ECTA Homework 3
Shape Matching Problem

YOUR NAME, your.email@h-brs.de

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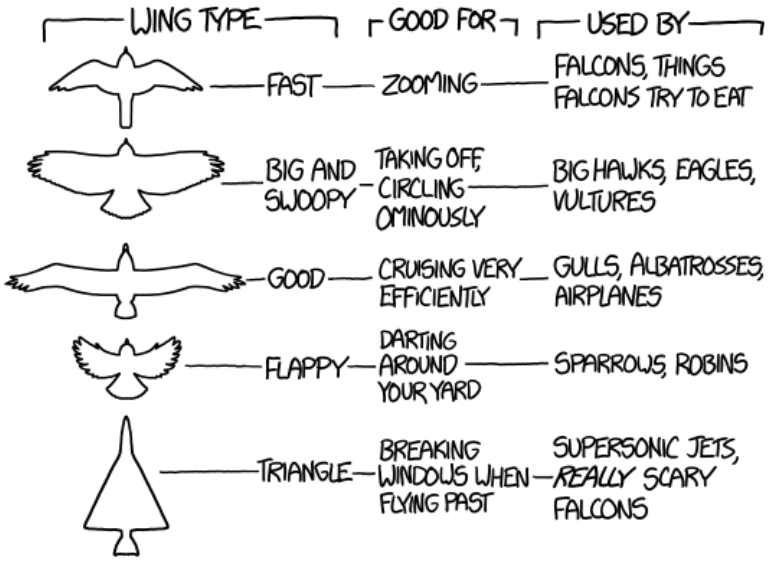

To optimize wings, it is useful to start with known design and then adjust them to specific tasks. How to convert from one representation to another? In this assignment you will convert the 4-dimensional NACA wing specific representation into a general B-Spline representation with 32 control points. You will compare 2 evolutionary methods, Genetic Algorithms and Evolution Strategies.

1 Assignment Description

Shape Matching Problem

1. Write your own Genetic Algorithm to solve the shape matching problem
2. Write your own version of the Covariance Matrix Adaptation Evolution Strategy (CMA-ES) to solve the shape problem.
3. Compare the performance of the two algorithms on three airfoils (NACA airfoil shapes: 0012, 5522, 9735). Is there a significant difference between a GA and an ES?

- Grading Scheme
  - ☐ Genetic Algorithm (20 pts)
    - ☐ Bitstring *or* Real-Valued (20 pts)
    - ☐ Bitstring *and* Real-Valued (+10pts)
  - ☐ Evolution Strategies (60 pts)
    - ☐ ES with 1/5 rule (30 pts)
    - ☐ CMA-ES with out evolution paths (30 pts)
    - ☐ CMA-ES with evolution paths (+10)
  - ☐ Comparisons (20 pts)
    - ☐ Big beautiful wall of data

2 Submission Instructions

To be perfectly clear we expect two submissions to LEA:

1. 1 PDF (report) – a modified version of your submission PDF, with your own code snippets, figures, and responses inserted
2. 1 ZIP (code and data) – a .zip file containing all code use to run experiments (.m files) *and* resulting data as a .mat file
3. Make sure to follow the naming scheme HW_NUMBER_LASTNAME1_LASTNAME2.suffix
4. → A valid name would be HW_02_Smith_Fernandez.pdf
5. Make sure both team members use the same filename!

3 The Assignment

3.1 Genetic Algorithm

- Genetic Algorithms are typically represented by a string, this string could take many forms, such as bitsrings or real-valued numbers. What are the advantages and disadvantages of each encoding in this application? How would you convert each into 32 real-valued numbers? How could you perform crossover and mutation in each? Which do you think would be best?

  1. Bitstring
     Your text here
  2. Real-valued
     Your text here

- Implement the encoding you think will perform best and plots its median performance over 20 iterations, using 20,000 evaluations.
  Your plot here

- ****Extra Credit**** Implement both encodings and compare them on matching task for <u>one</u> of the shapes. Is one significantly better? Can you explain why?
  Your text here + a figure w/significance here

3.2 Evolution Strategies

- CMA-ES is an advanced version of ES. As a first step implement a simple ES first.
  - In this ES mutation of all parameters should have equal strength which is adjusted by the 1/5th rule.
    (*every N generations change mutation strength: if* $> 1/5$*th of mutations resulted in an better fitness (i.e. a best solution) increase mutation strength, otherwise decrease mutation strength*). Test your implementation on one of the shapes.
  - Compare to your best GA. Is one significantly better than the other?
    Your text here + a figure w/significance here

- Now program CMA-ES without evolution paths.
  - Compare to your ES results. Is a there a significant improvement?
    Your text here + a figure w/significance here

- ****Extra Credit**** Now program CMA-ES with evolution paths.
  - Compare to your previous CMA-ES results. Is a there a significant improvement?
    Your text here + a figure w/significance here

3.3 Comparisons

Produce one plot which shows the performance of each algorithm. Run each algorthm 20 times on each shape (NACA airfoil shapes: 0012, 5522, 9735), with a budget of 20,000 function evaluations. For each run record the best ever found individual at each evaluation. For each algorithm plot the median fitness of this best ever individual. This may take some time, write a script to run and collect this data. The following should be on this plot (leaving out any algorithms you chose not to implement):

1. Binary GA
2. Real-Valued GA
3. ES
4. CMA-ES (without evolution paths)
5. CMA-ES (with evolution paths)