The comparation of the results of GA to combinational GA in the optimization problems

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Abstract: The application of coded design variables instead of real variables is the combination possibility with other optimization methods, the plurality of the number of evaluations, the independency of this method from the problem design space and using some searching points at the same time are the unique characteristics of this method. One of the limitations of this method is exact identification of the optimized point in answer space. In this paper, to increase the ability of genetic algorithm method, Hook-Jeeves method as one of the direct searching methods of Hillclimber is used. To combine with genetics algorithm and the results of this combination regarding the optimization of operation of an assumed water distribution system, it was compared with pure genetic algorithm and the accuracy of the answers was evaluated. In all the cases, combinational genetics presented acceptable results and the results of pure genetics algorithm were improved to more than 2.8%.

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Introduction

Considering the important role of water systems in fulfilling the agricultural, industrial requirements and the production of water electricity energy and aquatic creatures culture, etc, the importance of optimized operation of these systems such that besides maximum fulfillment of the requirements, the minimum damages of water distribution are revealed.

Here, using suitable optimization methods besides high accuracy have good calculation speed are necessary. Genetics algorithm based on some unique characteristics such as using some searching pints at the same time and high calculation speed in finding convergence path, is a good choice to use in optimization issues. Genetic algorithms act as the following periodical method: at first randomly a population of chromosomes is created and their fitness is calculated. In the following, by cross over and mutation operators, a new society with high fitness values is produced. Replication of one load hoop creates a generation. In each hoop, the previous community is ignored and instead of it, the new society is evaluated. The first generation is selected randomly and then considering the fitting of people and existing operators, the society is inclined to the people with high qualification [1, 2, 3]. The only important limitation of this method is the identification of the optimized answer exactly in answer space. It means that after the investigation of the variables of the problem based on objective function, optimized answers space is identified as convergence path in the form of various charts based on the number of investigated generations at a short time but in exact identification of optimized answer, is not highly accurate. To increase the efficiency of the method in this case, a method called Hillclimber and a combinational genetic method is used. Both methods of pure genetic algorithm and combinational genetics algorithm regarding the optimization of operation of an assumed water distribution system with the aim of minimizing the costs of operation are used and relate results are evaluated.

Materials and methods

Modeling

In figure 1 an assumed system consisting of a source and two water reservoirs with various levels are shown. System pumping stage is consisting of two similar pumps 1A, 2B in parallel stages. 1A pump is adjusted based on water level in reservoir A and pump 2B from water level in reservoir B. 3B pump is located in the middle of reservoirs and it is controlled of water level in reservoir B. The providing requirements in the first stage are set in the first stage with peak coefficient 1.7 at 7 and in the second stage with the peak value 1.5 at 18.

If the requirements are provided highly, the amount of transferred water from both reservoirs is done and in case of requirements providing at low level, the water under gravity line is transferred from reservoir A to reservoir B.

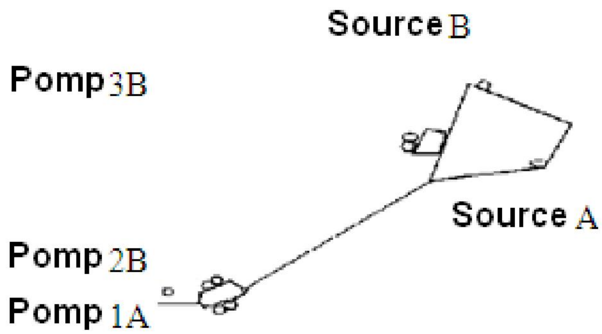

Fig 1: A view of the required system

Constraints

In genetic algorithm method the constraints of each of the variables are introduced in the form of some of functions called penalty and are involved in the calculations of objective function. The required constraints in operation optimization issue of the assumed system are as follows in improving the convergence of the obtained responses as:

The balance between the levels of reservoir water during operation process is of great importance. It means that the initial level of reservoir is similar at the beginning and the end of system performance period. On the other hand, to prevent the increase of the costs of pipes casing, considering a suitable limit in transferring in a 24-hour execution in the proximity of objective function to optimized response plays important role.

The investigated constraints are considered as adding the costs of penalty function to objective function in the calculations that are shown in Equation 1.

Where,

$Pi= A_i(Hsi-H_{Ei})$ $\quad H_{Ei}<H_{si}$

$Pi= 0$ $\quad H_{Ei}>=H_{si}$ ………….. Equation (1)

H_{Si}, H_{Ei}: The height at the beginning and end of simulation period in ith reservoir

Ai: Cross section of reservoir i

Based on equation 1, if the reservoir water at the beginning and end of operation process is in a similar level, H_{Si}-H_{Ei} is zero, or the final water level is at higher level of time period, the considered penalty is zero, otherwise it is increased as A_i (H_{Si}-H_{Ei}) A_i(H_{Si}-H_{Ei}).

Objective function

Generally, in operation optimization problems of water distribution systems, the main objective is creating an optimized level for good providing the requirements and good reservation in the reservoir and minimizing the operation cost. The operation cost or general pumping costs of each device of the variables with periodical simulation in a definite time period were investigated.

Considering the items, the related objective function is shown as:

Obj.Fun: Minimize(C_0=C_E+C_{PP}+C_{RP})...........Equation (2)

Where

C_0 : Objective function, CE : The cost of transferred energy, Cpp : The cost of pumping penalty, CRP: Penalty cost of low level of reservoir that is not used well.

To prevent the mixture of penalty costs of pumping and the penalty of lower reservoir levels and the importance of balance of reservoir levels at the beginning and end of operation period, $(C_{PP}C_{RP})^{1.2}$ is added to the calculations of objective function. When one of two assumed penalties is zero, the general influence of added penalty is ignored in the calculations. Thus, the penalty cost of reservoir level is zero in the calculated time period.

Execution calculations

Sensitivity analysis in using pure genetic algorithm

For operation optimization of the assumed system, by pure genetic algorithm, after consecutive replications, the maximum optimized answers were obtained of the following characteristics:

The probability of crossover and mutation: 0.9 and population size was 35. It means that in the selection of parents stage, after the random selection of the numbers in the range of 0, 1, if the selected number is less than 0.9, the relate chromosome in crossover pond is selected to participate in crossover stage.

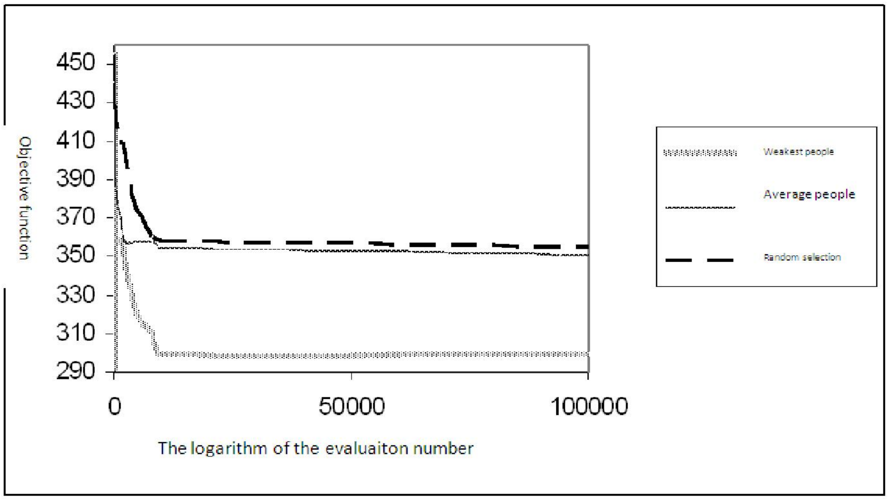

Fig 2: The comparison of replacing people with various values in the new generation

In figure 2, the results of replacing some pure genetic algorithms in three states of weakest, average and optimized random selection based on the number of objective function evaluations is calculated as logarithm scale. As is shown, in three stages, the convergence path of the optimized responses is similar. It means that genetic algorithm started its research from similar random points and finally after some evaluations, the optimized point is identified. It is obvious that by removing and replacing the weakest people of old generation by fittest people in the new generation, the speed to reach the optimized objective function is more than the time the average people or randomly selected people are replaced. Thus, optimization stages of each generation continues by replacing the weakest people of the initial generation by the children produced from the crossover of parents to the stage to reach the optimized answer.

Hook-Jeeves search method

The search by Hook-Jeeves method is one of the direct search methods Hill climber in identification of the optimized values of objective function. It is based on two types of main movement. It means that in each replication, by a new movement that leads into search simplification. In this method, a definite value of the function is selected as a basis and after the identification of the variables and calculation of objective function, the optimization is executed and the amount of optimized parameters are compared with the initial values.

Based on the comparison, the direction and amount of the initial movement is changed gradually. After consecutive replications, the initial movement model with the selected basis amount and finally the optimized value of the variables are identified. This method presented acceptable and reliable results in high calculations in the regions including the variables with small zones and in the calculation of lower limits in the space of variables with big zones. It can be said that if no modification is observed in the optimized parameters after some replications, the initial basis can be reduced to some extent and the operation can be followed by the new selected criterion [4,5].

In figure 3, the convergence by the mentioned method is evaluated during 6000 replications.

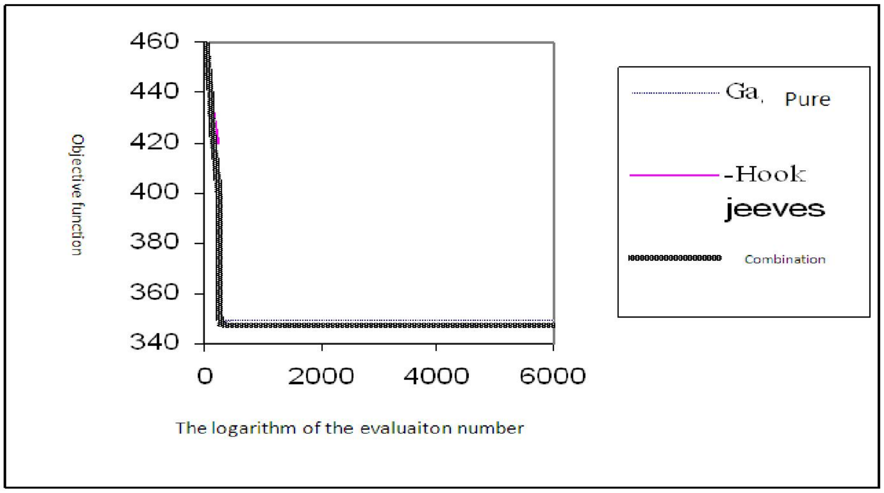

Fig 3: The view of convergence of genetic algorithm by various methods

As is shown in figure 3, although there is no considerable difference between convergence about pure genetic and combinational genetic, the speed to reach the relate convergence about the pure genetic is more than 30000 generations (evaluation) and about the combinational genetic is less than 700 generations. The direct search method Hillclimber with the start from similar points and a short path of optimized convergence, due to the lack of ability in continuing the convergence, by weak responses finish the search. To investigate the effect of the combination method of Hillclimber with pure genetics algorithm done for increasing the ability of this method in finding the optimized pint in optimization problem answer space, for both methods, pure genetic algorithm and combinational genetic algorithm were done and relate results were evaluated in Table 1.

Table 1: The comparison of the results of pure genetic algorithm and combinational genetic

Number	**The results of performance**		**The number of evaluations to reach the optimization with 0.5% of the genetic algorithm answers**	
Performance	Pure genetics after 100000 evaluations	Crossover genetics after 6000 evaluations	Pure genetics	Crossover genetic
1	347.71	347.1	2451	616
2	354.2	352.06	1957	1621
3	352.08	352.15	307	307
4	344.71	344.43	3695	1516
5	344.67	344.81	2045	785
6	364.94	354.79	2413	1345
7	344.19	344.74	14197	2212
Average	350.36	348.58	3866	1200

As is shown in Table 1, the results of pure genetic algorithm is ranging between 344.19, 364.94. In the combinational method, the farthest response to the optimized amount is 354.79 and the average of fitting is 348.58 and both responses have high fitting amount to the results of pure genetics. Also, the results of crossover method can modify the results of pure genetic algorithm that is observed obviously in the performance No. 6 with 2.8% modifications. The number of function evaluations about the pure genetic is about 307 to14197 and in combination method was ranging between 307, 2111 and this issue shows evidently the speed of evaluation of combination method to the pure method. As the average number of evaluated functions to find the optimization in combination method is less than 1.3 of the number of functions in pure state.

The combination of genetic algorithm issue with direct search method Hillclimber based on trial and error on direct search methods, is done based on combination and transfer criteria and the best result of genetic algorithm was performed by Hillclimber and the required answer was performed again by genetic method. In case of establishing finish criterion, the transfer process is stopped, otherwise, genetic algorithm is repeated again [6]. To investigate the accuracy of the answers of combinational genetics method, the details of some of the results are shown in the form of chart after 7 performance stages.

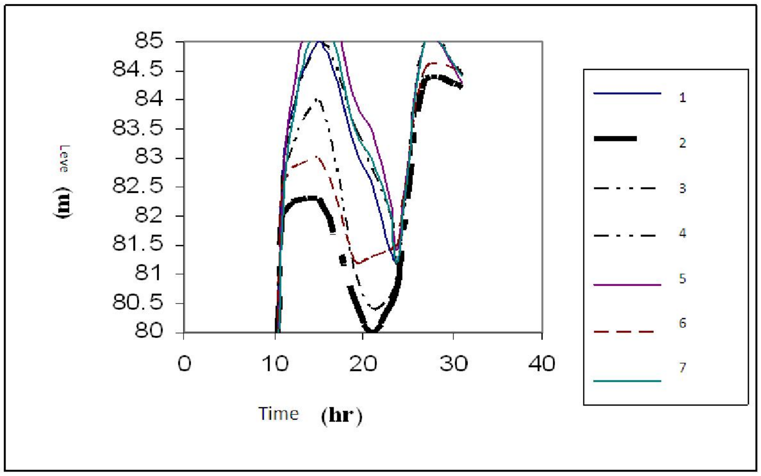

Fig 4: The behavior of reservoir A and pump IA in optimization of operation of the assumed system

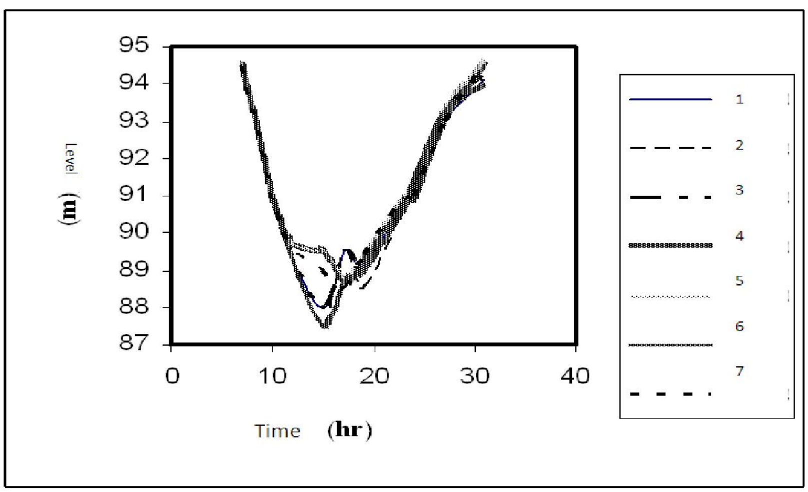

Fig 5: The behavior of reservoir B and pump IB in optimization of operation of the assumed system

In figures 4, 5, storage profiles are drawn about 7 optimization execution based on time and the order of the execution is based on increasing in operation cost. In figure 4, low level of reservoir A during off –peak (23-31) was kept as fixed level and the higher level was used to reduce the height difference between reservoirs A, B. This is done by reducing the transferred water volume from reservoir B to reservoir A by increasing the stored deficit in reservoir A. thus, the deficit water volume is pumped to the higher height and finally operation cost is reduced considerably [7]. In performances 1, 2, 4, 5, this method was used and as is shown in the figures, the least cost is relate to these items. The level of both reservoirs can be at minimum during peak hours (-23hour) and then follow up during Off-peak to increase the level of reservoir and reduce the relate costs considerably. In performance 2, this method was used. Performances 3, 6 are obtained from the combination of the over mentioned methods.

Conclusion

Genetic algorithm is one of the powerful methods in optimization problem and one of the advantages is some items as the application of coded design variables instead of real variables, the combination with other optimization methods, the plurality of the number of evaluations, the independency of this method from the problem design space and using some searching points at the same time. The only limitation of this study is exact identification of the optimized point in answer space that is combined with Hook-Jeeves method as direct search methods Hillclimber. Some of the optimized answers can be modified. In this paper, after establishing the required conditions to combine with the mentioned methods, the combinational genetic algorithm flowchart is explained and it is used in optimization of operation from an assumed water distribution system to make the pumping costs minimum. To investigate the efficiency of combination genetic method, the obtained optimized answers about pure genetic and combination genetic were evaluated in the form of tables and charts. Combination genetic besides facilitating in finding convergence path increased the accuracy of the required answers more such that the weakest responses of pure genetic were modified more than 2.8% in combination method.

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