Research Paper Engineering

Literature Review On Canal Irrigation Scheduling Using Ga

* Kalpesh Kumar A. Parmar, ** Patel Nimisha G.

*,** W.R.M, L. D. College of Engineering, Ahmedabad

ABSTRACT

Water is becoming a scarce resource as a result of the growing demand in various purposes such as hydropower, irrigation, and water supply etc. Canal irrigation scheduling is an important activity that significantly influences production of crops compared to other aspects of agriculture. Irrigation canal scheduling is the activity of preparing an optimal schedule of outlets on supply canal as per need of user, subject to canal system constraints. In this paper, the problem of canal irrigation scheduling with provision to open some outlet at specific time slot as per request of user using GA(Genetic Algorithm) is presented.

Keywords : canal, canal irrigation, Soil moisture. GA, integer programming.

The irrigation canal scheduling problem is the problem of preparing an operation schedule of outlets on the distributaries canal subject to certain constraints. In

Irrigation project water distribution i.e. conveyance of water from the source to the field head is the most important link between the supplier of water and farmers who actually put the water to use. If the water distribution is well operated, high returns can be obtained from irrigation project. There are two types of water

distribution methods. (i) Flexible method and (ii) rigid method.

In flexible method, water is supplied on demand of user and may be continuous during entire base period of crops. In case of rigid method, supply is fixed at constant frequency with constant or varied amount.

Rotational water distribution in irrigation project is a common practice throughout the world, which fall under category of rigid method. The supply is rotational among individual users in an outlet command area, among outlets on a distributaries canal and among different distributaries on main canal. Frequency of irrigation in command area is based on the soil-crop-climate conditions. The operational schedule of rotation delivery for distributaries is prepared considering its capacity, number of outlets on distributaries, their duration of supply and rotation period. In most of the irrigation projects, cropping pattern is changed with time due to which the outlets discharge is changed and there is a need to reschedule the operation of distributaries before each rotation.

Wang et al. (1995) identified a minor shortcoming in the formulation of objective function by Suryavanshi and Reddy (1986), which is that, the model minimizes the sum of all Xij and not the total number of stream tubes operating simultaneously. They proposed the sequence of outlets be within a certain group should be decided by the operators according to specific priorities. They developed an improved model by introducing dummy variable called the 'activation function'. For a given sub-channel, the activation function assumes a value of one if that sub channel is used irrespective of whether the sub-channel feeds one or several outlets else the activation function takes a value of zero. The objective function in this model is to minimize the sum of the activation function.

Wardlaw and Bhaktikul (2004) applied the GA approach to canal scheduling using the concept of 0-1 linear programming approach developed by Suryavanshi and Reddy (1986) and Reddy et al. (1999) and demonstrated its efficiency with an example of the Xi Le submain of the Hetao irrigation project, which is situated in the Inner Mongolia region of China.

Genetic algorithm (GA) is heuristic technique for searching over the solution space of a given problem in an attempt to find the best solution or solutions (Forrest,1993).

The use of Genetic algorithm was first proposed in 1975, by Holland (1992), who based his research on Darvin's principle of evolution. Inspired by the natural mechanisms of selection and reproduction, Holland created an 'intelligent' form of a random search that explore the solution more promising region and search for solution more intensely in those more promising regions. Since then, GAs has been applied to a variety of problem.

The GAs technique has its roots in the biological processes of 'survival of the fittest' and adaptation. Genetic algorithms are applicable to a variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, on differentiable, stochastic, or highly nonlinear.

GA manipulates a string of numbers in a manner similar to how chromosomes are changed in biological evolution. An initial population made up of strings of numbers may be chosen at random or may be specified. Each number slot is called a gene and an individual string of numbers is called a chromosome. A set of chromosomes forms a population. Each chromosome represents a given number of traits which are the actual parameters that are being varied to optimize the fitness function.

The fitness function is a performance index that we seek to maximize or minimize. The GA search starts from a population of many points rather than starting from one point as is the case in standard optimization algorithm. This parallelism means that the search will not become trapped on local optima. Genetic algorithms manipulate decision or control variable representations at a string level to exploit similarities among high-performance strings. This also helps GA based methodology to tackle functions with discontinuity. Performance evaluation of candidate solutions from the population is performed using the fitness function. The fitness function is evaluated using information of objective function. This avoids the necessity of using derivative information. The algorithm begins with random population of individuals in which each individual is represented by a binary or real coded string (chromosome) for one possible solution. Each of the individuals is assigned a fitness using the objective function combined with constraints, if any. The optimal solution is obtained after repetition of generation cycle. The operations used in GA are:

(A) reproduction or selection,

(B) cross-over, and

(C) Mutation.

Following are some advantages of GA compared with other classical optimization methods.

GA work with numerical values and there is no requirement of objective function to be a linear or differentiable function and it can solve problems with discrete decision variables.

GA generates several near optimal solution and they can provide sufficient flexibility in decision making.

GA usually does not get trapped to local optimal solution and they can find a near optimal solution with a high probability.

The formulation for canal scheduling given by Wardlaw and Bhaktikul, (2004) using GA is

$$Minimize\ Z=\sum_{i=1}^{n}\left\{\left[Q-\sum_{j=1}^{m}\left(q_j * ONOFF_{ij}\right)\right]^2+P_i\right\}$$

Where, Q =supply canal capacity (m3/s)

qj = capacity of lateral j (m3/s)

ONOFFij = 1 if outlet canal operates in time period

else it is zero m = number of outlets n = number of time blocks in the rotation period and

Pi= penalty function for canal capacity constraint

The value of ONOFFij is determined from the starting time (Sj) of outlet j as follows.

ONOFFij = 1 If i > Sj & i < (Sj + Dj)

and

ONOFFij= 0 otherwise

Where, Dj = operation duration for outlet j.

Sj = starting time of the outlet j, which is a decision variable of the problem.

Wang et al. (1995) suggested that the operational sequence of outlet within a certain group should be decided by operators on specific priorities. In this GA formulation of optimization problem, starting time (Sj) of the outlets is the decision variable, the lower and upper bound of which are to be specified by irrigation manager during execution of GA program. GA generates several near optimal solutions which give sufficient flexibility in decision making regarding the group formation of various outlets.

If it is required to start the specific outlets at any time slot of rotation period, it can be achieved by specifying their starting time within specified lower and upper bound as per requirement of user.

While preparing the operational schedule of any canal, many times irrigation manager has to consider the time slot demand of user in the rotation period.

We have applied GA for three different assumed situations in which certain canals outlet are opened at specified times as per demand by users. In the first situation it is assumed that upstream group of users i.e. outlet no. 1 to 8 have demanded supply of water in initial period of rotation so, initial sequence of outlets is arranged from the upstream end of the canal by specifying the lower and upper bound value of time slot as 1. In second situation canal outlet no.1, 2, 3, 8, 9, 10, 19, 21 and 25 are assumed to operate in first time slot of rotation period. In third situation outlet no.3, 8, 12, 16, 20, and 25 are specified to start in time slot 195, 140, 242, 104, 72 and 172 respectively.

The result of optimal starting time period of outlet obtained by GA for first, secondly and third situation are denoted by GA1, GA2 and GA3 respectively in table III. The results show that irrigation manager can plan the optimal schedule of canal which satisfies the time slot demand of some users in rotation period.

The inflow hydrograph of Famen secondary canal for proposed sequence of outlets arranged from the downstream end of the canal using IP by Wang Zhi et al. (1995) is shown in fig 1. Canal hydrograph using IP shown in fig.1 indicates that headgate setting is needed at the end of the rotation period to avoid the wastage of water.

The computed inflow hydrograph of the canal in the present paper, as shown in fig.2, 3, and 4 indicate that a small head gate regulation is required at intermediate time within rotation period of canal to avoid wastage of water.

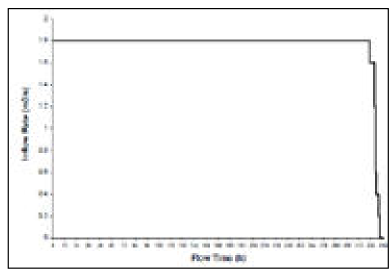

Fig. 1 Canal inflow hydrograph into canal using integer programming (IP).
WANG (1995)

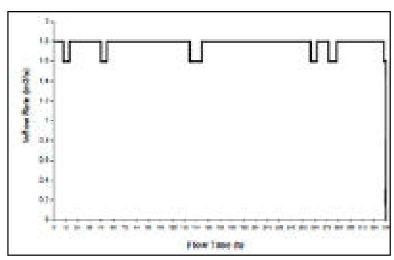

Fig. 2. Computed inflow hydrograph into canal using genetic algorithm (GA 1).

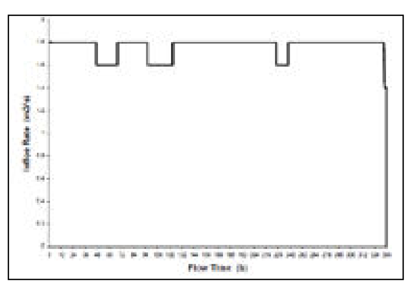

Fig. 3. Computed inflow hydrograph into canal using genetic algorithm (GA 2)

Conclusion

The methodology based on the GA approach to optimal irrigation canal scheduling problem with provision to open some outlet at specific time slot as per request of user. In present formulation, application of GA enables the operator to specify lower and upper bound of starting time of some outlets as requested by the user in rotation period which is not the case of the classical optimization technique like integer programming. GA model could be an efficient tool to irrigation manager for planning water delivery schedule for irrigation canal system as per the time slot demand of user.

Canal system management for delivering required amount of irrigation water at right time is very much depending upon suitable Irrigation Scheduling matching with constraint and flexibility of the canal system. The performances of this system depend on preparation of realistic canal operation plan and its implementation. In order to judge suitability of Irrigation Scheduling options, five options are selected and studied in respect of reference evapo transpiration of various crops in different seasons thereby working out crop water management, Net Irrigation Requirement and Irrigation Demand with canal running time. Crop yield and C.C.A will increase with optimum Irrigation Scheduling also saving water.

REFERENCES

1. Wang Zhi, Reddy J. M, Feyen J, “Improved 0-1 programming model for optimal flow scheduling in irrigation canals.” Irrigation Drainage Systems 9, 1995, pp.105-116. | 2. Wardlaw R. B, and Bhaktikul K, “Comparison of a genetic algorithm and Linear Programming Approach for Lateral Canal Scheduling.” Journal of Irrigation and Drainage Engineering ASCE Vol. 130(4), 2004, pp. 311–317. | 3. Anonymous, (1989). Planning for Prosority-Sardar Sarovar Development plan, Narmada Planning Group,SSNL, Gandhinagar. | 4. Allen, R.G., Jensen, M.E., Wright, J.L., and Burman, R.D., (1989). Operational estimates of evapotranspiration. Agron. J., 81:650-662.