University of Exeter

College of Engineering, Mathematics and Physical Sciences

ECM2423 – Artificial Intelligence & Applications

Course Work

Hand-in Date: 8th March 2017
Submission: Paper & Electronic

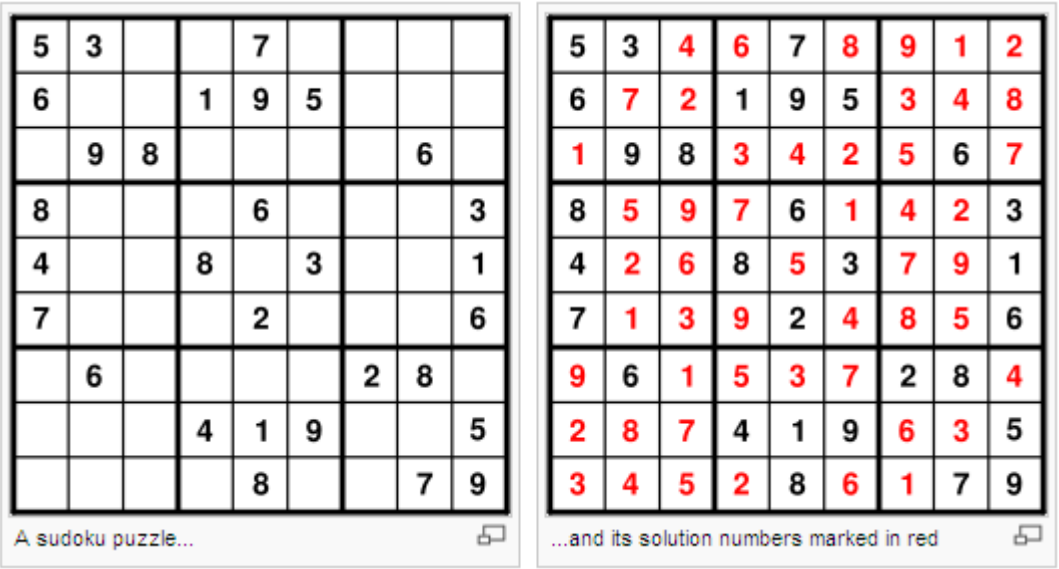
This course work comprises 20% of the overall module assessment. This is an **individual** exercise, and your attention is drawn to Taught Faculty's guidelines on Cheating and Plagiarism[1].

[1] http://as.exeter.ac.uk/support/admin/taught/studying-rulesandregulations/academicmisconduct/

PROBLEM STATEMENT

This assignment consists of designing, implementing, analysing experimentally and writing a report on an *evolutionary algorithm* to solve *Sudoku puzzles*.

In a *Sudoku puzzle*, the objective is to fill a 9×9 grid with digits so that each column, each row, and each of the nine 3×3 subgrids that compose the grid contains all of the digits from 1 to 9, from an initial partially competed grid.



5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

A sudoku puzzle...

5	3	4	6	7	8	9	1	2
6	7	2	1	9	5	3	4	8
1	9	8	3	4	2	5	6	7
8	5	9	7	6	1	4	2	3
4	2	6	8	5	3	7	9	1
7	1	3	9	2	4	8	5	6
9	6	1	5	3	7	2	8	4
2	8	7	4	1	9	6	3	5
3	4	5	2	8	6	1	7	9

...and its solution numbers marked in red

source: Wikipedia

An *evolutionary algorithm* is a general problem solving framework inspired to biological evolution. The pseudocode of an evolutionary algorithm is reported below.

```
BEGIN
  INITIALISE population with random candidate solutions;
  EVALUATE each candidate;
  REPEAT UNTIL ( TERMINATION CONDITION is satisfied ) DO
    1 SELECT parents;
    2 RECOMBINE pairs of parents;
    3 MUTATE the resulting offspring;
    4 EVALUATE new candidates;
    5 SELECT individuals for the next generation;
  OD
END
```

WHAT YOU NEED TO DO

1) Choose an appropriate solution space and solution representation.

2) Define an appropriate fitness function.

3) Define a crossover operator for the chosen representation.

4) Define a mutation operator for the chosen representation.

5) Choose an appropriate termination criterion.

6) Implement an evolutionary algorithm in Python following the pseudocode given in the previous section and the problem-specific components above.

7) Run experiments for the three Sudoku grids provided on the ELE page, for population sizes 10, 100, 1000, 10000. Each experiment (i.e., a specific combination of grid and population size) needs to be ran 5 times (each one with a different random seed) and average performance across runs considered. In total these amount to 3 x 4 x 5 = 60 runs.

8) For the analysis of results, answer the following questions:
a. What population size was the best?
b. What do you think is the reason for your findings in question 8.a?
c. Which grid was the easiest and which the hardest to solve?
d. What do you think might be the reason for your findings in question 8.c?
e. What further experiments do you think it may be useful to do and why?

9) Write a report (maximum 4 A4 sides) covering each of the above points and providing clear justification for all you design decisions. *The report must have a separate section for each of the above points.*

DELIVERABLES

The deliverables for this coursework comprise both electronic and paper submissions.

Paper: Submit your report on paper to the Education Office using BART. Submissions must be made by 12pm (noon) on the date indicated on the front page of this document.

Code: Submit your **clearly commented** python code **including clear instructions for executing your programs** as a zip via the web submission system at empslocal.ex.ac.uk/submit/ for work item “ECM2423 CW Technical Exercise”.

MARKING CRITERIA

This assessment will be marked using the following criteria:

Design (20%): the degree to which the report contains well-justified and well-described design of all the components of the evolutionary algorithm;

Program (20%): the degree of correctness of the code, including comments and any documentation; the degree to which the README file includes details on how to replicate the results in your submitted report;

Experiments (20%): the degree to which the report contains well-designed, well-described, reproducible experiments; the degree to which the report contains an understandable presentation of results, preferably with graphical illustrations;

Questions (20%): the degree to which the answers to questions contains insightful analysis of the experimental results;

Excellence (20%): the degree of additional excellence, for example, further experimentation, depth of analysis, excellence in presentation;