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VARIANTS OPTIMIZATION ALGORITHMS FOR SOLVING SYSTEMS OF LINEAR EQUATIONS

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This article describes options for increasing the rate of convergence of algorithms for solving systems of linear equations and considers the relaxation method for solving systems of linear equations

The subject of my report intersects with my master's thesis "Optimization algorithm for calculating the stationary gas networks". At this point a calculation algorithm based on the method of simple iteration, which is applied to the numerical methods and can be called the method of successive approximations, is developed in our university.

The idea of the simple iteration method is that the equation $f(x) = 0$ results in an equivalent equation $x = \varphi(x)$ so that the mapping $\varphi(x)$ was contracting. If it succeeds, then the sequence of iterates $x_{i+1} = \varphi(x_i)$

converges. This conversion can be done in different ways. In particular, the roots of the equation are retained in the form $x = x - \lambda(x)f(x)$, if $\lambda(x) \neq 0$ on the investigated interval.

The iteration method is the easiest to implement, however, this method is not very effective, due to the slow convergence.

Let us consider some ways to optimize the algorithms:

1) reducing the accuracy of the calculations;
2) the distribution of computing power;
3) the replacement of the basic algorithm for solving linear equations.

The first and third methods refer to software, and the second - to hardware. Let's dwell on each of them closely.

Reducing the precision of calculations is quite an effective way to increase the performance of algorithms for solving linear equations, as it reduces the required number of iterations to achieve the final result by several times, but if the algorithm is used in industry, this process is irrelevant as it usually requires less accuracy and is not specified in the condition. Therefore, this method can't be used in the context of the topic of my dissertation.

This hardware method implies partial transfer calculations to other computers or hardware of the local computer, which is not currently engaged in calculations. For example, we have two independent systems of equations, which ultimately influence the final decision. Having two computers, we can parallelize the solutions of these systems, and then put the final data together. The method is quite effective, but entails additional risks:

1) incorrect data transmission;
2) incorrect receive in processed data;
3) failure of network hardware;
4) inability to local use.

In this case, a replacement of the basic algorithm means changing the program used for solving systems of linear equations. Replacement of the basic algorithm, in our case, complicates the implementation, but at the same time, increases the efficiency of the algorithm as a simple iteration method has the slow speed of convergence. The methods for solving systems of linear equations are direct and iterative. Well-known iterative methods are:

1) Jacobi method (simple iteration);
2) Gauss – Seidel method;
3) The method of relaxation;
4) Multigrid method;
5) MethodMontante;
6) Abramov method;

7) The method of generalized minimal residual;
8) The biconjugate gradient method;
9) The stabilized biconjugate gradient method;
10) The quadratic biconjugate gradient method;
11) The method of quasi-minimal residual.

To optimize the existing algorithm I'm going to use a method of relaxation. Let's consider the method in details.

System of linear equations:

$$\begin{cases} a_{11}x_1 + \ldots + a_{1n}x_n &= b_1 \\ a_{21}x_1 + \ldots + a_{2n}x_n &= b_2 \\ & \ldots \\ a_{n1}x_1 + \ldots + a_{nn}x_n &= b_n \end{cases}$$

is reduced to the form:

$$\begin{cases} b_{11}x_1 + b_{12}x_2 + \ldots + b_{1n}x_n + c_1 &= 0 \\ & \ldots \\ b_{n1}x_1 + b_{n2}x_2 + \ldots + b_{nn}x_n + c_n &= 0 \end{cases}$$

where

$$b_{ij} = -\frac{a_{ij}}{a_{ii}}, \; c_i = \frac{b_i}{a_{ii}}$$

we find residual: R_j:

$$\begin{cases} R_1^{(0)} &= c_1 - x_1^{(0)} + \sum\limits_{j=2}^{n} b_{1j}x_j^{(0)} \\ R_2^{(0)} &= c_2 - x_2^{(0)} + \sum\limits_{j=1, j\neq 2}^{n} b_{2j}x_j^{(0)} \\ \ldots & \\ R_n^{(0)} &= c_n - x_n^{(0)} + \sum\limits_{j=1}^{n-1} b_{nj}x_j^{(0)} \end{cases}$$

Is chosen initial approximation: $X^{(0)} = 0$.

At each step, we must bring the maximum discrepancy to zero:

$$R_s^{(k)} = \delta x_s^{(k)} \Rightarrow R_s^{(k+1)} = 0, \; R_i^{(k-1)} = R_i^{(k)} + b_{is}\delta x_s^{(k)}.$$

Stopping condition:

$$|R_j^{(k)}| < \varepsilon, \forall j = \overline{1,n}.$$

The answer:

$$x_i \approx x_i^{(0)} + \sum_j \delta x_i^{(j)}$$

According to the preliminary calculations the relaxation method will increase the speed of convergence of the system of equations by two times.

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