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The method of selecting components of a complex system based on evolutionary calculations

Abstract: There is EA examines, namely genetic algorithms and methods of speeding up their work on the example of solving the problem of building a complex system - a personal computer.

As a practical part, a genetic algorithm was implemented, which solves the task using the proposed method of selecting components of a complex system, which, due to the use of evolutionary calculations, namely a genetic algorithm with a modified fitness function, allows to increase the efficiency of the process of composing elements of complex systems on the example of selecting components for personal computers or servers.

Keywords: PC, personal computer, genetic algorithms, evolutionary calculations, fitness function, complex system.

Introduction

Most of the technological concepts of mankind are based on a wide variety of natural phenomena. Therefore, according to Darwin's words, the human brain is considered the most powerful tool for solving various problems, which invented the evolutionary mechanism that formed the basis of genetic algorithms.

The increasing complexity of tasks solved by machines requires the use of such mimicry, resource-intensive and, on the other hand, powerful tools as evolutionary algorithms and neural networks. EAs are able to perform the necessary research many times, taking into account and involving the best results in the next iterations of the research. Currently, the practical application of such algorithms requires experienced specialists who will monitor the input sample, the process of recombination and mutation of research objects, which limits the use of EA to solving academic problems, namely, modeling and research of various processes.

We believe that the further development of these algorithms depends on the ease of practical application of these algorithms in applied fields, so the purpose of this work is the study of EA, namely genetic algorithms and methods of speeding up their work on the example of solving the problem of building a complex system - a personal computer.

Personal computer components

A complex system is solved - a personal computer or server, consisting of the following components:

- processor;

- motherboard;
- RAM;
- video card;
- power supply;
- permanent memory;
- body

Each of which is distinguished by a certain set of indicators that characterize the corresponding component and the level of its physical and logical compatibility with others. A successful combination of components by characteristics allows to avoid such a phenomenon as "bottle neck", which leads to excess power of some components over others and disrupts the balance in a complex system, leading to an increase in costs in accordance with the received final power.

As for first version of algorithms only several components were selected, such as CPU, Motherboard, GPU and RAM.

CPU (Central Processing Unit) is the main and main part of a personal computer, which is responsible for directly performing calculations. The CPU characteristics that will form the assessment of the power of this component are as follows:

- clock frequency;
- norms of the lithographic process (technical process, technical process);
- architecture;
- number of cores;
- volume of cache memory.

This component has only one characteristic, which will physically limit its choice in accordance with other components, first of all, the video card - the socket.

Due to logistical constraints, we will have a level power distribution with other components relative to the declared characteristics.

RAM is a memory that is volatile and is used in computer systems as a temporary storage of information that must be quickly accessed.

The most important parameters for selection are:

- frequency;
- latency scheme (timings);

These parameters directly affect the speed of memory, which is a powerful criterion for optimization.

RAM also has two parameters that exclude its ability to combine with incompatible motherboards, that is

- generation (DDR2, DDR3, DDR4);
- form factor (DIMM, SODIMM).

The motherboard is the main element of a personal computer, which provides communication between other components, namely the processor, RAM and main memory, video card, power supply and peripherals. It has the following characteristics, which are important to consider when assembling a computer:

- form factor;
- chipset (chipset);
- socket;
- support of a certain generation of RAM;
- availability of commonly used interfaces for connecting peripheral devices.

First, the socket of the motherboard must match the socket of the processor, because otherwise its installation in the processor connector is physically impossible due to the difference in interfaces (legs and contact pads). Secondly, the supported generation of RAM - differences in the physical connector and the ability of the processor to work with it, the amount of desired memory and the possible number of threads. The chipset is responsible for the maximum power of the personal computer, and the form factor affects the choice of the case.

Responsible for displaying graphics on the monitor, it can be discrete (a separate board connected to the motherboard) or integrated into the processor. The choice depends on the tasks faced by the personal computer. If this is a gaming solution, then it needs a powerful discrete video adapter, if not, then you can be satisfied with an inexpensive discrete solution, or even pay attention to those integrated into the processor.

The most important influencing parameters are length and power supply to choose the housing of the appropriate sizes and the power supply unit.

Accordingly, test models of components were created, containing the most important parameters that must be taken into account by the algorithm in the process of modeling possible final combinations of components and creating stable connections, taking into account the restriction introduced into the system regarding the physical compatibility of individuals, which will block the occurrence of such impossible combinations. For the simplicity of the study, it was decided to reduce the number of components required for selection to four, namely:

- CPU, for example AMD Ryzen 9 5950X;
- Motherboard on the example of ASRock Z370 Pro4;

− GPU on the example of AMD Radeon RX 6950 XT;

− RAM on the example of Kingston DDR4-2933 8192.

The table with all the characteristics of these components is in appendix B under number 1, and under number 2 you can see the table with simplified components due to the reduction of the least weighty characteristics and their separation by powerful or limiting categories.

Using the website www.pcbenchmarks.net, we will determine the following benchmark scores for specific components:

1. AMD Ryzen 9 5950X – 45942 points at a price of $548;
2. AMD Radeon RX 6950 XT – 27283 points at a price of $1,100;
3. ASRock Z370 Pro4 – 40,000 – points (subjective assessment of the author according to the used chipset) at a price of $195;
4. Kingston DDR4-2933 8192 – 15342 points at a price of $50.

Developed genetic algorithm

On the basis of the types of genetic algorithms, selections and practical applications of genetic algorithms that I have considered, it was decided to simulate the process of selecting computer components in the form of solving a Diophantine equation of the form:

$$a + b + c + d = price$$

where price is the planned amount of money planned to be spent on the computer.

Taking into account the benchmarks of the components described in the previous paragraph, we will calculate the coefficients for the Diophantine equation based on the mathematical expectation of the final price depending on the price of each of the components:

$$548 + 1100 + 195 + 50 = 1893 \quad => \quad 1893/4 = 473,25$$

And therefore, the Diophantine equation will have the following form:

$$1,157a + 2,32b + 0,4c + 0,1d = 1893$$

Let's reduce the coefficients to whole numbers by multiplying by 10:

$$11a + 23b + 4c + d = 1893$$

That is, the most optimal solution that satisfies the condition of the equation is selected components of the same power class. It is worth noting that depending on the field of use of a personal computer, the balance may shift in one direction or another, such as an overload of about 30% in the direction of the video card when designing a computer for gaming, 20% in the direction of the processor for office computers or double the amount of RAM for server machines.

It is customary to calculate the advantage of one solution over another using dispersion - the closer the components are to each other in terms of power, the more optimal the system will be.

The fitness function of the applied algorithm looks as follows:

$$f = x\Delta + yD$$

where x and y are weighting factors

The algorithm creates a new population as follows:

1. Sorts the existing population according to the fitness indicator;

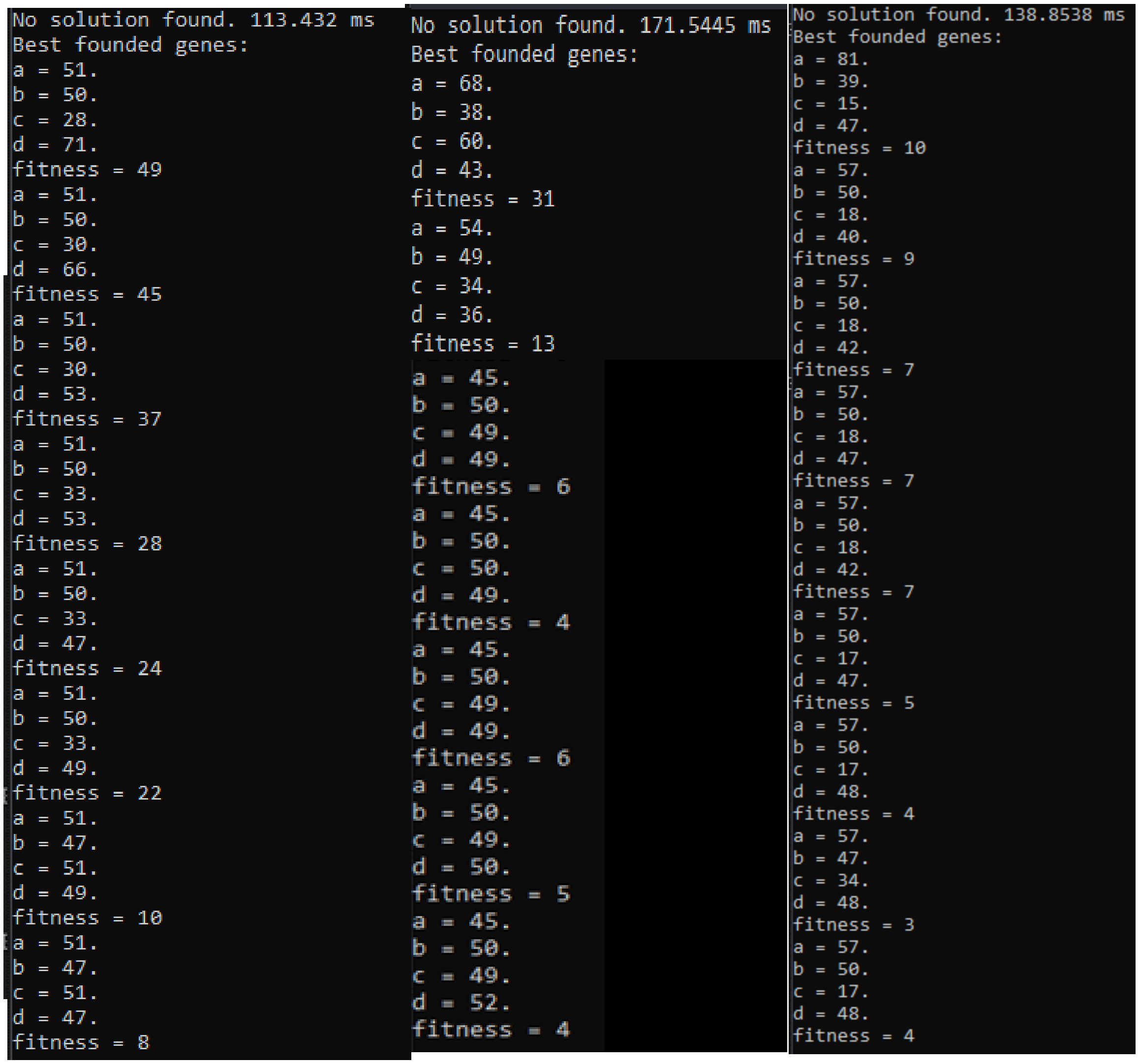
2. Makes a record of the best gene with a fitness deviation of less than 5% in the list of optimal solutions;

3. Selects parents with a survival rate of 20%, i.e. 20% of the best representatives of the population are crossed with each other according to the principle of 2 parents - 2 children;

4. Other representatives of the population are replaced by new randomly generated individuals.

The crossing of individuals takes place according to the crossover principle, in addition, both the number of genes to be exchanged and their position in the individual are chosen randomly. With a probability of 5%, a mutation occurs in both children.

If fitness by price and fitness by variance are taken with the same coefficients, then an ideal solution in the form of a gene is expected { 49, 49, 49, 49 }. With such a fitness function, the possibility of exact GA convergence is close to zero, so let's analyze the obtained solutions that fall into the top 5%. We will conduct an experiment and run the algorithm with a population size of 125 individuals and 1000 iterations for the coefficients (1; 1) (a), (1; 0.4) (b) and (1; 0.1) (c).



a) b) c)

Conclusions

Information from scientific articles on the use of genetic algorithms in solving various modern problems was processed, and a conclusion was made about the relevance of this method of finding approximate solutions. Several main directions can be named as future trends in the development of EA. The first of the modern trends is the hybridization of two or more algorithms to obtain better results. Currently, in the literature you can find an increasing number of works that present hybrid algorithms. Also, many researchers are working on modifications of EAs to improve their computational performance.

A genetic algorithm was developed that solves the problem of Diophantine equations, to which the process of selecting components was reduced. Considering that for the solution of this type of applied problems there is no need to achieve one hundred percent accuracy in solving Diophantine equations, we have a large number of optimal solutions that arise in the process of searching for the ideal, which indicates the effectiveness of the application of genetic algorithms to solve the problem of component selection.

A fitness function has been implemented, which evaluates the individual's fitness according to two criteria - the individual's proximity to the solution of the Diophantine equation and dispersion, because a balanced system is considered the most optimal option. The developed algorithm has a disadvantage in the form of a tendency to find local extrema, which can be solved later by increasing mutation, introducing cataclysms, etc.

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