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An improved RNA genetic algorithm for the parameter estimation multiple solutions of ordinary differential equations

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Abstract

In fluid mechanics, how to solve multiple solutions in ordinary differential equations is always a concerned and difficult problem. An improved RNA genetic algorithm inspired by RNA molecular structure and operators is proposed for solving the parameter estimation problems of the multiple solutions that described as the flow of the fluid through a porous channel with expanding or contracting walls. In this paper, multiple solutions can be found through changing accuracy and search coverage and multi-iterations of computer. At last, the ordinary differential equations is calculated, and the result has great accuracy and this method is practical.

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1. Introduction

In fluid mechanics, the multiple solutions of boundary value problems are important topics and have received considerable attentions. Many researchers had put forward some methods to solve such problems. In general, a shooting method based on the fourth order Runge–Kutta scheme is effective numerically, which have been used to solve a lot of problems. In order to solve such problems, the boundary value problems are transformed into initial value problems by introducing new unknown parameters, which are decided by the boundary conditions. However,

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it is difficult to find all the unknown parameters which satisfy the boundary conditions, especially for the problems that the equation has multiple solutions. Later, the Homotopy Analysis Method is proposed by Liao SJ (2003, 2004, 2009), which also is an efficient analytical method and has been used to solve many problems with multiple solutions Yabushita K and Yamashita M(2007), Abbasbandy S and Shivanian E(2009,2010), Liao SJ(2005). However, the HAM suffers from a number of restrictive measures, such as the requirement that the solution sought ought to conform to the so-called rule of solution expression and the rule of coefficient ergodicity. By great search ability of improved RNA genetic algorithm, the problem could be resolved.

For traditional genetic algorithm, it's easy to fall into local optimum especially in multi-peak value. To avoid premature, Wang KT and Wang N(2010), Atmar W(1994), Mansoornejad B and Mostoufi N(2008), Milani G and Milani F (2008), improved the traditional genetic algorithm and achieved better accuracy and computational stability, especially Wang incorporated traditional fitness function with Euclidean spaces distance to construct a type of special fitness function and introduced new genetic operators and mutation operator, that improves global search ability greatly. As the computational stability improves, this method has been applied to many related fields by many scholars Xu L,Liang N(2008), Wang KT and Wang N(2010),Luo J and Xu, L(2007) , Tao J L,Wang N(2007) ,Chen X,Wang N (2009) Figielska E(2009) had solved many problems by it.

In order to overcome the limitations of traditional genetic algorithm, a new fitness function and some genetic operators are introduced and a new mutation operator is addressed to avoid the local optimum. Combining this improved RNA genetic algorithm with Runge–Kutta method could be solved directly.

2. Procedure of the method

The procedure of this improved RNA genetic algorithm and Runge–Kutta method can be summarized as follows:

Step 1:Initialize a population with n individuals, n individuals contain $s_1, s_2, \dots, s_n$ and $t_1, t_2, \dots, t_n$.

Step 2:Having known s and t , use the Runge–Kutta method to calculate $f(s_1, t_1), f(s_2, t_2), \dots, f(s_n, t_n)$, rank the fitness value by size and divide individuals into odd and even groups.

Step 3:Use the new selection criterion to reselect the individuals, and generate new one.

Step 4:Take the improved RNA-recoding operator and RNA single-point crossover with probability operator in n individuals.

Step 5:Carry out mutation operator with mutation probability.

Step 6:Repeat step 2 to step 5 until the termination criteria are met, and the solution is found.

Step 7:If the absolute value of this solution and previous solution is more than ξ (ξ denotes the smallest distance of the two solutions, suppose that it is 0.1), then this solution would be saved, the number of solution gets three, iteration would be ended or go to step 1 with changing the search coverage and precision of s .

3. Example

$$F'''' + a(xF'''' + 3F'') + R(FF'''' - F'F'') = 0 \quad (1)$$

$$F(0) = 0, F''(0) = 0, F(1) = 1, F'(1) = 0 \quad (2)$$

This problem was proposed by Dauenhauer EC and Majdalani J(2003).The problem is described as the flow of the fluid through a porous channel with expanding or contracting walls. The multiple solutions about this problem had been solved by HAM.

In order to obtain numerical solutions, transfer the problem (1) and (2)into a system of first-order equations by denoting the F, F', F'', F''', F'''' using variables F, U, V and W , respectively

$$F' = U \quad (3)$$

$$U' = V \quad (4)$$

$$V' = W \quad (5)$$

$$W' + a(xW + 3V) + R(FW - UV) = 0 \quad (6)$$

The corresponding boundary conditions are:

$$F(0) = 0, V(0) = 1 \quad (7)$$

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