Autonomous Intelligent Systems,
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Exercises for Artificial Life (MA-INF 4201), SS11

Exercises sheet 8, due: Mon 20.06.2011

5.6.2011

Group	Name	48	49	50	51	52	53	54	$\sum$

Assignment 48 (2 Point)

Name, and describe at least three advantages of evolutionary algorithms.

Assignment 49 (1 Point)

Draw a typical development of the best fitness within the population (performance graph) during an evolutionary algorithm working with a deterministic rank based, elitism, $(\mu + \lambda)$-strategy with no mutation for the parents.

Assignment 50 (3 Points)

The inheritance operator, 1-point-cross-over of an evolutionary algorithm is producing λ offspring out of the $\mu = 2$ parents (p_1, and p_2).
The genomes of the parents, and the offspring are binary vectors of length L. The Hamming distance between the two parents p_1 and p_2 is exactly 1.

How large is the percentage of offspring that are identical to either parent p_1 or p_2?

How will the result change, if the Hamming distance between the parents is 2?

Assignment 51 (2 Point)

Determine a formula that calculates the probability ω_i for an individual i to be chosen as parent. The rank of the individual i shall be $r(i)$, the size of the population is P. The selection shall be probabilistic, fitness dependent, rank depending using the *Wheel-of-Fortune* method.

Assignment 52 (2 Points)

Explain what a so called *super-individual* is and why it should be avoided. Describe two methods to avoid it.

Assignment 53 (4 Points)

Describe the overall idea and the stucture of evolutionary algorithms, and discuss advantages and problems of EAs using the example of producing soft-drinks. Describe all essential steps that you propose for the EA with respect to the given task, and propose a setting of the relevant EA parameters whenever appropriate.

The soft-drink shall consist of water, sugar, carbon dioxyde and a mixture of additives. The task for the EA is to determine a mixture of additives to gain a *good* soft-drink. The mixture of additives can consist of up to $A = 20$ ingredients, out of possible $M = 50$ ingredients; None of the ingredients shall exceed 10% of the mixture.

Assume further, that you have access to a large pool of students, that are willing to test, and judge the quality of your creation.

Assignment 54 (1 Point)

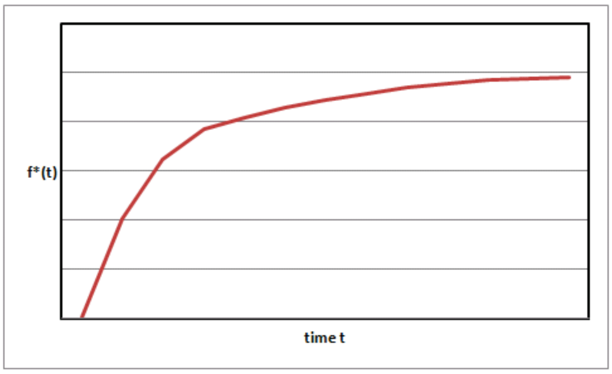
Find, and describe an application where an evolutionary algorithm can make sense, that has nor been mentioned in the lecture so far.

Assignment 48

Advantages of Evolutionary Algorithms:

1. provides quick solutions - whilst optimum search algorithms might take a long time to find the solution, EA is able to produce solutions fast, even if they are suboptimal. This means that an interruption of EA processing will still provide some solution, instead of providing none (optimum search) where time is of essence.
2. provides good solutions for nasty functions where no other good algorithm (like gradient descent) is known to work for
3. offers a framework such that it is comparably easy to incorporate prior knowledge about the problem.

Assignment 49



Assignment 50

How large is the percentage of offspring that are identical to either parent p1 or p2?

100% of the offsprings will be identical to the parents.

How will the result change, if the Hamming distance between the parents is 2?

50% to 100% of the offsprings will be identical to the parents, depending on the selection of parents and the position of the split. If L is large enough and you run many simulations, the probability approximates $\frac{2}{3}$(66%).

Explanation: The two bit flips (Hamming distance=2) divide the genome into three zones. The first and the last zone contain the flipped bit while the middle zone is always equal. The genome is *not* identical if the cross-over is chosen to be in the middle zone. The average probability (depending on the parents and the bit flips) of this is one third.

Eg.

Hamming distance = 1 produces *100% match*, ie. binary genomes that are genetically closest produce no variety in their offsprings.

2 bit vectors	3 bit vectors	4 bit vectors
`Parents:`	`Parents:`	`Parents:`

0|1 0|0 Produce offsprings: 00 01	11|0 OR 1|10 01|0 0|10 Produce offsprings: 110 010	1|110 OR 11|10 OR 111|0 1|111 11|11 111|1 Produce offsprings: 1111 1110

Hamming distance = 2 produces *50% - 100% match*

2 bit vectors	3 bit vectors	4 bit vectors
Parents: 1|1 0|0 Produce offsprings: 10 01 00 11	Parents: 11|0 OR 1|10 01|1 0|11 Produce offsprings: 111 010 110 011 Parents: 00|0 0|00 01|1 0|11 Produce offsprings: 001 010 000 000 011 011	Parents: 1|010 10|10 101|0 0|000 00|00 000|0 Produce offsprings: 1000 1000 0010 0010 1010 1010 1010 0000 0000 0000 Parents: 1|010 10|10 101|0 0|110 01|10 011|0 Produce offsprings: 1110 0010 1010 1010 1010 0110 0110 0110

Assignment 51
TODO

Assignment 52
A super-individual is an instance of the population with an outstanding fitness value. If the parent selection and/or the external selection is fitness based, the super individual will soon dominate the entire population and hence will limit the diversity of the population which is important for exploration. This is especially bad if the super-individual reflects a local maximum. A counter measure is to assure that a certain amount of diversity will be preserved. This can be achieved eg. if duplicates (of the super-individual) are removed of the population or if the external/parent selection is not only fitness based but also includes random instances.

Assignment 53

Population

P = 100, population size kept constant.

The genome is a vector of length 50:

> genome x = $(x_1, x_2, \ldots, x_{50})$,
>
> where x_i stands for the percentage amount of an additive a_i in the mixture (min 0% - max 10%) and the sum of all additives equals 100%. At any time, no more than 20 additives can be set.
>
> Example genome with 11 additives out of 50 are set:
>
> (10,10,10,10,5,5,10,10,10,10,10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)

Given the a priori knowledge, we can deduce that the maximum number of additives per mixture is 20 and the minimum is $\frac{100}{10}$ = 10. We shall hence instantiate an initial population of 100 individuals of 10 additives set to maximum value (we leave it to the inheritance to generate other values in between and genomes of different number of additives set).

Inheritance

k=2 parents, offspring genome calculated from the mean of the 2 parents. Eg.

(10,10,10,10,10,10,10,10,10,10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)

+

(0,0,0,10,10,10,10,10,10,10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,10,10,10)

=

(5, 5, 5, 10,10,10,10,10,10,10,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,5,5,5)

Mutation

We randomly pick 2 positions in the genome and switch values with a probability of 0,1.

Selection strategy

Fitness based elitism. We throw away illegal genomes where more than 20 additives are set. Rank proportional (wheel of fortune). Take the best μ individuals (μ + λ), with λ = 20, μ = 80.

Fitness function

Each student grades the soft drink on a scale of 0-4 (maximum grade is 4). Fitness function hence calculates the mean grade of the pool of students:

$$f(x) = \frac{\sum grade(x)}{no.of\ pupils}$$

Finishing

Algorithm stops when fitness no longer improves or the mean performance of the best 5 individuals is > 3.

Assignment 54

One example that became quite popular in 2008/2009 is the "Evolution of Mona Lisa" where genetic programming was used for polygon rendering:

http://rogeralsing.com/2008/12/07/genetic-programming-evolution-of-mona-lisa/

The procedure is described in 5 steps:

0) Setup a random DNA string (application start)
1) Copy the current DNA sequence and mutate it slightly (inheritance, mutation)
2) Use the new DNA to render polygons onto a canvas
3) Compare the canvas to the source image (fitness evaluation)
4) If the new painting looks more like the source image than the previous painting did, then overwrite the current DNA with the new DNA (external selection)
5) repeat from 1

Population size: 2 (parent + child)
External selection: only keep best individual
Fitness evaluation: pixel-by-pixel compare of the individual to the target image (mona lisa)
Mutation: Randomly add or remove points. Randomly change brush color (red/blue/green/alpha) and the points that contain to each polygon.