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Artificial intelligence of optimal real power dispatch with constraints of lines overloading

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ABSTRACT

In the literature on optimal power flow (OPF), it has been shown that the suggested ways offer a higher degree of satisfaction in optimizing overall production costs while fulfilling power flow equations, system security, and equipment operational constraints. Despite this, the overloaded of the transmission lines are taken as a performance index but not a primary constraint. This article presents an improved approach to artificial intelligence algorithms of optimal real power dispatch with the security of lines; the main difference concerning our point seen relies on the additional penalization of the choices, which does not respect this constraint. The problem is implemented in the IEEE 14-bus system with "5" generator units. The results of the simulations of the metaheuristic algorithms without/with constraint (overloaded lines) were compared. Furthermore, this article suggests hybridizing ant colony optimization (ACO) and genetic algorithm (GA) as a means to enhance the optimization performance of these algorithms. This hybridization involves using ACO to generate a set of initial solutions, which are then refined using GA. The compound results obtained by the ant system-genetic algorithm hybrid (H-ASGA) for the problem of overloaded lines validated its potential.

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1. INTRODUCTION

The economic dispatch problem plays an important role in power system operation. Their development during the last two decades has tracked on the one hand progress in advanced computer technology and the other in artificial intelligence optimization technology. The capacity of OPF to quickly identify the best solution while taking system security into account is the main area of attention at the moment. In this context, we discuss a new formulation of transmission line safety constraints that are assessed as penalties. Five optimization approaches are proposed to optimize the model, particle swarms (PSO), firefly algorithm (FA), artificial bee colony (ABC), genetic algorithm (GA) and ant colony optimization (ACO) [1]. Numerous comparisons are made on a reference test system to show the effectiveness of the proposed model and the five approaches metaheuristic.

The goal of the OPF is to identify the best possible mix of power generation that satisfies the overall demand and power system restrictions while minimising total fuel costs. The operating cost function of power generation units, it is expressed as (1) [2]–[4].

$$FT = \sum_{i=1}^{NG} f(P_{Gi}) = \sum_{i=1}^{NG}\left(a_i {P_{Gi}}^2 + b_i P_{Gi} + c_i\right) \quad (1)$$

Where $f(P_{Gi})$: Generating unit operation cost of a generator connected to bus i ($/h); P_{Gi} : Real power generation of a generator connected to bus i (MW); and a_i, b_i, c_i : are the generator's cost-of-fuel coefficients

2. SECURITY CONSTRAINED ECONOMIC DISPATCH BY ARTIFICIAL INTELLIGENCE

The goal of security constrained economic power distribution (SCED) is to reduce the fuel consumption of the generators or the overall operating costs of the system by determining the power output of each generating unit under the constraints of the system load demands [5], By observing the input-output characteristics of the generating unit, it can be seen that the power output is constrained by the minimal and maximal capacitie of the generating unit.

The outputs of the "N-1" generators may initialize freely within bounds when using metaheuristic methods, while the power balancing uses the Gauss-Seidel algorithm to adjust the output of the "reference generator" or extended bus generator. New points in the search space are generated by techniques known in the artificial intelligence (AI) literature. The AI type algorithms are in fact optimization without constraint; all information and constraint must be expressed in a fitness functions [6].

2.1. Constraint 1: Real power flow equation

The essential constraint in the operation of an electrical system is that the sum of the output powers must equal the load demand. The class of models that can be estimated using pool estimation, can be written as (2) and (3) [7]–[9], where NB: Total number of buses; NG: The number of generating units; NL: The number of transmission lines; and h_1 : Penalty factors of loss.

$$\sum_{i=1}^{NG} P_{Gi} = \sum_{i=1}^{NB} P_{Loadi} + \sum_{i=1}^{NL} P_{Lossi} \tag{2}$$

$$F_{loss} = h_1\left(\sum_{i=1}^{NG} P_{Gi} - \sum_{i=1}^{NB} P_{Loadi}\right)^2 \tag{3}$$

2.2. Constraint 2: Upper and lower thresholds for the generators' active power output

The active power generated must satisfy the maximum and minimum operating limits, that is, each unit's power output must be higher than or equal to the minimum power allowed and lower than or equal to the maximum power allowed for that specific unit [10]–[12].

$$\begin{cases} IF \quad P_{Gi} < P_{Gimin} & \Rightarrow \ P_{Gi} = P_{Gimin} \\ IF \quad P_{Gi} > P_{Gimax} & \Rightarrow \ P_{Gi} = P_{Gimax} \end{cases} \tag{4}$$

The stresses of the node voltage limits can be expressed by:

$$F_{PG} = \begin{cases} 0 & P_{Gimin} < P_{Gi} < P_{Gimax} \quad no\ violation \\ h_2 \sum_{k=1}^{NGmin} (P_{Gi}(k) - P_{Gimin}(k))^2 & P_{Gi} < P_{Gimin} \\ h_3 \sum_{L=1}^{NGmax} \left(P_{Gi}(L) - P_{Gimax}(L)\right)^2 & P_{Gi} > P_{Gimax} \end{cases} \tag{5}$$

Where $NGmin$: The set of generators violating minimum production limits; $NGmax$: The set of generators violating maximum production limits; h_2 : Penalty factors to the violation of minimum power output; and h_3 : Penalty factors to the violation of maximum power output.

2.3. Constraint 3: Upper and lower limits of node voltages

In general, functional constraints are more often soft limits than hard limitations in a strictly mathematical sense [5]. The following are possible expressions for the inequality restrictions on control parameters, such as the generator bus voltage limits [13].

$$F_V = \begin{cases} h_4 \ \sum_{k}^{NVmin} \left(V_i(k) - V_{imin}(k)\right)^2 & V_i < V_{imin} \\ h_5 \ \sum_{L}^{NVmax} \left(V_i(L) - V_{imax}(L)\right)^2 & V_i > V_{imax} \end{cases} \tag{6}$$

Where $NVmin$: The set of generators violating minimum voltage limits; $NVmax$: The set of generators violating maximum voltage limits; h_4 : Penalty factors to the violation of minimum voltage; h_5 : Penalty factors to the violation of maximum voltage

2.4. Constraint 4: Available transfer capacity of the transmission lines

If a single contingency (or numerous contingencies) takes place, there is no assurance that regular operation won't violate the line limits. The generations must be redistributed if such a circumstance occurs in order to satisfy the line limitations. There is consequently a need for an effective method of integrating the security limitations into ED [14].

In practical electrical power supply systems, it is very important to solve the OPF problem with lines overload constraints. The power balance constraint is included in the formulation and the incremental losses are accurately represented at the classic economic dispatch if power flow is solved concurrently with generation and cost minimization. As a result, the security of the lines can be included to be checked periodically during the optimum seeking process to ensure that the dispatch solution is within the operating limits [15].

$$F_{LO} = \begin{cases} 0 & |P_{ij}| \le P_{ij-max} \quad no\ violation \\ \sum_{k=1}^{NOL} \frac{P_{ij}(k) - P_{ij-max}(k)}{P_{ij-max}(k)} & |P_{ij}| > P_{ij-max} \end{cases} \quad k \in NOL \tag{7}$$

Where NOL: The set of overloaded lines; P_{ij} : The power flow at the line from bus "i" to bus "j"; P_{ij-max} : The power limit flow at the line from bus "i" to bus "j".

Given everything, the stochastic model's corresponding transformation is formally expressed by a new objective function as [16]:

$$FT = \sum_{i=1}^{NG} \left(a_i {P_{Gi}}^2 + b_i P_{Gi} + c_i \right) + F_{loss} + F_{PG} + F_V + F_{OL} \tag{8}$$

Since the issue in (8) is a high-dimension, non-convex optimisation problem, finding an analytical solution is very challenging. Numerous artificial intelligence (AI) techniques have developed recently that make it easier to solve optimisation issues that were previously challenging or impossible. The main benefit of AI approaches is that they are not constrained by restricted search space hypotheses like continuity, the presence of an objective function derivative, etc. These techniques are comparable in certain ways [17].

3. IMPLEMENTATION

The optimization method with "IA" can be summarized in the following steps: The optimization method with "IA" can be summarized in the following steps:

Step 1: Pick the initial control variable,

Step 2: To find a workable solution that complies with the equality condition for the power balance, solve the power flow issue. {PG(i)} i∈NG,

Step 3: load flow calculation to determine: production bus reference, load, loss, line overload,

Step 4: Evaluate fitness function,

Step 5: Obtain the power flow solution with updated control variables,

Step 6: Examine the convergence. In this case, the solution converges if ΔPGi are lower than the user-defined tolerance. Otherwise

A well-known benchmark system for power system analysis and optimisation algorithm testing is the IEEE 14-bus network. The literature presents the cost coefficients, maximum and lowest generation limitations, and load demand for each interval of the IEEE 14-bus [5], [18]. The optimization strategies of GA, FA,ABC, ACO and PSO with this new formulation for solution of the economic dispatch load problem were introduced in Table 1. It is evident from the comparison that the suggested technique offers an improvement in the overall cost reduction.

Table 1. Results of economic dispatch without lines overload constraint

IEEE 14 Bus System	Particle warm [19]	Sunflower [20]	Gravitational search [21]	GA	FA	ABC	PSO	ACO
PG1 (MW)	172.2998	194.6693	210.3368	167.3213 *	172.3926 *	171.6565 *	171.6277 *	171.6196 *
PG2 (MW)	47.3037	36.7904	20.2300	49.8893	47.2066	47.5756	47.5768	47.7001
PG3 (MW)	20.8993	27.9933	17.3500	20.3736	20.818	20.9549	20.9603	20.9795
PG4 (MW)	15.0895	0.0000	10.0400	17.2207	15.9887	15.8	15.8289	16.0389
PG5 (MW)	11.6331	8.8547	11.5000	12.1845	11.0563	11.4277	11.4159	11.0825
Total generation	267.2254	268.3077	269.2221	266.9894	267.4621	267.4147	267.4096	267.4207
Real load (MW)	259.0000	259.0000	259.0000	259.0000	259.0000	259.0000	259.0000	259.0000
Real loss (MW)	8.2254	9.3077	10.2221 1	7.9894	8.4621	8.4147	8.4096	8.4207
Fuel cost ($/hr)	715.2875	725.0132 **	735.7454 **	715.5140 2	716.0666 **	716.0568 **	716.0454 **	716.0604 **
Constraint 1,2,3	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
Constraint 4 overloaded lines	L2-3{58.57} L4-5{52.48}	L1-2{130.63} L2-3{56.51} L4-5{51.48}	L1-2{142.63} L1-5{65.69} L2-3{60.54} L4-5{55.79}	L2-3{58.60} L4-5{52.33}	L2-3{57.87} L4-5{49.61}	L2-3{57.76} L4-5{49.39}	L2-3{57.76} L4-5{49.39}	L2-3{57.77} L4-5{49.51}

*The power at the reference bus is calculated by the Gauss-Seidel algorithm

**The costs are calculated by the coefficients in the appendix

Figure 1 shows the topology of the IEEE 14-bus test system's network. The results shown are from [20]. The lines that are overloaded are in red. In the context of the practical application of the OPF, the optimal load flow solution presents an unavoidable limitation, of capacity to transit the powers of the lines; owever, these solutions result in a violation of lines {1-2, 2-3 and 4-5} limits. The distribution of powers is of course only a constituent, but very necessary, for the operation and planning of networks. Therefore, the result obtained does not meet the security constraints of the system.

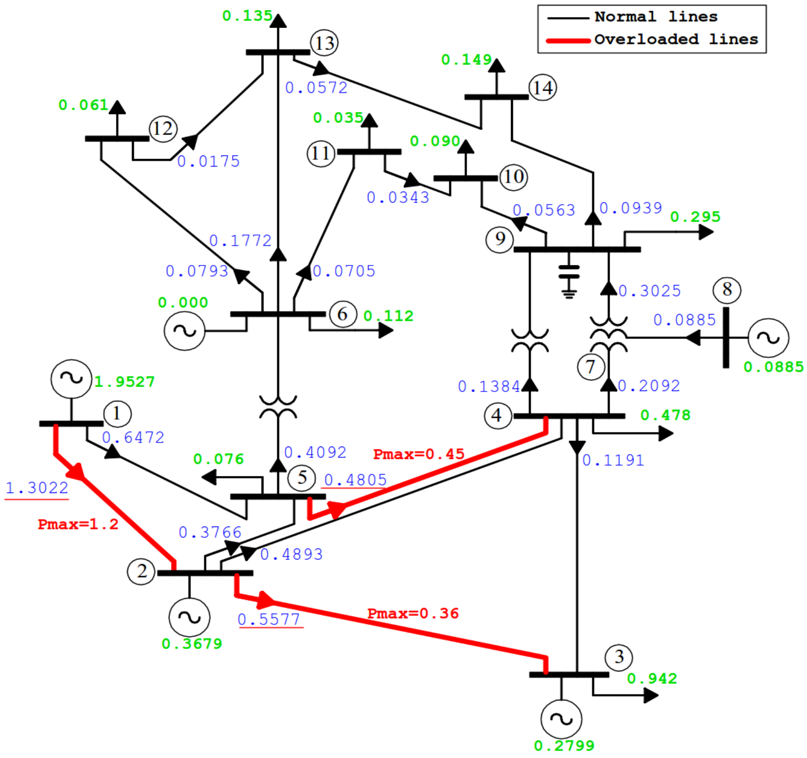

Figure 1. The 14-bus system with lines overload of ref [20]

4. OPTIMIZATION OF ECONOMIC DISTRIBUTION UNDER CONSTRAINT OF LINE OVERLOAD

The five meta-heuristics algorithms used are PSO, FA, GA, ACO and ABC for solving the security ED problem is tested on the IEEE 14-bus system with constraints of lines overload. The total system load is 259.00 MW. The corresponding load-scaling factor (LSF) is 1.0. Multiple iterations of the tests have been run to ensure the stability of the meta-heuristics optimisation strategies. Table 2 shows the best solutions to the objective function of the 14-bus problem taking into account lines overload. The elimination of line overload constraints has an impact on the primary objective function, this costs an increase in fuel cost from 9.83 to 9.9% depending on the method.

Table 2. Results of economic dispatch under constraint of line overload (LSF=1).

IEEE 14 Bus System	GA	FA	ABC	PSO	ACO
PG1 (MW)	123.0996	122.0295	123.6483	123.3977	122.8166
PG2 (MW)	29.3979	27.9233	26.3671	29.1437	31.5821
PG3 (MW)	50.2217	49.2821	49.1659	50.0694	50.9488
PG4 (MW)	40.0848	40.5972	38.8869	37.5642	38.7391
PG5 (MW)	20.7895	23.6637	25.4379	23.3765	19.5339
Total generation	263.5936	263.4957	263.5062	263.5515	263.6206
Real load (MW)	259.0000	259.0000	259.0000	259.0000	259.0000
Real loss (MW)	4.5936	4.4957	4.5062	4.5515	4.6206
Fuel cost ($/hr)	794.3059	794.1652	794.6702	794.1583	794.6661
Constraint 1,2,3	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
Constraint 4 Overloaded lines	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

Figure 2 show a comparison between the convergences of the objective function using the five meta-heuristics methods. After 100 iterations, the algorithm that yielded the lowest cost function value was the 'PSO' algorithm, with a cost function value of 794.1583$/h. The FA algorithm had the second-lowest cost function value of 794.1652 $/h, followed by GA with a value of 794.3059 $/h, and ACO with a value of 794.6661 $/h, The ACO algorithm also seems to converge to a certain value after the first few iterations. However, the values are much smaller than those of the ABC algorithm. The ACO algorithm seems to have a slower convergence rate than the ABC algorithm, but it eventually reaches a stable value after a larger number of iterations. The first value of the ABC algorithm is quite large, which indicates that the algorithm starts with a high value of the objective function. However, the values decrease significantly after the first few iterations and then remain stable, fluctuating only slightly around a certain value. We also see that the objective function converged fast, smoothly and stably, providing a better optimization performance to achieve the best solution with the PSO algorithm.

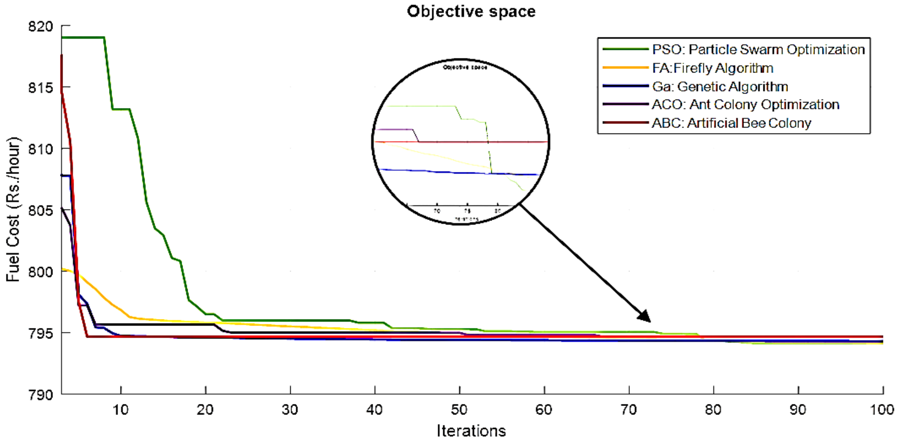

Figure 2. Convergence characteristics of 14-bus (5) generator system.

When comparing the various meta-heuristic methods used to solve ED problems, the algorithms are able to achieve similar results. However, there may be slight differences in precision between the different methods. From an engineering perspective, these small variations can be deemed acceptable and can be overlooked. Finally, in Table 3 the IA techniques, we show the lines overload are annulled in full.

It is important to note that the differences between the cost function values of the algorithms are relatively small. Overall, it is difficult to draw definitive conclusions about the performance of each algorithm [22], especially with the change in the parameters used for each algorithm. It may be helpful to run each algorithm multiple times with different parameters and a load scale factor of 1.2 to obtain a more robust comparison of their performance. The calculation results of ED with lines overload for the IEEE 14-bus system are shown in Table 4.

Table 3. Results of classic economic dispatch with lines overload

Lines	GA	FA	ABC	PSO	ACO	Line Limit	Lines	GA	FA	ABC	PSO	ACO	Line Limit
1⟶2*	0.8339	0.8307	0.8438	0.8357	0.8269	1.200	6⟶11	0.1286	0.1261	0.1207	0.1206	0.1274	0.1800
1⟶5	0.3971	0.3896	0.3927	0.3983	0.4013	0.6500	6⟶12	0.0863	0.086	0.0853	0.0853	0.0862	0.3200
2⟶3*	0.36	0.3601	0.3597	0.36	0.36	0.3600	6⟶13	0.2068	0.2055	0.2027	0.2027	0.2062	0.3200
2⟶4	0.3165	0.3069	0.3049	0.3149	0.324	0.6500	8⟶7	0.2079	0.2366	0.2544	0.2338	0.1953	0.3200
2⟶5	0.2224	0.2141	0.2136	0.2232	0.2299	0.5000	7⟶9	0.2723	0.2817	0.2914	0.2865	0.2704	0.3200
4⟶3	0.0863	0.0958	0.0974	0.0879	0.079	0.6500	9⟶10	0.0008	0.0016	0.0068	0.0069	0.0003	0.3200
5⟶4*	0.3998	0.3937	0.3879	0.3896	0.3996	0.4500	9⟶14	0.058	0.0595	0.0628	0.0629	0.0587	0.3200
4⟶7	0.063	0.0441	0.0362	0.0516	0.0735	0.5500	11⟶10	0.0917	0.0893	0.084	0.0839	0.0906	0.1200
4⟶9	0.0774	0.0721	0.071	0.0759	0.0809	0.3200	12⟶13	0.0244	0.0241	0.0234	0.0234	0.0243	0.1200
5⟶6	0.1238	0.1152	0.1229	0.1351	0.1346	0.4500	13⟶14	0.093	0.0915	0.0881	0.0881	0.0924	0.1200

*Solved problem of lines overload

Overall, FA outperforms the other algorithms in terms of minimizing the objective function for the 14-bus IEEE system after 100 iterations. However, it is important to note that the performance of these algorithms can be affected by the initial parameter values and stopping criteria used, so the results may vary depending on these factors. In Table 5 of the simulation results, all of the line overloads for the five metaheuristic algorithms have been eliminated.

Table 4. Results of economic dispatch with lines overload (LSF = 1.2).

IEEE 14 Bus System	GA	FA	ABC	PSO	ACO
PG1 (MW)	136.37	128.46	155.286	130.92	117.3557
PG2 (MW)	44.50	35.62	42.3297	35.87	47.6234
PG3 (MW)	77.49	72.04	83.2422	72.82	74.0549
PG4 (MW)	41.08	54.94	26.9137	52.49	53.618
PG5 (MW)	17.27	25.08	10	24.14	23.2172
Total generation	316.712	316.1397	317.7717	316.2463	315.8692
Real load (MW)	310.8	310.8	310.8	310.8	310.8
Real loss (MW)	5.912	5.3397	6.9717	5.4463	5.0692
Fuel cost ($/hr)	1114.6634	1094.4405	1148.7644	1096.2605	1107.5641
Constraint 1,2,3	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
Constraint 4 Overloaded lines	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied

Table 5. Results of classic economic dispatch with lines overload

Lines	GA	FA	ABC	PSO	ACO	Line Limit	Lines	GA	FA	ABC	PSO	ACO	Line Limit
1⟶2	0.8904	0.8647	1.0089	0.8788	0.7672	1.200	6⟶11	0.1469	0.1642	0.1288	0.1606	0.1634	0.1800
1⟶5	0.4732	0.4200	0.5440	0.4304	0.4064	0.6500	6⟶12	0.1024	0.1045	0.1003	0.1041	0.1044	0.3200
2⟶3	0.3601	0.3600	0.3552	0.3600	0.3563	0.3600	6⟶13	0.2449	0.2538	0.2357	0.2519	0.2534	0.3200
2⟶4	0.4030	0.3468	0.4519	0.3548	0.3600	0.6500	8⟶7	0.1727	0.2508	0.1	0.2414	0.2322	0.3200
2⟶5	0.2983	0.2407	0.347	0.2489	0.2565	0.5000	7⟶9	0.3165	0.3180	0.3172	0.319	0.3143	0.3200
4⟶3	0.0015	0.0562	0.0513	0.0484	0.0396	0.6500	9⟶10	0.0065	0.0102	0.0242	0.0068	0.0095	0.3200
5⟶4	0.4463	0.4498	0.4485	0.449	0.4401	0.4500	9⟶14	0.0749	0.0644	0.0859	0.0665	0.0649	0.3200
4⟶7	0.1406	0.0658	0.2124	0.0762	0.0804	0.5500	11⟶10	0.1025	0.1195	0.0847	0.1160	0.1187	0.1200
4⟶9	0.1152	0.0874	0.1423	0.0915	0.0921	0.3200	12⟶13	0.0280	0.0300	0.0259	0.0296	0.0299	0.1200
5⟶6	0.2030	0.1001	0.3076	0.1175	0.1113	0.4500	13⟶14	0.1067	0.1173	0.0956	0.1152	0.1169	0.1200

5. HYBRIDIZATION OF ANT SYSTEM-GENETIC ALGORITHM [23], [24]

The ant system-genetic algorithm hybrid (H-ASGA) combines the advantages of two commonly used optimization algorithms to improve the efficiency of searching for optimal solutions. This method uses ant colonies to construct candidate solutions using meta-heuristics rules and pheromone trails left by other ants. Then, the genetic algorithm is applied to the candidate solutions to perform selection, crossover, and mutation operations to generate even better solutions. These new solutions are then provided to the ants to further explore the search space. Thus, H-ASGA is a powerful and effective method for solving optimization problems by combining the advantages of both algorithms. The steps involved in this algorithm are as follows [25], [26]:

- Step 1: Initialize the population: generate a set of random solutions for the genetic algorithm (GA). Set up the initial pheromone values for the ant colony optimization (ACO) algorithm.
- Step 2: Evaluate fitness: utilise a fitness function to determine each population member's level of fitness. f(PG), where PG(Real power generation) is the solution.
- Step 3:Update pheromones: update the pheromone values based on the fitness of the solutions found by the ants using the following formula:

$$\tau(i,j) = (1 - \rho)\,\tau(i,j) + \Delta\tau(i,j) \tag{9}$$

were
τ(i,j): is the pheromone value on edge (i,j)
ρ : is the pheromone evaporation rate
Δτ(i,j) : is the amount of pheromone deposited by an ant on edge (i,j)

- Step 4:Select parents: use selection techniques to choose the fittest individuals from the population to be parents for the next generation. This can be done using the fitness proportional selection method, where the chance of picking a person is related to how fit they are.
- Step 5: Apply genetic operators: apply genetic operators, such as crossover and mutation, to the selected parents to generate new offspring for the next generation. This can be done using the following formulas:

$$\begin{cases} Offspring1 = Parent1 + \alpha\,(Parent2 - Parent1) \\ Offspring2 = Parent2 + \alpha\,(Parent1 - Parent2) \end{cases} \tag{10}$$

where α is the crossover parameter.
Step 6: Apply local search: Apply a local search algorithm, such as hill climbing or simulated annealing, to refine the solutions found by the GA. This can be done using the following formula:

$$x' = min\, f(x + \delta) \tag{11}$$

were,
x' is the current solution, δ is a small perturbation,
"min" finds the solution with the smallest fitness.

- Step 7: Combine solutions: combine the solutions found by both the ACO and GA algorithms to create a hybrid solution. This can be done using a weighting factor, where the hybrid solution is a linear combination of the two solutions:

$$Hybrid\ solution = \omega * ACO\ solution + (1 - \omega) * GA\ solution \tag{12}$$

where ω is the weighting factor.

- Step 8: Evaluate fitness: evaluate the fitness of the hybrid solution using the fitness function.
- Step 9: Update pheromones: update the pheromone values based on the fitness of the hybrid solution using the formula from step 3.
- Step 10: Repeat: repeat the process from step 4 until a satisfactory solution is found, or until a predetermined stopping criterion is met.

The proposed idea and method have also been tested on IEEE 14-bus systems. The system was simulated using the following scenarios [27]:

- Case 1: The original data, but with the load-scaling factor applied LSF=1.2
- Case 2: The original data, but with the power limit of the lines:
  L1-2 reduced from 1.2 to 0.8 pu
  L4-5 reduced from 0.45 to 0.3 pu
  L6-13 reduced from 0.32 to 0.2 pu
- Case 3: The initial data with a line outage L1-5;
- Case 4: The original data including outage of line L1-2;

In power systems, the economic dispatch (ED) model is used to optimize the allocation of power generation resources, such as generators, to meet the electricity demand while minimizing the cost of production. Violations can occur when the power generation exceeds the transmission capacity or violates other operational constraints. Therefore, the ED model with ant system-genetic algorithm hybrid can be used to adjust the generators' output to prevent such violations. The results of the adjustments made using the ED model are presented in Table 6.

In the context of the IEEE 14-bus network, the hybridization of ACO and GA has shown promising results. These results demonstrate how the ED model can successfully optimize the allocation of power generation resources and prevent any operational violations, leading to a more efficient and cost-effective power system. One study found that the hybrid approach outperformed both ACO and GA individually in terms of convergence rate and solution quality, the hybrid approach was able to find multiple optimal solutions, which is important in power system analysis where there may be multiple optimal solutions.

Table 6. Results H-ASGA of economic dispatch with lines overload

IEEE 14 Bus System	Case 1	Case 2	Case 3	Case 4
PG1 (MW)	129.05	78.3739	93.289	52.3651
PG2 (MW)	33.61	73.4122	31.2652	93.5825
PG3 (MW)	71.46	64.9058	53.727	44.0837
PG4 (MW)	55.87	22.1545	55.097	40.6134
PG5 (MW)	26.13	23.6405	29.9899	32.0005
Total generation	316.125	262.4869	263.3681	262.6452
Real load (MW)	310.8	259.0000	259.0000	259.0000
Real loss (MW)	5.3254	3.4869	4.3681	3.6452
Fuel cost ($/hr)	1092.8796	891.7594	842.0107	864.9385
Constraint 1,2,3	Satisfied	Satisfied	Satisfied	Satisfied
Constraint 4 Overloaded lines	Satisfied	Satisfied	Satisfied	Satisfied

6. CONCLUSION

This article demonstrated a new optimization approach, without taking into account the lines overload. The performance of the proposed methods (GA, FA, ABC, ACO, and PSO) was compared to that of recently published optimization techniques, and it was found that the proposed methods achieved better results. The results showed that the H-ASGA hybrid approach provided more diverse, efficient, and faster solutions than pure ACO or GA approaches; his advantage also lies not only within the best production cost but also in reliability and speed of execution.

This Paper also discussed and gave a solution for violation of an unavoidable constraint of overloading transmission lines. When line overload limits are taken into account, optimal load-flow calculations become a potent and practically useful tool for the operation and design of the system. The OPF technique is flexible enough to accommodate a number of different limitations. The application of this algorithm can lead to more efficient and cost-effective operation of electrical networks. In order for the OPF to accurately depict ideal performance in real-world situations, there are still several obstacles to overcome in its development.

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