Evolutionary Algorithms

Practical Assignment 2

Real-Valued Optimization Using Evolution Strategies

In this Practical Assignment you are presented with a Large-Scale Multi-Disciplinary Mass Optimization in the Auto Industry. This problem consists of a function with real-valued input parameters that is to be minimized:

\[ f(x) \rightarrow \min, \ x \in \mathbb{R}^N \]

subject to \(0 \leq x_i \leq 1\), for all \(i \in \{1, \ldots, N\}\)

with \(N = 124\) (i.e., a 124-dimensional search space)

and 68 inequality constraints of form \(g_i(x) \leq 0\). (\(g_i(x) > 0\) means the constrain is violated)

The aim of this problem is to find the best solution which can minimize the fitness value and also violate less constrains. The problem can be found in the file PA2.zip, to be downloaded from http://natcomp.liacs.nl/EA/pa/PA2.zip.

Assignment

Implement an Evolution Strategy (ES) in MATLAB using \((\mu + \lambda)\)-selection to optimize these problems. The choice between plus or comma selection can be made beforehand, or depending on what you discover to deliver the best results w.r.t. the given optimization problems. Your algorithm should be able to operate on arbitrary values of \(\mu\) and \(\lambda\).

Describe your implementation by means of pseudocode, accompanied by a textual explanation, providing the possibility for the reader to easily re-implement the ES exactly as you did and re-creating/verifying your results. Report on the performance of your algorithm, presenting the average performance over 10 runs on the test problems, using a budget of 2,000 function evaluations.

Please note, because it is not easy to get a feasible improvement for this problem, 3 violations of constrains is allowed and the final formula we used to compare your results is:

\[ F = f(x) + 2 \times \text{number of } (g_i(x) > 0) \]

Deadline: before Friday 5 December 2014, 5pm.

Your submission should consist of two files (no more, no less): a report in PDF format (≥4 pages) and the ES implementation in MATLAB. These are to be
1) sent by email to z.yang@liacs.leidenuniv.nl;
2) delivered in print to room 160, or put in mailbox of Zhiwei Yang in room 156.

Read carefully the MATLAB Implementation Details and the Report Structure Guidelines provided below.
MATLAB Implementation Details

Your ES implementation should consist of one .m file named `lastname1_lastname2_es.m` (replacing lastname1 and lastname2 by your own names) and should be structured as follows:

```matlab
function [xopt, fopt, gopt] = lastname1_lastname2_es(fitnessfct, N, lb, ub, eval_budget)

... end
```

Here, `fitnessfct` is a handle to the fitness function, $N$ denotes the dimensionality of the input to `fitnessfct`, $lb$ is an $N$-dimensional row vector of lower bounds, $ub$ is an $N$-dimensional row vector of upper bounds, and `eval_budget` denotes the function evaluation budget; $xopt$ is the best solution found, $fopt$ the accompanying best fitness value and $gopt$ the accompanying best constrains.

The `mopta08` fitness function is of the following form:

```matlab
[f, g] = mopta08(x)

... End
```

Where $f$ is the fitness and $g$ is a vector of constrains.

For windows and linux, we have different versions of `mopta08.exe` and `mopta08.m`. You can see it from the PA2.zip. The input.txt and output.txt are used for the evaluation function.

The implementation should start from the start point given by `start.txt`.

To run your ES on `mopta08` with $N=124$, $lb=[0]^N$, $ub = [1]^N$, and a budget of 2000 function evaluations you type

```matlab
[xopt, fopt, gopt] = lastname1_lastname2_es(@mopta08, 124, zeros(1,124), 1 * ones(1,124), 2000)
```

The `mopta08` functions expect an $N$-dimensional row vector $x$ as input (i.e., a vector with a single row and $N$ columns).

We will compare all submissions using an automated script, this requires all plotting, printing to the command line etc. to be disabled in the submitted version of your work! Submit one ES, and configure it to the tested settings that you found to perform best.
Report Structure Guidelines (≥4 pages)

Title + Authors (names, email addresses, and student numbers)

Introduction

Introduction text here.

Problem Description

Brief description of the optimization problem here.

Implementation

Outline of your algorithm, algorithm parameters, and settings used for those parameters. Make sure that the algorithm and the results are reproducible from your description.

Experiments

Description of the experiments and the results. Use the following tables and figures to report on the results:

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>ES configuration A</th>
<th>ES configuration B</th>
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<tbody>
<tr>
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<td>Avg</td>
<td>Std dev</td>
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</table>

Table 1: Final solution quality after 10,000 function evaluations, averaged over 20 runs

![Performance on Benchmark Problem 1](image)

Figure 1: Algorithm convergence, averaged over 20 runs

Make sure to present your results in a way that is convenient to the reader, do not blindly include plots of all your experiments, try to combine data in figures!

Discussion and Conclusion

Summarize the results and conclude your report.