# Green Optimization and Its Solution

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**Abstract:** The concept of green environmentalism is put forward and becomes a social focus. Resource economy and environment friendly have been the current trend, and become the emphases the project management must take into account. Accordingly multi-objective project optimization involved with the resource and the environment becomes the research hot and difficulty. In view of the problem complexity, multi-step solution strategy is put forward. Firstly the improved genetic algorithm is adopted to optimize the project to obtain a set of satisfactory solution. Secondly gray correlation analysis is adopted to make multi-objective decision. Finally the optimal solution is obtained after computation. The instance examination indicates that the strategy and the method are simple and effectual.

**Keywords:** Environment friendly, multi-objective, genetic algorithm, gray correlation

## I. Introduction

Environment pollution, resource lack and population expansion are three leading issues which threaten human nowadays. Since 90s in last century, the strategy that environment problem should be prevented from the root and be controlled during whole process begins to infiltrate the polity of the national environment development, and the continual development strategy has become the global collective point. Engineering project is the channel with which human society changes nature ecosystem most intensively, therefore damages nature environment badly. In addition engineering project consumes a great deal of energy and resource, and produces a lot of pollution.

Since reform and openness, the quantity and the scale of project in China develop quickly. Now investment amount for these projects is very large, and these projects involve with all fields which includes the economy, the culture, the science, the national defense. The project amount, the investment sum, the fund source and the management complexity all preponderate over before. How to manage these large projects becomes the immense challenge the project management theory and the project management practice are faced with. Traditional project management adopts organization and management measure to optimize time, cost and quality [1]. With the closure of Copenhagen international climate conference, low carbon economy, environment friendly become the key word of world development again. Premier Wen emphasized for several times: pay attention to resource economy and construct environment friendly society. In order to achieve above new objective, it's necessary to take the resource and the environment into account during the project management.

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## II. Multi-Objective Decision-Making

At the present, project management mainly concentrates the optimization of time, cost and quality, and hardly considers the environment factor. In order to reveal the resource and environment effect, the project optimization model will adopt new indexes for decision-making.

(1) Resource consumption R. It includes material utilization factor, energy utilization factor, equipment utilization factor, and so on.

(2) Environment influence E. It includes atmosphere pollution, liquid pollution, noise pollution, and so on.

(3) Cost C. It includes direct material cost, direct manpower cost, other direct cost and indirect cost.

(4) Time T. If time is shorter, then project predominance is stronger.

(5) Quality Q. Improving project quality is the important factor to increase the project competition capability.

Consequently, reducing cost, shortening time, improving quality, reducing resource and reducing pollution are the basic requirement for project management. There are close relation among five indexes, and they compose the decision-making objective system.

The multi-objective system made up of time, cost, quality, resource and pollution is very complicated. These indexes affect each other, so it's difficult to make decision. After the deep analysis, it can be known that willingness to pay can be applied to evaluate the loss because of the pollution. It's difficult to optimize five indexes synchronously, and it's hardly possible to obtain the optimal solution where each index is optimal. However, it's feasible to adopt intelligent algorithm to obtain a set optimized solution and then to adopt gray correlation analysis to make decision.

## III. Improved Genetic Algorithm

Genetic algorithm is typical optimization algorithm and widely applied to all kinds of project optimization. Hence genetic algorithm is adopted to optimize the objective in prophase. However, because normal genetic algorithm has some disadvantages, such as prematurity, it's necessary to mend the genetic algorithm in order to improve the performance of genetic algorithm [2]. The improved genetic algorithm as Fig.1 is adopted to solve the optimization problem in the paper.

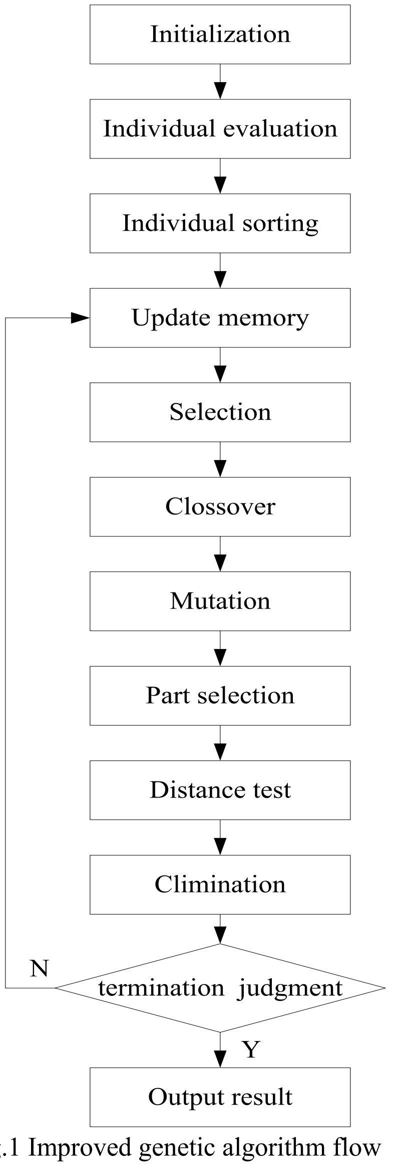


Fig.1 Improved genetic algorithm flow

Step1 Initialization

Set evolution counter t, namely t=1. Create initial population made up of M initial individual P(t).

Step2 Individual evaluation

Calculate the affinity of each individual.

Step3 Individual sort

Sort all individuals of population P(t) according to affinity.

Step4 Update memory

Clear memory and insert previous N individuals into memory according to affinity.

Step5 Selection

Carry out selection operation for population P(t) according to roulette strategy and then obtain P1(t).

Step6 Crossover

Carry out two-point crossover operation for population P1(t) and then obtain P2(t).

Step7 mutation

Carry out mutation operation for population P2(t) and obtain P3(t).

Step8 Partial selection

Incorporate M individuals got in Step7 and N individuals stored in Step4, and then obtain new population with (M+N) individuals. Then the difference of these individuals will be detected by distant measure. In view of large calculation scalar, the algorithm doesn't measure all individuals. So only select half individuals randomly from the population with (M+N) individuals.

Step9 Measure distant

Measure the distant between any two individuals for the population obtained in Step8.

Step10 Elimination

Sort the Hamming distant got in Step9 and select N couples of individuals whose distant is closest, and then elimination the individual whose affinity is smaller from every couple.

Step11 Termination judgment

Judge whether the termination condition is met. If meet then output the calculation result and the algorithm ends, or update counter t, namely t= t +1, and then go to Step4.

## IV. Gray Correlation Model

Only a set of satisfactory solution is obtained after optimized by genetic algorithm, so it's necessary to confirm the optimal solution. Now the gray correlation model is competent for the decision-making. The main idea of gray correlation is to judge whether sequence curves relate close according their comparability degree. If the curves are closer each other, then the correlation of sequence is bigger, or it's smaller [3]. Supposing there are m preparative scheme and every scheme is made up of n evaluation indexes. The data sequence can be formed as follows.

X1={X1(1), X1(2), X1(3), … , X1(n)}
X2={X2(1), X2(2), X2(3), … , X2(n)}
X3={X3(1), X3(2), X3(3), … , X3(n)} （1）
…
Xm={Xm (1), Xm (2),\Xm (3), … ,Xm (n)}

During gray correlation analysis, preparative scheme data sequence needs to compare to ideal scheme data sequence. Apparently ideal scheme data sequence is reference data sequence, and named as X0

X0={X0(1), X0(2), X0(3), …, X0(n)} （2）

The difference between preparative scheme data sequence Xi and ideal scheme data sequence X0 in k-th point is defined as correlation coefficient $\xi_i(k)$ of X0 in in k-th point. Its calculation expression is defined as follows.

$$\xi_i(k) = \frac{\min_{i\in m}\min_{k\in n}|X_0(k)-X_i(k)| + 0.5\max_{i\in m}\max_{k\in n}|X_0(k)-X_i(k)|}{|X_0(k)-X_i(k)| + 0.5\max_{i\in m}\max_{k\in n}|X_0(k)-X_i(k)|} \quad (3)$$

Average value of n correlation coefficients between Xi and X0 is defined as correlation degree ri, namely

$$r_i = \frac{1}{n}\sum_{k=1}^{n}\xi_i(k) \quad (4)$$

In fact, ideal scheme is unknown, so it needs to be constructed artificially. Ideal scheme can be constructed with preparative scheme. According to the characteristic, all indexes can be divided into two kinds: cost type index and benefit type index. The optimal value of two kinds of indexes can be calculated with Equation (5). Then the ideal scheme data sequence X0 is formed with these optimal values and it is considered as reference data sequence.

$$X_0(k) = \begin{cases} \min_{i\in m}\{X_i(k)\} & \text{if } k \text{ is cost type index} \\ \max_{i\in m}\{X_i(k)\} & \text{if } k \text{ is benefit type index} \end{cases} \quad (5)$$

An outstanding problem of multi-objective evaluation is that the dimension of every index is not same. There is not uniform standard, so it's difficult to compare them. Hence, before these indexes are evaluated, their value should be transformed into range [0, 1]. Accordingly the subjection function of fuzzy mathematics is introduced here and is adopted to transform all index values into the comparable value.

The importance of indexes which determines scheme performance varies, so every index should be set corresponding weight, namely weightiness coefficient should introduced into correlation degree equation. Usual methods determining weight include average square deviation method, expert mark method, binomial coefficient method, primary component analysis method, variable weight rank method and so on.

The correlation coefficient $\xi_i(k)$ of all indexes of all schemes can constitute correlation coefficient matrix C.

$$C = \begin{bmatrix} \xi_1(1) & \xi_1(2) & \cdots & \xi_1(n) \\ \xi_2(1) & \xi_2(2) & \cdots & \xi_2(n) \\ \cdots & & & \\ \xi_m(1) & \xi_m(1) & \cdots & \xi_m(n) \end{bmatrix} \quad (6)$$

In view of the weight, the concept of weighting correlation is introduced here. Correlation degree vector R is calculated by operating Weight set W and correlation coefficient matrix C. The element of correlation degree vector R is correlation degree ri, namely

$$R = C\cdot W = \begin{bmatrix} \xi_1(1) & \xi_1(2) & \cdots & \xi_1(n) \\ \xi_2(1) & \xi_2(2) & \cdots & \xi_2(n) \\ \cdots & & & \\ \xi_m(1) & \xi_m(1) & \cdots & \xi_m(n) \end{bmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ \cdots \\ w_n \end{bmatrix} = [r_1, r_2, \cdots, r_n] \quad (7)$$

$$r_i = \sum_{k=1}^{n}\xi_i(k) \quad (8)$$

## V. Application Instance

An actual engineering project involved with five indexes: time, cost, quality, resource and pollution, and it needs to be optimized and to find the optimal solution. Now the strategy above is applied to optimize and make decision. Firstly genetic algorithm is adopted to carry out prophase optimization and find eight satisfactory solutions which are just preparative schemes. In the project, quality belongs to benefit type index and other four indexes belong to cost type index. Time, cost, quality, resource and pollution are respectively expressed as g1~ g5, and eight preparative schemes are respectively expressed as X1~ X8. Every preparative schemes and index data are shown as Tab.1.

Tab.1 Every preparative schemes and index data

| | g1 | g2 | g3 | g4 | g5 |
|---|---|---|---|---|---|
| X1 | 120 | 226 | 0.90 | 155 | 24 |
| X2 | 131 | 218 | 0.92 | 158 | 22 |
| X3 | 110 | 201 | 0.93 | 164 | 30 |
| X4 | 129 | 219 | 0.88 | 122 | 26 |
| X5 | 135 | 205 | 0.94 | 159 | 21 |
| X6 | 112 | 233 | 0.85 | 142 | 25 |
| X7 | 122 | 229 | 0.89 | 125 | 21 |
| X8 | 115 | 212 | 0.87 | 169 | 33 |

Ideal scheme data X0 can be constructed from the preparative schemes data sequence X1~ X8 according to the index characteristic using Equation (5).

X0=[110，201，0.94，122，21]

After the preparative schemes data sequence X1~ X8 are normalized, the judgment matrix B can be obtained.

$$B = [b_{ik}]_{m\times n} = \begin{bmatrix} 0.6 & 0.21875 & 0.55556 & 0.29787 & 0.75 \\ 0.16 & 0.46875 & 0.77778 & 0.23404 & 0.91667 \\ 1 & 1 & 0.88889 & 0.10638 & 0.25 \\ 0.24 & 0.4375 & 0.33333 & 1 & 0.58333 \\ 0 & 0.875 & 1 & 0.21277 & 1 \\ 0.92 & 0 & 0 & 0.57447 & 0.66667 \\ 0.52 & 0.125 & 0.44444 & 0.93617 & 1 \\ 0.8 & 0.65625 & 0.22222 & 0 & 0 \end{bmatrix}$$

Now adopt Equation (3) to calculate correlation coefficient $\xi_i\left(k\right)$, and then use Equation (6) to construct correlation coefficient matrix C. The result is as follows.

$$C=\begin{bmatrix} 0.55556 & 0.39024 & 0.52941 & 0.41593 & 0.66667 \\ 0.37313 & 0.48485 & 0.69231 & 0.39496 & 0.85715 \\ 1 & 1 & 0.81818 & 0.35878 & 0.4 \\ 0.39683 & 0.47059 & 0.42857 & 1 & 0.54545 \\ 0.33333 & 0.8 & 1 & 0.38843 & 1 \\ 0.86207 & 0.33333 & 0.33333 & 0.54023 & 0.6 \\ 0.5102 & 0.36364 & 0.47368 & 0.88679 & 1 \\ 0.71429 & 0.59259 & 0.3913 & 0.33333 & 0.33333 \end{bmatrix}$$

Then use average square deviation method to determine the index weight and get weight W, namely

W=[0.13245，0.31376，0.12058，0.20204,0.23117]

Then calculate the correlation degree according to Equation (7) and (8) based on correlation coefficient matrix and weight set, and finally obtain the correlation degree vector R as follows.

R=[r1, r2, r3, r4, r5, r6, r7, r8]
=[0.49801, 0.56328, 0.71162, 0.58002,
0.72539, 0.50681, 0.64913, 0.47212]

It's obvious that r5> r3> r7>r4> r2> r6> r1> r8, namely, the correlation degree of fifth scheme X5 is maximal, so fifth scheme X5 is optimal.

## VI. Conclusion

It can be known from above calculation result that fifth scheme X5 is optimal though time index and cost index are not optimal. The result is that resource consumption and environment influence of fifth scheme X5 are comparatively excellent, and other indexes are also good. However, though certain indexes of some schemes achieve optimal value, these schemes are not optimal scheme. For example, time index and cost index of thirth scheme achieve optimal value, but esource consumption and environment influence are bad. This leads to the result that the scheme isn't optimal scheme. Because multi-objective engineering project optimization involved with environment friendly is very complicated, if only one method is used, it's difficult to obtain the optimal sulution. Multi-step strategy is adopted in the paper. Firstly genetic algorithm is used to get a set of satisfactory solutions, then gray correlation model is adopted to make decision, finally the optimal solution is obtained. The strategy is not only simpe but also effectual.

## Acknowledgments

This project is supported by youth fund about humanities and social science of Ministry of Education (No.07JC63038), Guangdong province natural science fund (No.9451064101002828), the Fundamental Research Funds for the Central Universities, SCUT.

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