Applying on RAGA in Estimating Internal Rate of Return of Hydropower Project

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Abstract: Internal rate of return, a kind of important economic analysis index, is often used by evaluating economic feasibility for engineering. Substantively, estimating internal rate of return is to solve higher-order equation with one unknown. Due to its precision disadvantage, complicated calculation, and especially theories lacks, traditional linear interpolation is unsuited to do with these questions. Real Coding Accelerating Genetic Algorithm (RAGA), a new method, has overall optimization ability, less calculation quantity, adaptability to interspace size of the optimistic search variety, swiftly calculation and high accuracy. It can be used and proved to calculate internal rate of return effectually. [Nature and Science 2003;1(1):72-74].

Key words: RAGA; internal rate of return; linear interpolation

Introduction

The investment of hydropower engineering was gradually taken back by its net income of each year. If everything is OK, at the end of economic life, the amount of the investment can be returned at the right moment. Because this process has nothing to do with outside factors, only with its own investment, net income of each year and increment rate of possessive funds, the rate of discount is so called as internal rate of return. Solving higher-order equation with one unknown usually can get internal rate of return, an unknown rate. Unfortunately, at present, a simple and effectual solution method cannot be really obtained because linear interpolation, which is often used before, can't attain satisfactory accuracy for that there is no linear relation between rate of discount and internal rate of return (Liu, 2003). Real Coding Accelerating Genetic Algorithm (RAGA) can resolve this problem nicely, and it can acquire desired result from big scope, meanwhile its accuracy is obviously higher than what traditional linear interpolation can do. Moreover, RAGA does not need attempt to calculate it many times, then the calculation is reduced greatly, and also overcome the result which varied with different persons only because this linear interpolation method is adopted. As we know, Internal rate of return can make sure the capital income and foreshow the biggest interest rate afforded without financial crisis. Hydropower engineering usually possessing big project investment, a long project constructing and project repayment period, needs higher accuracy that can reflect the income ability of investment well. In this way, RAGA provides the new method for us with the way of thinking. Scientific and dependable data can be available.

1. The Brief Introduction of RAGA

Standard Genetic Algorithm (SGA), the traditional genetic algorithm, usually adopts the coding method of binary system. Its individual genotype is also called binary coded string that only uses coding sign 0 and 1. Binary coding is not only simple and easy to proceed its crossover, selection and mutation etc., but also easy to make good use of the mode axioms to theoretically analyze algorithm. In despite of this, Standard Genetic Algorithm's shortage is still obvious: it can't reflect the special structure characteristics of a problem enough, and its part-search ability is also worse due to its random attributes when optimization question of continuous functions is handled. Furthermore, to research optimization question of continuous functions containing many dimensions and needing higher accuracy, the binary coding shows disadvantages. Firstly, the binary coding exits mapping error when continuous functions proceed to discrete process. If the length of coding string is shorter, the requested accuracy cannot be obtained. If the length of coding string is longer, even though its accuracy is improved, the search scope of genetic algorithm swiftly extends. Secondly, the binary coding cannot reflect particular attributes of problems well. It is difficult to generate special genetic operator for special problems. As a result, many precious experiences from research on classic optimal algorithm cannot be made good usage, and special restricted condition isn't easy to be handled. In order to overcome these shortages of binary coding method, we may adopt real number coding, and make the individual coding length fitly equal to decision variable number. This kind of coding has a few advantages: (1) be qualified to denote bigger number; (2) be qualified to obtain higher accuracy; (3) be qualified to search from big scope; (4) reduce the calculation complexity and improve calculation efficiency; (5) be easy to unite genetic algorithm and classic optimal algorithms; (6) be easy to design genetic operators aiming to specialized problems; (7) be easy to handle complicated restricted conditions.

2. The Estimation of Internal Rate of Return

Internal rate of return is kinds of discount rate, which can make total amount of net present value of each year in project economic life, happen to be equal to zero. We now introduce the expression below:

$$\sum_{t=0}^{n}(CI - CO)_t(1 + IRR)^{-t} = 0 \quad (1)$$

Equation inside: IRR——internal rate of return;

$(CI - CO)_t$——net present value of T year

n——life period of project

As we know, equation (1) is a higher-order equation with one unknown. Hence, it isn't easy to be solved. At present, the linear interpolation method is usually used. Its expression is as the following:

$$IRR = i_1 + \frac{NPV_1}{NPV_1 + |NPV_2|}(i_2 - i_1) \quad (2)$$

i_1——lower rate of return that we attempt to calculate;

i_2——higher rate of return that we attempt to calculate;

NPV_1——net present value we calculate by i_1 (positive value);

NPV_2——net present value we calculate by i_2 (negative value).

Because hydropower engineering's lifetime is long (several decades), it is difficult to calculate internal rate of return by traditional mathematics method. According to the equations above, we consider that the accuracy of the linear interpolation method is low and its calculation is complicated. Hence, we attempt to turn equation （1） to minimization problem, another method to calculate internal rate of return. From equation（2－1）, they obtain

$$\min Q = \min \left|\sum_{t=0}^{n}(CI - CO)_t(1 + IRR)^{-t}\right| \quad (3)$$

Therefore, internal rate of return is really to solve non-linear optimization problem, and RAGA is easy to handle it.

3. The Process That Model Realizes

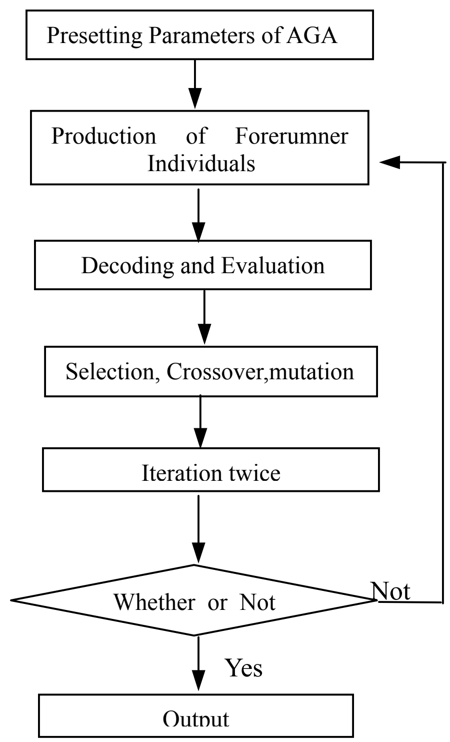
Figure 1 shows the steps and calculation process of RAGA. In comparison, selection, crossover and mutation of RAGA proceed to parallel computation. In consequence, RAGA's search scope is bigger than SGA's, and there are more chances to get optimal value. RAGA can gradually narrow the scope of optimistic variable by making use of accelerating circulation. The accuracy of solution is improved quickly.

RAGA's control parameters are made up of community scale n, excellent individual number s, mutation probability P_m, crossover probability P_c, and their value will influence final optimistic value. Having done a great deal of numerical experiments and actual application, we obtain experimental relation between n and s:

$$s / n > 6\% \quad (4)$$

When we apply RAGA, we suggest n: over 300 number, s: over 20, P_m: 0.8, P_c: 0.8 (Jin, 2000). If these are satisfied, we can get better result.

Figure 1. Flow Chart for RAGA



4. Example Analysis

Zipingpu water conservancy project, located at 6 km and on the upstream from Dujiangyan, Chengdu, China, is a key project to exploit the upstream of Minjing River reasonably. It tackles the difficulties of water and power shortage and flood control in Dujianyan irrigation area and Chengdu city. Its main functions are irrigation and municipal water supply, comprehensive benefits of generation, flood control, tourism and aquaculture. Its installed capacity has 0.76 million KW, average annual energy output has 3.417 billion KW.h. The total static investment reaches 5.75039 billion yuan (Chinese dollar) and the total dynamic investment reaches 6.23600 billion yuan. Its construction period will last 7 years and operation period will last 30 years, so the total economic calculation period will last 37 years. The net cash flow of each year is shown in Table 1, and the calculation of the internal rate of return of Zipingpu engineering by different measures according to equation (3) is shown in Table 2.

Table 1. Zipingpu Project Net Cash Flow (unit: ten thousand Chinese yuan)

Year	1	2	3	4	5	6	7	8
NCF	–26274	–63040	–96349	–116874	–122121	–84969	–28916	53465
Year	9	10	11	12	13	14	15	16
NCF	59031	76491	76047	75575	75010	74415	73786	73122
Year	17	18	19	20	21	22	23	24
NCF	73059	72996	72932	72869	72806	72742	72679	72616
Year	25	26	27	28	29	30	31	32
NCF	72553	72489	72426	56881	56818	56754	56691	56628
Year	33	34	35	36				
NCF	56628	56628	56628	–263074				

Table 2. The Internal Rate of Return of Zipingpu Engineering (unit: ten thousand Chinese yuan)

method / result	Internal rate of return	Remains value Q
Linear interpolation	8.81%	997.945
Fminbnd function	8.79%	97.021
RAGA（accelerate once）	8.7870%	38.4226
RAGA（accelerate two times ）	8.7880%	6.7341
RAGA（accelerate three times）	8.7878%	2.2189

It must be pointed out that the RAGA method is applied straight when the mark of cash flow change once. If it changes many times, all this shows that the income from the engineering investment is laid out some other external engineering. The external rate of return isn't always as same as the internal rate of return. If so, firstly we should convert the surplus income into external investment according to the external rate of return, then this part fund is further returned to internal engineering. The literatures suggest that we may estimate the internal rate of return by net investment examination method to any cash flow, whose expression would be of the form:

$a_0, a_1, a_2, \cdots, a_n$, r means internal rate of return, e means external rate of return, so the net investment of j year can be written in the form:

$$NI_0 = a_0 \qquad (5)$$

$$NI_j = N_{j-1}(1+i) + a_j, (j = 1,2,\cdots,n) \qquad (6)$$

If $NI_{j-1} < 0(j = 1,2,\cdots,n)$, the parameter i is set by internal rate of return. If not, the parameter i is set by external rate of return. At the same time, the net investment of n year must be equal to zero. We now introduce the expressions below:

$$NI_n = NI_n(r) = 0 \qquad (7)$$

Furthermore, we obtain

$$\min \ Q = |NI_n(r)| \qquad (8)$$

Finally, we may apply the RAGA method to proceed the calculation.

5. Conclusion

Estimating the internal rate of return is actually to solve a kind of complicated and non-linear problem, by the RAGA method, higher accuracy, less error, more rationality we can obtain. When the cash flow mark of engineering change over twice, we should avoid confusing external rate of return and internal rate of return, otherwise it will bring important error for decision-making.

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