Sewage Control planning Model of Parameter Selection Optimization Simulated Annealing Algorithm

Xiaohui Chen, Wenzhou Yan, Kang Liu

Xi'an University of Architecture and Technology,
Xi'an 710055, Shaanxi, China

Abstract
The application of the standard simulated annealing algorithm (SA) in sewage control plan has some ineffective problems. This paper presents a programming model based on sewage control parameter optimization simulated annealing algorithm. First use advantaged group limited policy and optimal individual replacement policy to optimize the convergence of genetic algorithm. Then use the improved genetic algorithm simulated annealing algorithm to further optimize the population, returning the optimized population to the simulated annealing for algorithm operation as a parent to optimize the parameter selection mechanism of annealing. Finally, use the improved simulated annealing algorithm to construct sewage control programming model. The simulation results show that the parameter optimization simulated annealing algorithm has a better effect on sewage treatment compared with standard SA algorithms and genetic algorithms.
Key words: ANNEALING ALGORITHM, ADVANTAGED GROUPS LIMITATION, OPTIMAL INDIVIDUAL REPLACEMENT, SEWAGE CONTROL, PARAMETER SELECTION MECHANISM

Introduction

With the rapid development of industries and cities, the water was serious polluted with large amount of waste into rivers and lake [1]. In order to eliminate pollution, protect the environment, people contributed to control water pollution by researching into various wastewater treatment technology, putting in a lot of material and financial resources to build sewage treatment plants. However, with the water pollution control engineering development towards depth and breadth, the development and improvement of wastewater treatment technology did not bring significant economic benefits, the sewage treatment costs increase every year [2]. Water pollution control system planning with systems analysis techniques can save a lot of costs, therefore, the foundation and basis of modern water quality to control water pollution is adoption of system planning.

In the past three decades, numerous articles and monographs were published at home and abroad, so that the application of system engineering used in environment problem presented the unprecedented prosperous situation. Canada carried out the optimization management planning of St. John's River Water resources. Hailne S made a multi-objective land use plan towards Momee

River in America [3]. Huang carried out an integrated environment management and planning research to Mackenzie and Niagara rivers in Canada [4] .Chinese scholars studied the international relevant latest theories and methods in many aspects of basin environmental planning, and made progress. Guoru Huang took the water pollution control system of Urumuqi Shuomo river as example, carried out the preliminary study of water pollution control system planning in arid areas[5]. Wei Wang applied simulated annealing algorithm in water pollution control system planning of Xiang Jiang river[6]. Guangming Zeng applied improved genetic algorithm in water pollution control system Multi-objective planning, Not only to overcome the shortcomings of traditional genetic algorithm, but also got simple solving process and rational optimization results [7].Aiming to the Multi-objective, Dynamic and uncertainty of environment system, Huaicheng Guo first presented a fuzzy multiple objective programming method based on uncertainty and interactivity applied in environment programming at different levels, and first combined indeterminacy fuzzy multiple objective programming model (IFMOP) with system dynamic model(SD),formed a complete planning model system [8].Such kind of model takes an important role to solve the environment system programming problem with complex dynamic behavior. With the progress of water pollution control programming in our country, some new concepts and methods welled up, meanwhile, the development of computer technology, system engineering and new calculation method promoted the development of pollution prevention plan, such as the application of graphic information systems[9], Genetic Algorithms [10] improved the work efficiency. From the past to the present, the water pollution control programming in our country has improved gradually, initially formed system, program and method from macro to micro, from theoretical to practical, from planning to practice.

Aiming at the existing defects of simulated annealing algorithm, this paper puts forward sewage control planning model based on the parameter optimization simulated annealing algorithm, and simulation experiment was performed to verify the effectiveness of the improvement strategy.

Defect analysis of simulated annealing algorithm

Simulated annealing algorithm generates a sequence of combinatorial optimization problems solution by Metropolis algorithm, using the transition probabilities with Metropolis criterion:

$$P_k(i \Rightarrow j) = \min\left(1, \exp\left(-\frac{\Delta f}{T_k}\right)\right) \quad (1)$$

To determine whether to accept the transfer from the current solution to the new solutions, formula (1) $\Delta f = f_j - f_i$ is the objective function of the difference between the old and new solutions. T_k is The temperature level of the k iteration, given by:

$$T_k = r^{k-1} T_0 \quad (2)$$

T_0 is the initial temperature, selected by specific condition, the same magnitude as evaluation function value. r is cooling coefficient, usually $(0.90, 0.99)$; T_e is Termination temperature, usually $0.001T_0$.

Simulated annealing algorithm accepts new solutions, based on the Metropolis guidelines, searching in "optimize" direction; and accept the "deterioration" program according to a certain probability, so the algorithm has the ability to escape from local minima in order to obtain a global optimal solution or progressive global optimal solution.

Application of simulated annealing algorithm is widely used, but its argument is difficult to control, the main issues are the following three points:

(1)Set initial value of the temperature T

The initial temperature T setting is an important factor simulated annealing algorithm for global search performance. The initial temperature is high, the possibility of the global optimum solution is big, but has to spend a lot of computing time; On the other hand, you can save computing time, but the global search performance may be affected. In the actual application, the initial temperature generally required several adjustments based on the experimental results.

(2)Annealing rate

Global search performance of simulated annealing algorithm is also closely related to the annealing speed. In general, the "full" search in the same temperature (annealing) is quite necessary, but it takes time to calculate. In practice, reasonable conditions of annealing balance are set based on nature and characteristics of the particular problem.

(3)Temperature management

Temperature management is one of the problems in simulated annealing algorithm. In practical applications, since it is necessary to consider practical computational complexity and other issues, the cooling mode is often as follows:

$$T(t+1) = k \cdot T(t) \quad (3)$$

k is a positive number slightly smaller than the constant 1, t is the number of cooling.

Simulated annealing algorithm also has some shortcomings: (1)In order to avoid falling into the local optimum, simulated annealing use Boltzman mechanism, but at every step of cooling, it is a very time-consuming process to reach equilibrium distribution; (2)The temptation spatial region of simulated annealing is litter, we could not take advantage of the region had been tentatively to guide the search, and it is difficult to judge which area has more opportunities to get the optimal solution. In this sense, simulated annealing is called "random walk."

Simulated annealing algorithm parameters optimization

Convergence optimization based on improved Genetic Algorithm

Genetic algorithm is one of stochastic optimization algorithms. But it is not simply a random comparison search, it effectively uses the information to guide the search to improve the quality of state by the evaluation of chromosomal and the role of genes in chromosome pair. This paper uses advantaged groups limited policy and optimal individual replacement policy to optimize the convergence.

Probability selection method contrary to the laws of biological evolution is adverse to find the optimal solution. In order to improve the average fitness of each generation, we proposed a priorities program of advantage groups. $\overline{f}(t)$ is the average fitness group of $A(t)$, $\overline{f}(t+1)$ is the average fitness group of $A(t+1)$. The algorithm advantaged groups of priority strategy is as follow:

$while\,(\overline{f}(t+1) < \overline{f}(t)\,\&\&\,\overline{f}(t+1)\,!=1)\; do\,\{$

One of the unreplaced individuals with the highest fitness in $A(t)$ replaces one of individuals with the lowest fitness value in $A(t+1)$; recalculate $\overline{f}(t+1)$;

Optimize the average fitness of each generation until the optimum is found.

The reason the best individual replacement strategy is adopted is: in probability selection method, if the individual's fitness value is high, then the probability of next generation groups is naturally higher, but cannot exclude the possibility of being eliminated. The optimal individual replacement policy in this paper—— a particular individual $A_{\min}(t+1)$ with the worst fitness in $t+1$ is replaced by some best individuals $A_{\max}(t)$ in t and $t+1$, then:

$$A'(t+1) = A(t+1) - A_{\min}(t+1) + A_{\max}(t) \quad (4)$$

$$A(t+1) = A'(t+1) \quad (5)$$

Thus, the best individual may retain in the evolution of , at the same time a number of methods is easy to understand with no additional burden.

Simulated annealing algorithm based on improved genetic algorithm

Simulated annealing algorithm based on improved genetic algorithm can be described: optimize initial population by annealing algorithm, and simulated annealing algorithm further optimizes the advanced population from annealing algorithm, then the optimized population returns to the annealing algorithm to anneal as the father population. Genetic simulated annealing algorithm present a high probability of sudden tonal at high temperature, which suggests rough search of population; it presents chemotaxis local search at a low temperature, which suggests fine search of population. This mix is not only mixture of algorithm construction, but complement of search mechanism and evolution thought. This mix is not only mix of algorithm construction, but the complement of search mechanism and evolution thought to solve the complicated optimization problem.

(1)Set control parameter: population size n, initial temperature $T = T_0$, The largest genetic algebra N.

(2)Optimization, temperature update times $l = 0$, generate new initial population $P_l(k)$, $k = 0$.

(3)Operate the existing species, to produce the next generation of population.

1)Calculate the Fitness function $f_l(t_l)$ in population $P_l(k)$, and chose n chromosome form population $P_{ls}(k+1)$ from $P_l(k)$, according to the determined by the adaptive function of probability distribution.

2)Cross the population $P_{ls}(k+1)$ to get population $P_{le1}(k+1)$ according to the conventional method of genetic algorithm, i and j in population $P_{le1}(k+1)$ participating in cross is accepted according the acceptance probability of formula (6) and (7),

After the iteration, choose the new group $P_{le}(k+1)$.

$$p_i = \begin{cases} 1, f(i') \le f(i) \\ \exp(f(i) - f(i'))/t_l, f(i') > f(i) \end{cases} \quad (6)$$

$$p_j = \begin{cases} 1, f(i') \le f(i) \\ \exp(f(j) - f(j'))/t_l, f(j') > f(j) \end{cases} \quad (7)$$

$f(i)$ is the target of i in population $P_{le}(k+1)$, $f(i')$ is the target of i in population $P_{le1}(k+1)$, $f(j')$ is the target of j in population $P_{le1}(k+1)$.

3)Variate $P_{le}(k+1)$ to get $P_{lm1}(k+1)$ according to the conventional method of genetic algorithm, the mutated individuals accept according to the acceptance probability formula (1) to get new population $P_{lm}(k+1)$.

4) $P_i(k)=P_{lm1}(k+1)$, $k=k+1$. Judge whether genetic algebra is maximum, if is so, then go to step (5), else, turn to step (4).

(4)Update temperature $t_{l+1}=d(t_l)$, $P_{l+1}(k)=P_l(k)$, $l=l+1$, $k=0$. If meet the stopping rule, stop counting and output optimal solution; Otherwise to step 1)

(5)Output optimal solution.

In the genetic simulated annealing algorithm, using the Metropolis guideline probability to determine whether to accept data processing, it is a significant feature of simulated annealing. The crossover and mutation operation of algorithm is consistent with the general processing method of genetic algorithm.

The sewage planning control model based on improved simulated annealing algorithm

Deal with the constraint conditions based on infeasible degree concepts, then using improved simulated annealing algorithm to solve the optimization problem for waste water planning control.

(1) The generation of initial population

First use the infeasible degree concept, solution infeasible degree is defined as:

$$\Phi(x_i)=\sum_{j=1}^{J}[\min\{0,g_j(x_i)\}]^2+\sum_{k=1}^{K}[h_k(x_i)]^2 \qquad (8)$$

g_j and h_k is inequality constraints and equality constraints of problems. The infeasible degree is the distance from a solution x_i to the feasible region, the farther from x_i to the feasible region, the greater the infeasible is, whereas the less; When x_i is feasible solution, not feasible degree is zero.

Initial population selection is operated by defining a threshold, determine the solution to be chosen or rejected according to each candidate solution infeasible degree compared with the threshold value. Define thresholds are as follows:

$$\Phi_{crit}=\frac{1}{T}\sum_{i=1}^{pop\_size}\Phi(x_i)/pop\_size \qquad (9)$$

T is an adjustable coefficient, changing from T_{start} to T_{end} with the iteration, pop_size is the population size. Threshold is the product of an adjustable coefficient and average infeasible degree of the current population.

When the infeasible degree of a solution is greater than the threshold, then the solution is rejected, or is accepted and enters to the next generation of genetic operations. In order to ensure the population size is changeless, the rejected is replaced by the solution which has minimal infeasible degree in the current generation.

Specific initial population generation algorithm is as follows:

1) Randomly generated a uniform distribution within the solution space of the population;

2)Calculate the infeasible degree $\Phi(x_i)$ of each solution x_i and the selection threshold of the infeasible degree Φ_{crit} of current generation ;

3)Each solution x_i in the population, if $\Phi(x_i)>\Phi_{crit}$, refuse x_i and is replaced by the infeasible degree minimum solutions, or accept it;

4)If it has already satisfied the requirement of the feasible solution in the initial population proportion (usually is 20 ~ 40%) or has iterated $k_{\max 0}$ times, stop the operation; Otherwise the modify the coefficient T and return to step 2.

(3) Constraints

This article handles the constraints use the concept of infeasible degree.

1)The constraint of sewage treatment capacity

Sewage treatment capacity constraint is the sewage pipe network capacity calculation results must satisfy the continuity equation and energy equation. The continuity equation means for any node the node traffic flow must be equal to the flow from the node. And the energy equation refers the relationship that the head loss sum equal to zero of each ring of each section in the network. The two equations are as follows:

$$\sum q_{ij}+Q_i=0 \qquad (10)$$

The constraint of sewage pipe diameter

Study of sewage pipe network results show that the annular pipe network is replaced by tree pipe network, the economic effect is optimum, but the reliability is the worst. So in order to guarantee the reliability of the sewage treatment, the loop system is normally used. Therefore, it is necessary to constraint the pipe diameter.

Its expression is as follows:

$$D_{i,\max}\ge D_i\ge D_{i,\min} \qquad (12)$$

the sewage flow rate constraints

To prevent sewage coagulation, the flow rate of section must be greater than the minimum flow rate. To reduce the erosion of pipe reduce the possibility of a tube at the same time, speed of flow in the pipe section must be smaller than the maximum velocity:

$$v_{i,\max}\ge v_i\ge v_{i,\min} \qquad (13)$$

By calling the sewage treatment calculation subroutine modules, each individual in the initial population, calculate the infeasible degree of each individual and the selection threshold of infeasible degree of current generation to satisfy the constraint conditions of the population. Optimize the population using the annealing genetic algorithm, the minimum pollution is the optimal solution.

determination of fitness function

In this article, the original fitness uses the linear transformation method. Assume the original fitness is $f = 1/W$, transformed fitness is f'. Linear transformation is as follow:

$$f' = a \times f + b \tag{14}$$

The mean value of the original fitness f_{avg} is equal to the transformed average fitness f'_{avg} to ensure the copy number of individual with the average fitness is expected in the next generation is 1: $f'_{avg} = f_{avg}$;

2)Transforme fitness maximum individual is equal to the specified multiples of original fitness average to control the copy number of the largest fitness individual in the next generation, $f'_{avg} = C \cdot f_{avg}$. Among them, C is the copy number of the best individual expectation. Specify multiple can be between 1.0 ~ 2.0.

To ensure the minimum fitness is nonnegative, a and b are as follow:

$$a = \frac{f_{avg}}{f_{avg} - f_{\min}} \tag{15}$$

$$b = \frac{-f_{\min} f_{avg}}{f_{avg} - f_{\min}} \tag{16}$$

f_{avg} is averages of the original fitness; $f_{\min}$ is the lowest value of the original fitness.

the parameter adjustment of improved algorithm of

The adaptive adjustment p_c and p_m are as the following formula:

$$p_c = \begin{cases} P_{c1} - \dfrac{(P_{c1} - P_{c2})(f' - f_{avg})}{f_{\max} - f_{avg}}, f' \geq f_{avg} \\ P_{c1}, f' < f_{avg} \end{cases} \tag{17}$$

$$p_m = \begin{cases} P_{m1} - \dfrac{(P_{m1} - P_{m2})(f_{\max} - f)}{f_{\max} - f_{avg}}, f \geq f_{avg} \\ P_{m1}, f < f_{avg} \end{cases} \tag{18}$$

$f_{\max}$ is the biggest fitness in the population; f_{avg} is the average fitness of each generation population; f' is the larger of the two individual fitness value; f is the fitness value of variation individual .

Algorithm performance simulation

In order to verify the performance of the improved algorithm proposed in this paper, take a certain area of sewage pipeline as an example, using the standard simulated annealing algorithm (SA), genetic algorithm (GA), and the improved simulated annealing algorithm (Improved - SA) for sewage control programs. Figure 1 ~ 3 is the result of three kinds of processing algorithm.

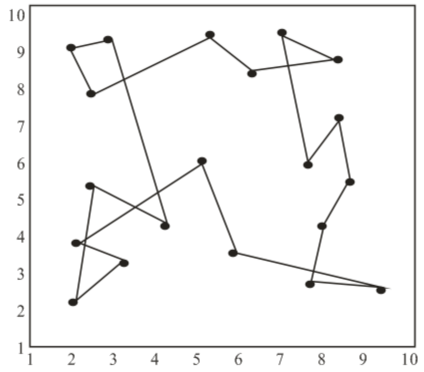

Figure 1. Results sewers planning standard GA algorithm

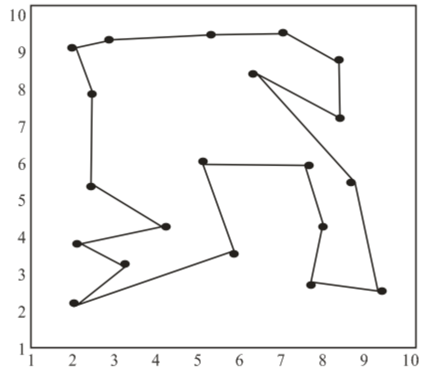

Figure 2. Standard SA sewers planning Results

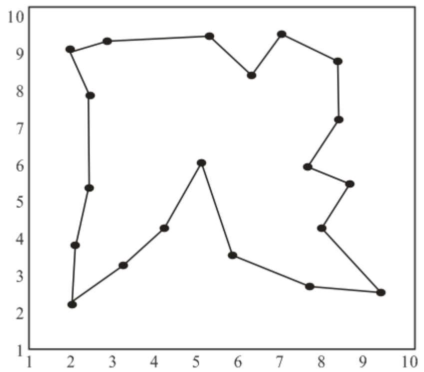

Figure 3. Improved planning results sewers SA Algorithm

We can see from the above results, the parameters optimization simulated annealing algorithm this paper presented has better effect of sewage treatment planning related to the standard SA algorithm and genetic algorithm.

Conclusion

With the acceleration of industrialization and urbanization, water pollution has become a hot and difficult problem. Especially the river basin water pollution control is complex. Therefore, exploring new ideas and new solution to the basin water pollution control methods is significance to protect river basin water resources sustainable utilization. Aiming at the existing defects of simulated annealing algorithm, this paper puts forward sewage control planning model based on the parameter optimization simulated annealing algorithm. The parameters optimization simulated annealing algorithm this paper presented has better effect of sewage treatment planning related to the standard SA algorithm and genetic algorithm.

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