USAGE OF GENETIC ALGORITHMS IN SOLVING TASKS OF INTEGER PROGRAMMING

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Genetic algorithm is one of the directions of evolutionary calculations (EC). The first results in the sphere of EC were obtained at the beginning of 70s. The works by A.G.Ivachnenko, L.A.Rastrigin, J.H.Holland, H.-P.Schwefel, L.J.Fogel are fundamental in this sphere. Authors of this works have shown that the usage of some formalized principles of natural evolutionary process is very effective for a general description of algorithms of search, optimization and teaching.

Methods of EC do not guarantee the detection of global extreme for polynomial time. They allow however to obtain an acceptable decision for a large dimension task, when a computing complexity of other methods is unacceptable. A necessary number of calculations may appear rather large, but a degree of increasing the computing complexity in methods of EC is not essential in comparison with the dimension increase of an initial task.

EC are effectively used at present for solving real tasks of engineering projecting, planning, routing and allocating, managing portfolios of bonds and shares etc. In other words these methods are widely used not only in solving technical tasks, but also in applied tasks of economy and humanitarian spheres.

A substantial disadvantage of EC, including genetic algorithms, is that they are rather an approach than a universal algorithm. As a result the decision of such a task will essentially depend on how the basic notions and algorithm parameters are defined and interpreted.

In this work a genetic algorithm for solving optimization tasks of integer programming is proposed. Tasks of such a class allow describing and solving a number of economy situations and problems (optimization of equipment purchases and its allocation, pricing etc.). Nowadays there is a number of algorithms for solving tasks of integer programming, e.g. branch-and-bound method, Gomory method, Danzing-Mann method and a number of simplex-method based algorithms, which are adapted for tasks with integer arguments. All these methods however have one common disadvantage: to obtain the optimal decision, which is often only a bit better than already obtained quasi-optimal decision, it is necessary to perform a large number of calculations. That is why actual is the task of developing an algorithm characterized by small computing complexity and which allows obtaining a quasi-optimal decision under the defined conditions. And genetic algorithm meets these requirements. It should be stressed in this connection that this algorithm does not exclude obtaining the optimal decision.

One of the actual directions of using genetic algorithms is the solution of linear programming tasks. In this work a genetic algorithm for solving tasks of integer programming is proposed. The main components of this algorithm are defined for solution of the above-mentioned task. In contrast to traditionally used algorithms, it is applied an integer encoding of chromosomes in this one. This circumstance enabled adapting a universal genetic algorithm directly for solution of an integer-programming task.

As it is noticed in works of leading specialists in the sphere of evolutionary calculations (K.A. De Jong, T.C.Fogarty, D.B.Fogel) the effectiveness of genetic algorithm (GA) usage directly depends upon a way of interpreting its main components and procedures applying to the given task.

To formalize the process it is necessary to set stages of the algorithm and to determine its main parameters. In particular, GA has three logically distinguished stages.

At the first stage of GA an initial population is formed, which is a set of potential solutions. Each of all these solutions is considered to be a chromosome. The population, which is examined at a certain period of time, is called current. At the very beginning of algorithm work the current population coincides with the initial one.

The second stage of GA is to form new generations of chromosomes. A new generation is generated in two main procedures - crossing and mutation. Crossing procedure is a search for solutions within a local extreme field. In this operation an exchange of elements (genes) between two accidentally chosen chromosomes is carried out. These chromosomes are called parents. The results of such transformation are offsprings, which combine characteristics of both parents. The number of chromosomes participating in the crossing procedure is determined by coefficient called the crossing speed. Crossing speed is ratio of a number of participating in the crossing procedure chromosomes to their overall number in the current population.

Mutation is a random change of a certain number of chromosomes genes. Like in crossing a number of chromosomes undergone the mutation is determined by a coefficient - mutation speed.

The third stage consists in reducing size of the current population (selection). In the obtained population containing all the parents and the offsprings (or only offsprings) a selection of candidates to the best decision is carried out. In other words, chromosomes with the largest value of fitness-function are chosen. This function shows how close is the examined chromosome to the optimal solution.

All the above-described stages are applied to the obtained population, which has already become current. The process is repeated till we see improvements in chromosomes characteristics in each following generation or until we obtain a determined number of generations.

For each concrete applied task the following components should be defined within the genetic algorithm: Chromosomes; Size and rule of forming an initial population; Fitness-function.

Thus, a vector of variables, i.e. a target solution, is interpreted as a chromosome in the developed genetic algorithm. However genes take values from all possible range of variables values. The initial population is formed from n chromosomes (n - a number of task variables). Criterion function is used as a fitness-function.

In this algorithm original crossing procedures are proposed. The main idea of the crossing procedure consists in providing the search for an optimal solution at the expense of a slight change of features (characteristics of this solution). In other words, this procedure allows examining possible solutions within a certain extreme area.

Based on its logical sense, the crossing procedure is interpreted in the following way. Let A - a chromosome vector, which genes take values from the following range 0, 1, ů, m-1. The crossing procedure of chromosomes A1 and A2 is defined then as an exchange of genes parts which have the same serial numbers. It is proposed in the developed algorithm each gene should include such feature as a level of influencing the performance of conditions. This feature is defined depending upon a coefficient value for a certain variable and on a value of this variable in the current chromosome. The number of chromosomes participating in the crossing procedure is determined by the coefficient - crossing speed a: 0 < a < 1. The coefficient shows how many chromosomes from the current population are involved in the crossing procedure. In addition, chromosomes participating in this procedure depend upon the value of fitness-function.

Mutation is a procedure of changing values of a set of chromosomes genes (features of a solution) to the opposite. Such definition of mutation allows broadening the search area of optimal solution and escaping the "trap" of local extreme. To execute the mutation procedure let's make use of the following rules. Value of ak changes with probability PI according to the rule "not ak"=(m-1)-ak , and with probability PC according to the rule "not ak"=(ak+1) (mod m). Values of probabilities PI and PC are determined experimentally at the stage of preliminary preparation of algorithm.

The definition of genetic algorithm based on the integer values of genes allowed synthesizing genetic algorithms for the task of forming a mathematical model of economy system with partly defined parameters and algorithm of search for optimal values of system parameters under the given conditions of the system.