GENETIC ALGORITHMS

E-learning laboratory instructions

DISCRETE KNAPSACK PROBLEM

This problem is concerned with a knapsack/container that has positive volume (or capacity) V. There are *N* distinct items that may potentially be placed in the knapsack/container. Item *i*th has a positive volume w_i and benefit b_i.

Let $x_i \epsilon \{0,1\}$ denotes if *i*th item is placed in the knapsack/container. The problem can be stated as follows:

maximize

$$\sum_{i=1}^{N} x_i b_i$$

subject to the constrains:

$$\sum_{i=1}^{N} x_i w_i \leq V$$

GENETIC APPROACH TIPS

The problem stated above can be easily solved using genetic approach framework. Let us assume that N=4. Volumes of items are {2 1 4 5}, benefits related to them {3 2 6 8} and the knapsack capacity V=9.

Encoding chromosomes

A chromosome can be represented as an binary word of size equal to the number of the items N. Each bit denotes whether an item is included in the knapsack ('1') or not ('0'). For example, the following chromosome:

1 1 0 0

indicates that the 4th and 3rd item are included in the knapsack, with the benefits of this package 5 and the volume 3.

Initial population

We are starting with defining size *M* of population. Please note that size of population cannot be too numerous. The initial population is selected randomly. Provide that only those chromosomes that satisfy constraints (summary volume is smaller than V) are included in the population. For our example the initial population can be as follows:

1 0 0 1

1 0 0 0

1 1 0 0

0 0 0 1

Fitness function

The fitness function is just the function being the subject of maximization:

$$\sum_{i=1}^{N} x_i b_i$$

Taking into account the constrains defined we can set the value of this function as 0 if the volume/weight of the package is greater than the capacity V of the container .

Selection

The goal of this stage is to select parents for new generation which have the best fit. There are many methods of selection. In this laboratory You will use the *roulette-wheel* one.

Roulette-wheel is a simple method of implementing fitness-proportionate selection. It is conceptually equal to giving each individual a slice of a circular roulette wheel equal in area to the individual's fitness. The wheel is spun M times, where M is the number of the individuals in the population. On each spin, the individual under wheel's marker is selected to be the parent for the next generation.

Crossover

Based on the selected individuals in the selection process, pairs of parents are selected for mating. The selection of each two parents may be done sequentially (1–2, 3–4, and so on) or in a random way.

For each pair the crossover is performed. In this exercise please use one-point crossover. Let us consider the following pair of parents taken for this operation:

Bit no 4 3 2 1

1 0 | 0 0

0 1 | 0 1

Randomly select point of splitting the chromosomes, for example 3, and flip the bits (genes) of the tails (bits 1 and 2). The offsprings after recombination are:

1 0 0 1

0 1 0 0

Mutation

Next variation operator is mutation. For each offspring, select randomly one gene (bit) flip its value.

Termination

Stop the algorithm after reaching given number of generations.

TASK STATEMENT

The goal of this laboratory exercise is to get You familiar with fundamentals of genetic approach to optimization. The task for You is to solve discrete knapsack problem using genetic algorithm.

The problem must be solved for N=10 and N=15.

For implementation use the methods pointed out in the above section (roulette wheel selection, one point crossover, 1 bit mutation).

The volumes and benefits values You are selecting individually.

Examine influence of the following aspects on the convergence, and quality of the solution:

a) Population size,
b) Number of pairs being crossed over,
c) Chromosome size (N).

REPORTS

Reports must contain:

a) Problem description
b) Program code and executable file in case of not using MATLAB
c) Solution of the problem obtained for various parameters (look above).

All steps of implementation must be commented and discussed.

Report must be uploaded to e-learning platform (platforma.polsl.pl), not later than a week after completing the laboratory (scheduled laboratory date).