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Water Delivery Optimization Program, of Jiroft Dam Irrigation Networks by Using Genetic Algorithm

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Abstract

Water is the most important critical liquid for living. With the population increases and human's need ever-increasing to water supply. The optimum use of water sources at the irrigation networks is needed. One of the effective factors in operation from irrigation networks, to achieve suitable efficiency at the project level, is water delivery program. In addition to time of exploitation from channels, water delivery scheduling is considers too, because while designing it the type of water delivery plan effects on construction size, channel capacity, and finally construction cost. For the reason that traditional optimization methods for water delivery had many limitations, therefore, genetic algorithm method was used for optimization. That has a numerical optimization method with search ability of specific maximum or minimum parameters index to remove these limitations. In this research, Jiroft irrigation network has been considered. The distribution channels embranchment located random in different irrigation blocks, and obtained the best discharge of each embranchment and complete time of irrigation plan by genetic algorithm parameters. The results shows the best irrigation plan with different objectives supply, are the reduction of water distribution channel capacity to embranchments, the reduction of necessary time for watering plan fulfillment and the reduction of time waste in each irrigation period.

Keywords: *water delivery plan, Jiroft irrigation network, genetic algorithm, irrigation blocks.*

1 Introduction

The management method of network irrigation or the water delivery method to the farm basins depend on three parameters such as: delivery stream discharge, water delivery duration (Fr), and water delivery period in each irrigation term. These three parameters specify the water delivery program to the farm and finally exploitation network of irrigation. These parameters obtain by water suppliers at the beginning farming season, therefore the water delivery methods are created based on demand and rotational methods. Since the low efficiency and high water consumption at irrigation networks usually depend on the farmers and lack of facilities, but not to ignore network management support in this work [1]. Practically, the determination of exploitation index and physical system plan of the network has a direct effect on exploitation management and water delivery method to the farmers [2]. To solving this problem, for locating irrigation embranchment in different blocks that cause to change distributive canal capacity and time variable for completing irrigation program, we have to create optimization program. For this reason, an irrigation optimum program with using different blocks in Jiroft Dam irrigation network were used, by genetic algorithm that obtained a good results [3].

2 Genetic Algorithms (GA)

The GA technique can be considered as an optimization tool that can approximately identify an optimum solution reasonably quickly. The GA technique is one of the more efficient techniques to handle the “harder-to optimize” problems, especially those involving large numbers of unknowns. Irrigation water order scheduling is one such problem, because of the huge number of possible schedule plans and the complicated way that irrigation systems would respond to different schedule plans. It should be pointed out that, in general, GA optimization still requires a large number of evaluations of solutions [4]. Genetic algorithms are one of the more recently developed optimization techniques. They are based on an analogy of the biological processes of “survival of the fittest” and adaptation. Genetic algorithms search among a population of points (solutions) simultaneously, work with a coding of the variable set and use probabilistic transition rules. A population of m points (solutions) is chosen initially at random in the solution space. The objective function values are calculated at all points and compared. From these m points, two points are selected randomly, giving better points higher chances of success. The two selected points are subsequently used to generate a new point in a certain random manner with occasionally added random disturbance. This is repeated until m new points are generated. The generated populations of points are expected to be more concentrated in the vicinity of optima than the original points.

The new population of points can be used again to generate another one and so on, yielding points more and more concentrated in the vicinity of the optima.. A GA optimization run can be terminated when it has reached a specified number of evaluations of solutions or satisfied some kind of convergence criterion. The best solution found in any GA run cannot be guaranteed to be the absolute optimum solution, but when tested properly for a particular optimization problem, may be considered to be a good approximation to the optimum solution [6].

3 Components of Genetic Algorithms

Standard genetic algorithms involve three basic functions: selection, crossover, and mutation. Each function is briefly described below.

3.1 Selection – Individuals in a population are selected for reproduction according to their fitness values. In biology, fitness is the number of offspring that survive to reproduce. Given a population consisting of individuals identified by their chromosomes, selecting two chromosomes as parents to reproduce offspring is guided by a probability rule that the higher the fitness an individual has, the more likely the individual is selected. There are many selection methods available including weighted roulette wheel, sorting schemes, proportionate reproduction, and tournament selection.

3.2 Crossover - Selected parents reproduce the offspring by performing a crossover operation on the chromosomes (cut and splice pieces of one parent to those of another). In nature, crossover implies two parents exchange parts of their corresponding chromosomes. In genetic algorithms, crossover operation makes two strings swap their partial strings. Since more fit individuals have a higher probability of producing offspring than less fit ones, the new population will possess on average an improved fitness. The basic crossover is a one-point crossover. Two selected strings create two offspring strings by swapping the partial strings, which are cut by one randomly sampled breakpoint along the chromosome. The one-point crossover can be easily extended to *k*-point crossover. It randomly samples *k* breakpoints on chromosomes and then exchanges every second corresponding segments of two parent strings.

3.3 Mutation - Mutation is an insurance policy against lost bits. It works on the level of string bits by randomly altering a bit value. With small probability, it randomly selects one bit on a chromosome then inverts the bit from 0 to 1 or vice versa. The operation is designed to prevent GA from premature termination, namely converging to a solution too early [5].

4 Materials and methods

Despite the fact that arrangement of suitable irrigation program for irrigation network is one of the most factors to improve network efficiency. In this research the purpose is optimum water distribution improvement, by using cultivated area products in the network. For this reason, the program presented that can obtain unsure water needs by using this parameters, considerable area, products type, their cultivated area products. Then consider this water needs as input in target function for presentation of a complete irrigation program. By running genetic algorithm, the most optimum distribution channel discharge, and complete period of irrigation program, which is the least distribution channel capacity and period were calculated. This program is useful for different scheduling agricultural estate, and for presentation of water distribution program in the network. We used the seasons which have more water needs, and according to the agricultural products water needs in service lines. The discharge distribution in the main channel performs. With the best irrigation program the service lines time table for basin to decrease. Distribution channel discharge which is simultaneous irrigation, and reduce the irrigation program period based on genetic algorithm function.

5 Target function

In the presented program need a target function for improvement irrigation program that can reduce the time of main channel discharge, and irrigation fulfillment. In this research according to agricultural estate products, and the type of products, the program will obtained automatically the irrigation unsure water needs of service lines, and to give the best irrigation program. So the target function must be written that optimize these objectives together, and at the same time.

For comparison of water delivery programs and achievement to the best choice, the target function presented as one condemnation and two condemnations. In first case the maximum reduction of distribution channel capacity during irrigation period, and in second case, the previous value reduction and period reduction for irrigation program fulfillment at the same time were used. Since the important part of irrigation project in optimum operation forms the networks is the need period reduction for irrigation program fulfillment.

So in this research two condition target function were used as follow:

$$FF = \min\left\{\max\left(\sum_{i=1}^{n}\left(\left(\frac{a(i)}{x(i)}\times x(i+n)\right)_1,\dots,\left(\frac{a(i)}{x(i)}\times x(i+n)\right)_b\right)+\sum_{j=1}^{t}\sum_{i=1}^{n}\sum_{k=1}^{b}\left(\left(x(i)\times x(i+n)\right)_n\right)_t\right)\right\}$$

(1-1)

a= water needs of service lines irrigation.

b= number of blocks.

n= number of irrigation network service lines.

t = obtained maximum time of irrigation from the first sentence.

Form the above target function it can be conclude, that to obtain the best irrigation program that cover all agricultural estate products of irrigation network service lines, and can obtained the water need of service line irrigation from different time table, based on area condition. According to this function the best irrigation model is irrigation time table, distribution channel, maximum discharge and maximum time of irrigation program fulfillment of the irrigation networks. Different irrigation blocks can be used in this equation; these blocks are simultaneous irrigation of service lines in the network. The target function locates the considerable service lines in different blocks that present the best irrigation model. Notice that in this model the irrigation program fulfillment time should not be more than irrigation frequency time table (Fr).

6 Results and discussion

To have the best irrigation program in a network, we have to choose the correct parameters, which may warranty the optimum used of the water in the minimum time table. In this research Jiroft irrigation network were consider as a case study area, according to the last consideration and study on Jiroft irrigation network, the agricultural estate products has the best service line capacity, to reduce distribution channel and fulfillment time of irrigation program. For the reason of service line capacity should not to be more than maximum capacity of distribution channel, the special coming program is presented which can optimize and design the water channels in the irrigation network, based on different agricultural estate products simultaneously. So, the distribution channels named mc, pc_1, pc_2 in Jiroft irrigation network with 33 service lines were study, and the service lines capacity obtained by different products. The planning and optimization at irrigation network should improve on maximum irrigation needs for the agricultural estate products in the network, until that the products which need more water not to have irrigation stress. While the maximum need of water for all products in Jiroft irrigation networks such as Citrous fruits**,** grass, grains, corns, and summer crops, is about last week of the March, the maximum irrigation need for different products occurs in this time, so this planning perfumed based on this week. The maximum water irrigation need for the agricultural estate products have used from water national document and penman-mantis method. Table (1) and (2) show the agricultural estate products in Jiroft irrigation network and unsure water needs of agricultural estate products level of service line respectively.

According to the presented model, the above mentioned conditions performed for 13 irrigation blocks (13 branches irrigated simultaneously). Fig. (1) shows the best diagram of target function value against the generation numbers.

Table 1: The agricultural estate products at Jiroft irrigation network.

Summer products (ha)	Grains (ha)	Grass (ha)	Citrous fruits(ha)	Service line name
-	-	10	25	MC-to1
-	-	15	32	MC-to2
-	-	37	60	MC-to3
-	-	8	9	MC-to4
-	25	-	25	MC-to5
20	80	20	150	MC-PC2-L1
-	121	-	121	MC-PC1-to1
-	117	-	115	PC1-to2
-	-	5	41	PC1-to3
-	-	-	16	PC1-to4
13	-	-	4	PC1-to5
5	-	23	7	PC1-to6
40	-	30	90	PC1-to7
4	-	-	7	PC1-to8
-	-	-	60	PC1-to9
-	-	11	56	PC1-to10
4	-	-	14	PC1-to11
-	-	30	38	PC1-to12
-	-	33	20	PC1-to13
-	-	39	38	PC1-to14
-	-	39	24	PC1-to15
-	-	14	21	PC1-to16
45	-	55	26	PC1-to17
-	30	23	34	PC1-to18
-	-	28	26	PC1-to19
-	-	12	20	PC1-to20
15	15	-	10	PC1-to21
-	34	30	19	PC1-to22
-	-	21	10	PC1-to23
-	26	30	19	PC1-to24
-	50	17	13	PC1-to25
-	15	-	18	PC1-to26
-	30	-	26	PC1-to27
146	543	530	1194	cumulative

Table 2: The irrigation unsure water needs of service line agricultural estate products..

Gross irrigation requirement (m3/10 Days)	Service line No.
18800	MC-to1
25560	MC-to2
53960	MC-to3
9760	MC-to4
15750	MC-to5
111000	MC-PC2-L1
76230	MC-PC1-to1
72750	PC1-to2
23080	PC1-to3
7680	PC1-to4
10630	PC1-to5
22350	PC1-to6
90400	PC1-to7
6040	PC1-to8
28800	PC1-to9
34360	PC1-to10
9400	PC1-to11
38640	PC1-to12
32040	PC1-to13
44760	PC1-to14
38040	PC1-to15
19600	PC1-to16
80030	PC1-to17
36460	PC1-to18
31520	PC1-to19
17760	PC1-to20
17100	PC1-to21
34620	PC1-to22
19080	PC1-to23
33420	PC1-to24
25300	PC1-to25
10890	PC1-to26
16980	PC1-to27
112790	cumulative

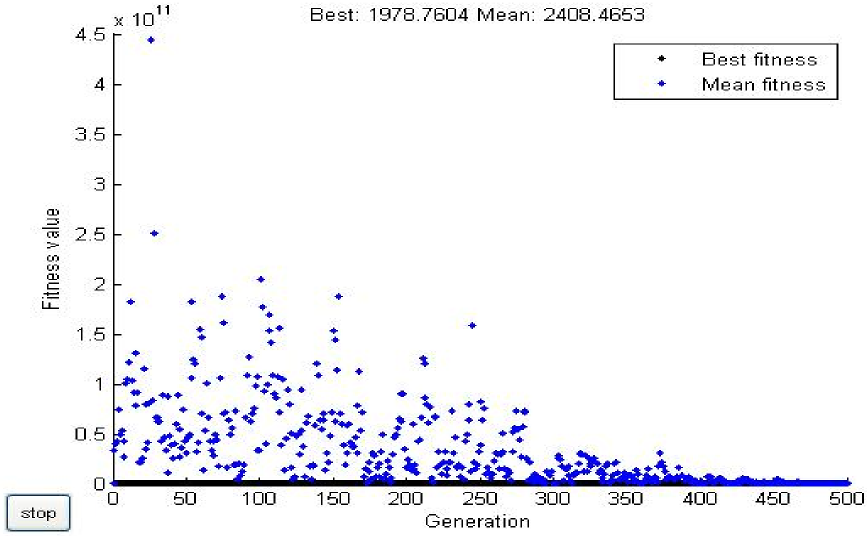

Fig. 1: The best target function valve against 500 generations for 13 irrigation blocks.

According to fig. (1), the best target function value became 1978.76 that show the total maximum distributive channel discharge, maximum fulfillment time of irrigation program, and target function penalty, that we find out the best response. It shows that the main channel maximum discharge and irrigation maximum time.

Table 3: The obtained parameters from the program for 13 irrigation blocks.

Number of block	Max discharge of main channel	Irrigation maximum time (hour)
13	1474	238

Based on the values in table (3) the fulfillment time of irrigation program is 238 hours which is lower than regular time needed for agricultural products (240 hr). Fig (2) also shows the situation hydrograph of opening valve for 13 blocks.

In fig. (2) the maximum capacity of distributive channel is conducted during irrigation periods. Therefore, based on this hydrograph, the opening valve situation numbers are 30, that we can have special program for distributive irrigation at the network.

Table (4) shows the service lines capacity and irrigation periods, whit 13 branches from the total branches, irrigate simultaneously, because of the time interval among each branch to the head of main channel, there is slight delay at the beginning time. Fig (3) shows the water delivery time table.

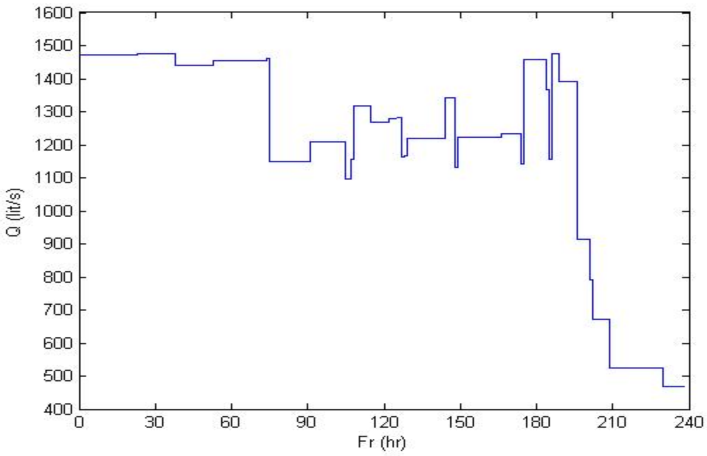

Fig. 2 The situation hydrograph of opening valve for 13 blocks.

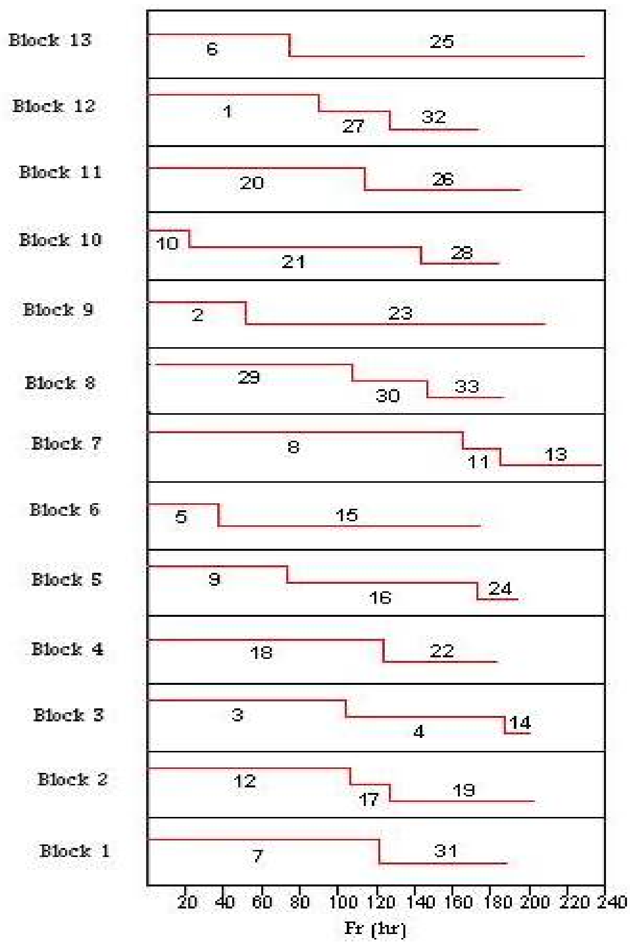

Fig. 3 Diagram of water delivery time table to branches for 13 block cases.

Table 4: Embranchment capacity and their irrigation period based on considerable program.

End time of irrigation	Start time of irrigation	Deliver y period (Hr)	Branch capacity (lit/s)	Branch	No
90.51	0.04	90/47	56.10	MC-to1	1
52.89	0.46	52/43	132.25	MC-to2	2
104.79	0.68	104.11	142.08	MC-to3	3
83.99	0.85	83.14	30	MC-to4	4
38.91	1.05	37.86	88.93	MC-to5	5
74.69	0.45	74.24	367.74	MC-PC2-L1	6
123.23	1.25	121.98	72.83	MC-PC1-to1	7
166.56	1.37	165.19	138.82	PC1-to2	8
75.74	2.04	73.7	82.19	PC1-to3	9
25.15	2.51	22.64	87.34	PC1-to4	10
22.93	2.85	20.08	150	PC1-to5	11
109.92	3.65	106.27	60	PC1-to6	12
56.84	3.80	53.04	469.11	PC1-to7	13
17.5	3.80	13.7	120	PC1-to8	14
141.54	4	137.54	53.92	PC1-to9	15
104.92	4.12	100.8	90	PC1-to10	16
25.09	4.23	20.86	120	PC1-to11	17
129.36	4.40	124.96	85.26	PC1-to12	18
79.36	4.55	74.81	120	PC1-to13	19
118.85	4.67	114.18	108.97	PC1-to14	20
125.99	4.91	121.08	88.46	PC1-to15	21
64.6	4.98	59.62	90	PC1-to16	22
161.41	5.04	156.37	146.52	PC1-to17	23
26.94	5.23	21.71	419.25	PC1-to18	24
161.28	5.32	155.96	56.26	PC1-to19	25
86.51	5.45	81.06	59.89	PC1-to20	26
43.47	5.85	37.62	115.014	PC1-to21	27
47.31	6	41.31	210	PC1-to22	28
113.72	6.23	107.49	50.29	PC1-to23	29
47.44	6.56	40.88	210.26	PC1-to24	30
73.8	6.77	67.03	82.63	PC1-to25	31
53.1	6.97	46.13	51.84	PC1-to26	32
46.56	7.08	39.48	89.84	PC1-to27	33

7 Conclusion

The obtained results indicate that the genetic algorithm method is useful for water distribution problem in irrigation channels, that can optimize some different objectives and the max time for irrigation fulfillment obtained during agricultural season for all products, so we have to present a time table program for it.

Because, there is high costs for water channel building in irrigation network, the harmony between service line capacities with agricultural estate products level have higher priority degree. The parameters in this program are useful in improvement of water channel planning based on regional conditions for future, the agricultural estate products optimization, with irrigation time table and scheduling are the most important advantages of this program.

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