

F21BC – Biologically Inspired Computation
CW2 – Evolving Artificial Neural Networks
Dr. Patricia A. Vargas

Overview

For this assessment you are being formed into groups of one or two students.

Each group will develop a program to **evolve** a **MLP** (Mutli-Layer Perceptron) artificial neural network for a task of function approximation. The functions to be approximated are named: linear, cubic, sine, tanh, xor and complex. Data will be provided separately for each function on a txt file format.

Function name	Equation
linear	$y = x$
cubic	$y = x^3$
sine	$y = \sin(x)$
tanh	$\tanh(x)$
xor	$y = x_1 \oplus x_2$
complex	$y = 1.9 \{ 1.35 + e^{x_1 - x_2} \sin[13(x_1 - 0.6)^2] \sin[7x_2] \}$

The program should allow you to:

1) Choose the MLP parameters to be evolved:

- the weights, the activation function or both

2) Choose the evolutionary parameters:

- crossover rate
- mutation rate
- initial population size
- max number of iterations

3) Visualise on running time the graphs of:

- the desired output and the ANN output for each function

- the mean squared error (MSE) = $\frac{1}{n} \sum_{i=1}^n (d_i - u_i)^2$

where:

n – max number of samples

d – desired output

u – output of a neuron on the output layer

The MLP topology will not be explicitly evolved (*). Therefore, all MLPs will have the same topology:

- one or two neurons at the first layer (will depend on the input function)
- one hidden layer with 5 neurons
- one neuron at the output layer

Only the weights of the MLP and the activation function of each neuron could be evolved (*).

Here is the list of activation functions that should be used during the evolutionary process:

Number	Activation function name	Equation
0	Null	0
1	Sigmoid	$\frac{1}{1 + \exp(-x)}$
2	Hyperbolic Tangent	$\tanh(x)$
3	Cosine	$\cos(x)$
4	Gaussian	$\exp\left(-\frac{x^2}{2}\right)$

The population of MLPs should be created randomly at the beginning of the evolutionary process. The weights should be initialized from random values inside an interval chosen by the user. The max interval should be restricted to [-5,+5].

The data containing the functions to be approximated will be provided on separate files.

The best MLP evolved (minimum MSE) over 50 runs for each function in comparison to all other groups will receive an extra 10% increase on its total Coursework 2 mark (up to a 100).

HAND_IN: Each group will be asked to hand in on the 16th of November, at the School Office, before 3pm:

- a hard copy of a **1500** words report on your results and program development rationale (please check marking scheme below).
- a CD with the program code and an electronic copy of the report.

PLEASE CONTACT PATRICIA VIA EMAIL TO p.a.vargas@hw.ac.uk TO INFORM WHETHER YOU ARE GOING TO WORK ALONE OR WITH SOMEONE AND YOUR NAMES by at most by the 22nd of October. No group changes will be allowed after that date. Please use the subject "BIC – CW2 – Groups"

What you must do:

1. Develop a program for the **task**. Marks are awarded for creativity and performance as well (please check marking scheme below).
2. Hand in **the 1500** words report about your program development rationale. We expect your written submission to do more than merely summarise your program code but to explain in details the technique or framework you have

employed or used as an inspiration to create your program and detailed discussion on the of results for each function. Of course I also expect some evidence you have READ about your topic (reference real papers and books please and not only websites and NO Wikipedia).

Your report should contain the following sections:

- 1- Introduction
- 2- Program development rationale
- 3- Methods
- 4- Results
- 5- Discussion and conclusion
- 6- References

3. Please read carefully the marking scheme on the next page.

(*) FOR MASTER STUDENTS ONLY:

All tasks above plus:

You should also evolve the MLP topology for each function.

Therefore, it is expected that the resultant MLPs will have different topologies in terms of number of neurons at the first layer, number of hidden layers and number of neurons on the hidden layer(s). You should add a schematic of the best MLP's topology evolved for each function in your report.

IMPORTANT: All MLPs must be fully connected irrespective of the evolved topology.

Marking scheme: This assessment scores **20%** of the overall course assessment.

REPORT	A (100%)	B(<80%)	C(<60%)	D(<40%)	Final
Content					
15	Very clear; make use of relevant material	Clear; make use of some relevant material	Not so clear; some relevant material is missing	Unclear; no relevant material	
Rationale/ Discussion					
20	Strong evidence of use of techniques learned during the course; creativity	Some evidence of use of techniques learned during the course; some creativity	No evidence of use of techniques learned during the course; some creativity	No evidence of use of techniques learned during the course; no creativity	
30	Strong evidence of reading and thought. Very good analysis of the results.	Evidence of reading and thought. Good analysis of the results.	Some evidence of reading and thought. Weak analysis of the results.	No evidence of reading and thought. No analysis of the results.	
Performance					
20	Task is well accomplished for all 6 functions.	Task is well performed in less than 5 of the functions.	Task is well performed in less than 3 to the functions.	No satisfactory result achieved for any of the functions.	
App/Style					
10	Report very well structured and divided into sections; consistent use of font Arial, size 12.	Report well structured and divided into sections; use of font Arial, size 12.	Report structured and but not divided into sections; use of different fonts and sizes.	No structure and no division into sections; use of different fonts and sizes.	
References					
5	Perfect use of the Harvard Referencing Style.	Use of the Harvard Referencing Style.	Mix use of referencing styles.	No referencing style.	
Total = 100					