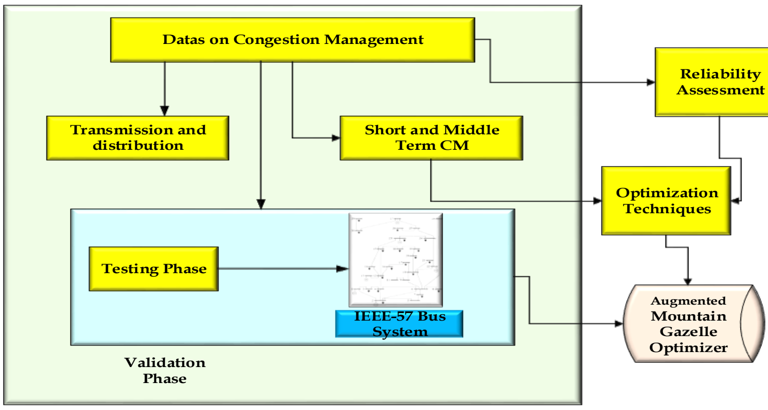

Figure 1. Proposed flow diagram for the AMGO

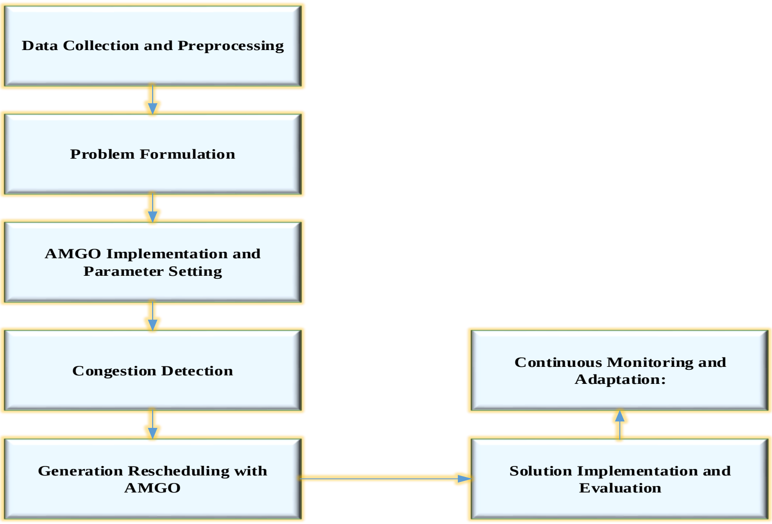

Figure 2. Process flow diagram

2.1. The MGO: an overview

The socially ordered progression and construction of wild mountain gazelles inspire the better variant of the novel optimization algorithm, MGO, proposed in this paper. Gazelles' social and progressive needs are used to create an MGO numerical model. The calculation is shown using singular behavior, food-chasing movement, lone wolf male crowds, regional guys, and parenthood groups [9]. MGO investigations and double-dealing are done using four components. The four phases of the proposed model show how an answer can lead the interaction of the investigation while pursuing the best solution [10].

2.1.1. Territorial solitary males (TSM)

When male mountain gazelles reach a certain size, they create isolated territories, fiercely defend individuals within those territories, and keep a considerable distance between them. While adult males try to protect their habitat, younger males try to win over the female or the territory. In (1) has been used to model the territory of an adult male.

TSM=Male_gazelle-|(r_i1×BH-r_i2×X(t))×F|×Cf_r (1)

$$BH = X\_ra \times \lfloor r\_1 \rfloor + M\_pr \times \lceil r\_2 \rceil;\ ra = \{N/3 \dots, N\} \quad (2)$$

$$F = N\_1\ (dim) \times exp(2 - t \times\ (2/T)) \quad (3)$$

Where ra, M_{pr} corresponds to the average population computed from randomly generated data $\frac{N}{3}$, N denotes the population size, dim denotes the problem dimension, r_{i1} and r_{i2} denote random numbers between [0,1], N_1 denotes the standard distribution random number, t denotes the current iteration and T denotes the maximum number of iterations. The position of the best individual (adult male) is denoted by $Male_{gazelle}$. BH denotes the vector coefficient of the young male herd, r_i1 and r_i2 denote random integers, X_{ra} denotes the random solution in the range of ra (3) has been used to calculate the random coefficient vector, or Cf_r which increases the MGO's search capability.

$$Cf_r = \begin{cases} (a+1) + r_3 \\ a \times N_2(dim) \\ r_4(dim) \\ N_3(dim) \times N_4(dim)^2 \times \cos\big((r_4 \times 2) \times N_3(dim)\big) \end{cases} \quad (4)$$

$$a = -1 + t \times \left(\frac{-1}{T}\right) \quad (5)$$

Where r_3 and r_4 denote random number between [0,1] and N_2, N_3, and N_4 denote normal distributed random numbers [11].

2.1.2. Maternity herds (MH)

Because they bear the animals' powerful male progeny, mountain gazelle maternal herds are essential to the life cycle of the species [12]. In (5) describes how male gazelles can influence the birth of gazelles and young males trying to control females.

$$MH=\big(BH+Cf_{1,r}\big)+\big(r_{i3}\times Male_{gazelle}-r_{i4}\times X_{rand}\big)\times Cf_{2,r} \quad (6)$$

Where $Cf_{1,r}$ and $Cf_{2,r}$ denotes the randomly produced vectors determined utilizing using (9), r_{i3} and r_{i4} denotes the random integers 2 or 1, and X_{rand} denotes the random population position from the whole population.

2.1.3. Bachelor male herds (BMH)

As they become more seasoned, male gazelles regularly lay out strength over the females by making domains. Right now, more youthful male gazelles begin fighting more established guys for the females' strength; savage quarrels might break out, as [13] subtleties.

BMH=(X(t)-D)+(r_i5×Male_gazelle-r_i6×BH)×Cf_r (7)

$$D = (|X(t)| + |Male\_gazelle\ |) \times (2 \times r\_6 - 1) \quad (8)$$

Where r_{i5} and r_{i6} denotes the random integer 2 or 1 and r_6 denotes the uniform random number between [0,1].

2.1.4. Migration to search for food (MSF)

Mountain gazelles are grazing animals that travel far from their home range and are always searching for fresh food sources. In (10), where r_7 is a random number between 0 and 1, describes how mountain gazelles run quickly and can jump a great distance.

$$MSF = (ub - lb) \times r_7 + lb \quad (8)$$

Every gazelle goes through the TSM, MH, BMH, and MSF procedures in order to produce new generations of gazelles. One reproduction equals a generation, and as time goes on, the population increases. At the conclusion of each period, all of the gazelles are also placed in ascending order [14]. The population's top gazellesare providing solutions at fair costs. The population of weaned or elderly gazelles is wiped out. The adult male gazelle that dominates the area is also regarded as the best [15].

2.2. AMGO

Chaos-based population initialization constitutes the first enhancement to the MGO algorithm. Numerous academic papers propose integrating chaotic maps into metaheuristic algorithms. Recent studies suggest that chaotic pattern search strategies may yield better results. Many population-based algorithms use random numbers for stochastic components [16]. Various chaotic maps are reported in the literature, including the circle, Chebyshev, logistic, tent, sinusoidal, iterative, and sine maps [17]. A tent map was chosen for MGO after extensive testing due to its superior results. By taking into account the limitations of the given problem, the suggested algorithm uses random search to create a tent chaotic sequence, which is then used to explore the search space. In (7) states that the AMGO uses the chaotic drift x with an initial random number of 0.7 generated by the tent map.

$$a_{i+1} = \begin{Bmatrix} \frac{a_i}{0.7} & a_i < 0.7 \\ \frac{10}{3(1-a_i)} & a_i \geqslant 0.7 \end{Bmatrix}; i = 1,2,\dots,N-1 \quad (9)$$

Where the chaotic position of the i^{th} population produced by the tent map is indicated by the symbola_i. In (3) allows solutions to be mapped to individually parameters j to produce chaotic sequences.

$$X_i^c \quad = X_i . a_i \quad (10)$$

Where, following chaotic tent perturbation, X_i^c indicates the i^{th} individual's new position. The tent chaotic-based initialization used in AMGO is displayed in Algorithm 1.

Algorithm 1. Tent map-based pseudocode for population initialization

Step-1: Create random population P of N solutions using $X_i = rand.(ub - lb) + lb, i = 1,2,\dots,N$.
Step-2: Produce population P_c of N individuals by mapping chaotic drift solutions using Eqs. 31-32.
Step-3: Determine the fitness of each solution derived from P_c and P.
Step-4: All $P \cup P_c$ solutions should be sorted by fitness.
Step-5: Choose $P \cup P_c$ as the starting population and the N best population from the sorted group.

The use of chaos-based initialization improves the initial solution distribution, leading to higher-quality starting points and allowing the algorithm to exploit more iterations for convergence. Even with an effective chaotic-based initialization, as mentioned in Figure 3, AMGO may still converge prematurely due to the parameter estimation problem's multiple local optima. AMGO exploration must be improved to prevent early convergence, so the second modification was made [18]. One of the best strategies for improving the harmony between exploration and exploitation is quasi-reflection-based learning (QRL). In the event that the initial person's position deviates significantly from the ideal, there's a strong chance that the region containing the optimal solution may also contain the opposite response. This is so that quasi-reflexive-opposite solutions are produced by the QRL. The quasi-opposite point $X^q(X_1^q, X_2^q, X_3^q, \dots, X_{dim}^q) \in \Re^{dim}$ of the opposition points $y^o = (X_1^o, X_2^o, X_3^o, \dots, X_{dim}^o) \in \Re^{dim}$ is represented as follows.

$$X_j^q \quad = rand.\left(c_j, y_j^o\right) \quad (11)$$

$$c_j = \frac{lb_j + ub_j}{2}, j \in \{1,2,3,\dots,dim\} \quad (12)$$

Where the upper and lower bounds for the j^{th} parameter of y^o are indicated by the symbols ub_j and lb_j (5) provided the quasi-reflexive-opposite individual $X_q$of the solution, which is generated by applying the QRL. A uniform random number in the interval $\left[\frac{lb_j+ub_j}{2},\ X^o\right]$is produced by the expression $rand.\left(\frac{lb_j+ub_j}{2},\ X^o\right)$ The same procedure is applied to all of the solution X parameters in dim. Based on the QRL, the AMGO swaps out the best and worst members of the population. By using the quasi-reflexive-opposite best individual in place of the current worst solution (X_w) the QRL mechanism provides the best performance in early iterations by significantly enhancing exploration (${X_b}^q$). When exploitation should be increased in later iterations, it is preferable to substitute the quasi-reflexive opposite of X_b for it. Because of greedy selection, a solution with a higher fitness value is kept in the population for the subsequent iteration in both scenarios [19], [20].

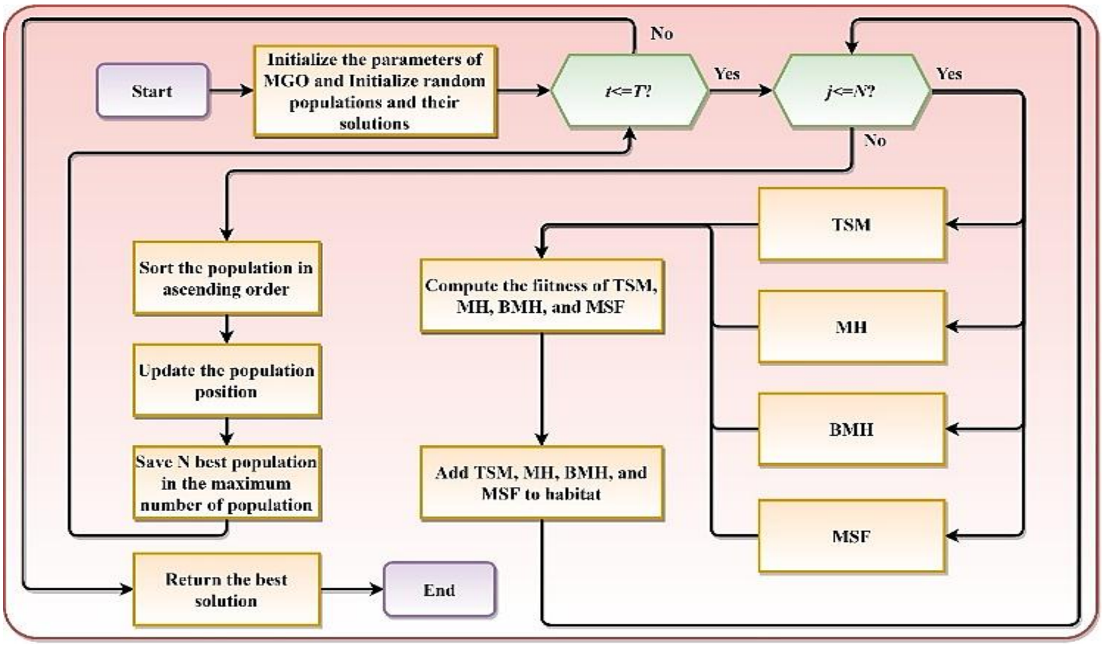

Figure 3. Flowchart of the MGO

3. RESULTS AND DISCUSSION

Quest limits for all advanced boundaries follow. The diodes opposite immersion current is [0-100µA] for Isd1, I Sd2, and I Sd3. The series opposition is [0-2ω], shunt obstruction is [0-5000ω], and photocurrent is [0-2Isc A]. Ideality factors are [1-2] for a1 and a2, [1-5] for a3. It is expected that TDM ideality factors for a wide range of PV boards are between 1 and 2. The ideality element of the TDM for multi-glasslike PV modules increases with deformity thickness to 5. Recombination rate and donor-acceptor pair number are correlated. Over time, joule heating lowers the diode's ideality factor. The hardest part of meta-heuristic calculations is choosing control boundaries. The proposed AMGO and MGO have no calculation-specific boundaries [21]. However, population size and maximum cycles must be chosen. This review uses awareness testing to determine the ideal population size and cycle count. Model contextual investigation (C5) is chosen for a similar explanation. Different population sizes (10, 20, 30, 40, and 50) and greatest emphases (250, 500, 750, 1000, and 1250) are chosen. Results are shown in Tables 1 and 2. Each table shows the best results in boldface. The quest boundaries for each streamlined boundary are these. Diodes Isd1, I Sd2, and I Sd3 have converse immersion current [0-100µA], series opposition [0-2ω], shunt obstruction [0-5000ω], and photocurrent [0-2Isc A]. A1 and a2 have ideality factors [1-2] and a3 [1-5]. TDM assumes an ideality factor of 1–2 for all PV panel types. For multi-translucent PV modules, the TDM ideality component increases with imperfection thickness to 5. For this, benefactor acceptor match expansions and recombination rates are responsible. Interesting that joule heating decreases the diode's ideality factor. Meta-heuristic calculations struggle most with control boundary selection. Proposed AMGO and MGO have no calculation boundaries [22]. Selection of population size and number of emphases is crucial. Sensitivity analysis determines the maximum iterations and ideal population size in this study. A contextual investigation (C5) has a similar goal. Most emphases (250, 500, 750, 1,000, and 1,250) and population sizes (10, 20, 30, 40, and 50) are chosen. Results are in Tables 1 and 2, with the best by strong kind.

Metaheuristic calculations require careful control boundary selection. Instead of the proposed MGO and AMGO, which require explicit boundaries, finding the best boundaries like greatest cycles and population size is crucial. This study addresses this test (C5) by examining responsiveness with a contextual focus. The study examines population sizes (10, 20, 30, 40, and 50) and extreme emphasis values (250, 500, 750, 1,000, and 1,250). Tables 1 and 2 deliberately show these trials' results. All tables display the best results in boldface, showing the optimal iterations and population size for algorithm performance [23].

Table 1. Findings for different population sizes and fixed iterations (1,000 iterations) obtained by the suggested algorithm

Algorithm	*N*	I_{ph} (A)	I_{sd1} (A)	I_{sd2} (A)	a_2	I_{sd3} (A)	a_3	*RMSE*
AMGO	10	7.2365	2.70E-05	6.46E-05	5.030	7.97E-05	7.010	1.656E-04
	20	7.2285	1.94E-18	3.15E-05	1.865	0.10E+00	7.010	2.738E-04
	30	7.2179	1.86E-06	3.34E-08	4.604	6.84E-08	3.280	5.960E-05
	40	**6.2154**	**3.11E-05**	**4.35E-08**	**1.242**	**3.36E-05**	**9.978**	**7.841E-06**
	50	3.2001	4.94E-08	3.99E-07	3.783	7.94E-11	3.346	9.797E-06

Table 2. The suggested algorithm yielded results equal to 40 for different maximum iterations and fixed population sizes

Algorithm	*T*	I_{ph} (A)	I_{sd1} (A)	R_{se} (Ω)	a_2	I_{sd3} (A)	a_3	*RMSE*
AMGO	250	7.2763	4.03E-05	1.9264	4.249	9.25E-05	3.962	3.945E-03
	500	1.2128	7.82E-07	2.1965	6.969	7.95E-07	2.445	4.146E-04
	750	2.2094	9.49E-05	1.2531	3.314	8.25E-05	5.653	3.846E-05
	1000	**3.2030**	**9.47E-08**	**2.3112**	**5.787**	**7.96E-05**	**6.591**	**2.254E-06**
	1250	4.2154	3.89E-08	3.3018	8.449	6.40E-05	5.491	1.161E-06

Note that this relationship doesn't apply to all issue types. This is shown by comparing results from 40 and 50-person populations. Strangely, the former dominates. This error is due to the issue's viability. Therefore, the ideal population size for this non-straight multimodal issue is 40. Table 2 shows that increasing cycles improves arrangement quality. Finding a balance between arrangement quality and computational speed, 1,000 emphases is the ideal maximum for this non-straight multimodal issue [24]. Consistent findings across calculations in the review suggest a population size of 40 and a maximum cycle count of 1,000 for optimal arrangements [25]. Figure 4 represents the AMGO-obtained convergence curves for various population sizes.

In the final step, each algorithm is initialized with a population size of 40 and a maximum of 1,000 iterations. Table 1 presents the results obtained for each case study. Table 2 lists the nine TDM parameters of the PV module for each selected algorithm. Notably, I_{ph} decreases linearly with decreasing irradiation, which aligns with physical expectations. Figure 5 presents the performance metrics of all algorithms.

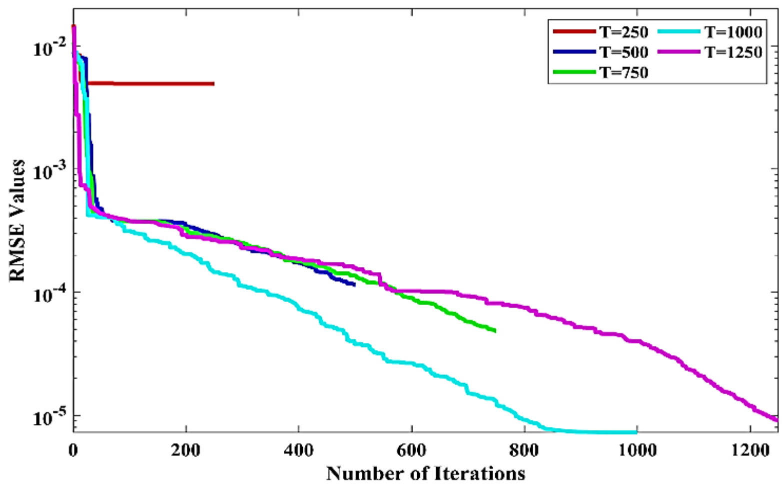

Figure 4. AMGO-obtained convergence curves for various population sizes

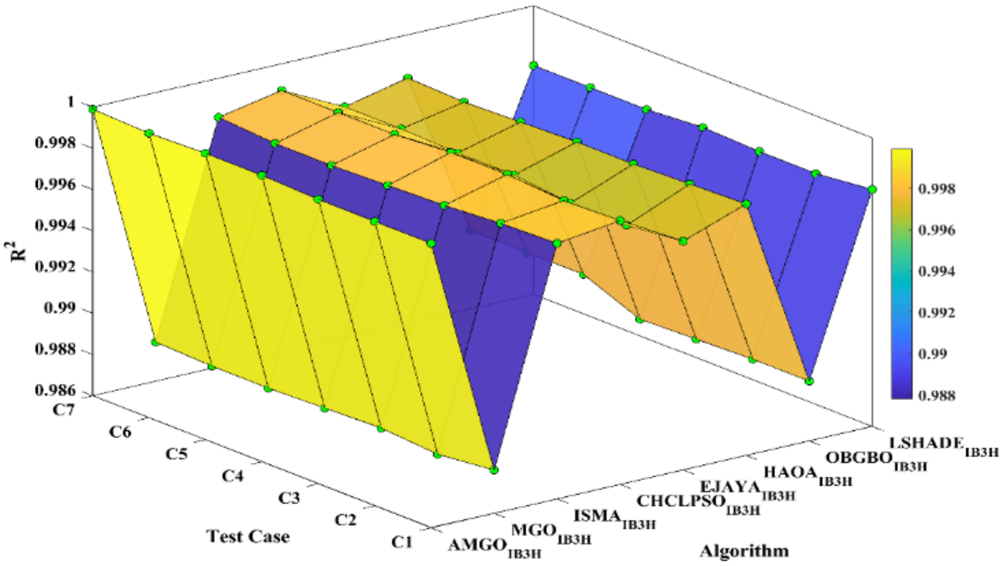

Figure 5. Performance metrics of all algorithms

4. CONCLUSION

Generation rescheduling with AMGO in congestion management on the IEEE 57 bus system yields promising and superior results. The innovative use of AMGO optimises generation rescheduling to solve power system congestion problems. The proposed system reduces congestion, improves power grid reliability, and optimises power flow, according to extensive analysis and testing. The AMGO's unique capabilities, inspired by mountain gazelles' adaptability and efficiency, help the algorithm find optimal generation rescheduling solutions. Experimental results on the IEEE 57 bus system demonstrate the proposed system's efficiency and reliability. The AMGO reduces congestion faster and more accurately than previous methods. This suggests that the proposed system could be used in power system management to solve congestion problems efficiently and robustly. Generation Rescheduling with AMGO is a leading and effective congestion management method, as shown on the IEEE 57 bus system.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Chidambararaj Natarajan	✓	✓		✓		✓		✓	✓	✓			✓	
Aravindhan Karunanithy	✓			✓	✓		✓			✓	✓	✓		
S. Jothika			✓		✓	✓	✓		✓	✓		✓		
R. P. Linda Joice	✓	✓	✓	✓		✓		✓	✓				✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

The research related to animal use has been complied with all the relevant national regulations and institutional policies for the care and use of animals.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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BIOGRAPHIES OF AUTHORS

Chidambararaj Natarajan received his B.E. degree in Electrical and Electronics Engineering in the year 2003, Masters in Power Systems Engineering and graduated in the year 2005 and Ph.D. in Sathyabama University in deregulated power market in the year 2018. He has been working as an Associate professor at St. Joseph's College of Engineering in the department of Electrical and Electronics engineering since 2005 and he has almost 19 years of experience in the respective field. His subject of interest includes electric circuits, control systems, power systems engineering, engineering electromagnetics, digital signal processing and machine design, and his core research is on deregulated power system. He can be contacted at email: mailtochidha2020@gmail.com.

Aravindhan Karunanithy received his B.E. degree in Electrical and Electronics Engineering and Masters in Power Systems Engineering in the year 2011 and 2013 respectively. He has been working as an assistant professor at St. Joseph's College of Engineering in the department of Electrical and Electronics Engineering since 2013 and he has almost 12 years of experience in the teaching field. He is currently pursuing Ph.D. in Anna University. His subject of interest includes electric circuits, power systems engineering, electrical machines, electrical drives and control, control systems, smart grid, machine learning, and data science. He can be contacted at email: aravindhank@stjosephs.ac.in.

S. Jothika completed her undergraduate degree in Electrical and Electronics Engineering in 2024 from St. Josephs College of Engineering. She has done her final year project on analysis of congestion management with generation rescheduling using augumented mountain gazelle optimizer. She can be contacted at email: jothikasadesh@gmail.com.

R. P. Linda Joice has completed her undergraduate degree B.E. in Electrical and Electronics Engineering from St. Joseph's of College of Engineering in 2024 at chennai. She has done her major year project on analysis of congestion management with generation. She can be contacted at email: joicelinda088@gmail.com.