

# Nature Inspired Search and Optimisation

## Exercise 1

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The assignment is to make an algorithm for the function

$$f(x) = y \tag{1}$$

### 1 Describe a suitable chromosome representation of an individual

There are three possible options for representation: Binary, Gray coding and real-valued. The value for  $x$  in the given function 1 will most likely be on a continuous scale and possibly floating point.

Binary can up to double the real value with a single mutation which, though possibly advantageous during the initial search stages, may cause massive variations while fine tuning final stages of find local minima.

Due to these Hamming Cliffs, binary coding would not be a suitable for this function. Gray coding would overcome this problem as adjacent integers can be reached by a single bit-flip; This means that, using Gray coding, changing a single bit causes a small change in the value of the real number it represents.

Despite this, Gray coding is the most difficult for a human to understand as real numbers and binary are more common place. Both binary representations also have the flaw of string size as, for a floating point number, the string length required to maintain accuracy grows exponentially. For example:

Given domain  $[2,2]$  and precision of 6 decimal places Divide domain  $[2,2]$  into 4 1000000 intervals We need 22 bits ( $4 * 1000000 \leq 2^{22}$ ) Whereas for real values, we would only need 7.

For these reasons combined I have decided to use real-valued representation. This will cause the recombination functions to be more complex but will be easier for user to follow while maintaining small mutations and conserve memory.

## 2 Design a suitable fitness function

A fitness function should maximise the fitness of the best solution. Because of this, the mathematical result of the fitness function should be greatest when  $f(x)$  is closest to 0.

$$y - |f(x)| \quad (2)$$

?? will be my fitness function as the further from  $y$   $f(x)$  is, the smaller the result is. The maximum fitness possibly by this function is 0.

## 3 Describe what evolutionary operators you would use

The assignment states that we are to find all vectors  $x$  that satisfy equation 1. This means that my evolutionary algorithm can find multiple local minimum. For this I need an evolutionary operator that quickly searches the a large search space then converges on local

Intermediate recombination For this reason I will use Discrete Recombination, specifically quadratic recombination mean.

$$x'_j = \frac{1}{2} \cdot \frac{(x_2j^2 - x_3j^2)f(x_1) + (x_3j^2 - x_1j^2)f(x_2) + (x_1j^2 - x_2j^2)f(x_3)}{(x_2j - x_3j)f(x_1) + (x_3j - x_1j)f(x_2) + (x_1j - x_2j)f(x_3)} \quad (3)$$

Equation 2 shows quadratic recombination for three parents.

This will find the parabola connecting 3 current points and produce a single child at  $\min(x)$  of that parabola.

## 4 Describe the selection scheme you would use

*Tournament*( $\mu + \lambda$ )-selection.  $\mu$  parents generated by Fitness Proportional Selection with a scaled fitness function

Fitness Proportional Selection

Exponential Scaling:

$f(x) := \exp(f(x)/T)$ , where  $T > 0$

- 5 Describe the experiments that you would carry out and the quantities that you would report to assess your solution. (You do not need to implement this but you need to describe your design.)