Lancaster University

School of Computing and Communications

SCC361 AI Coursework Part 2

Submission deadline

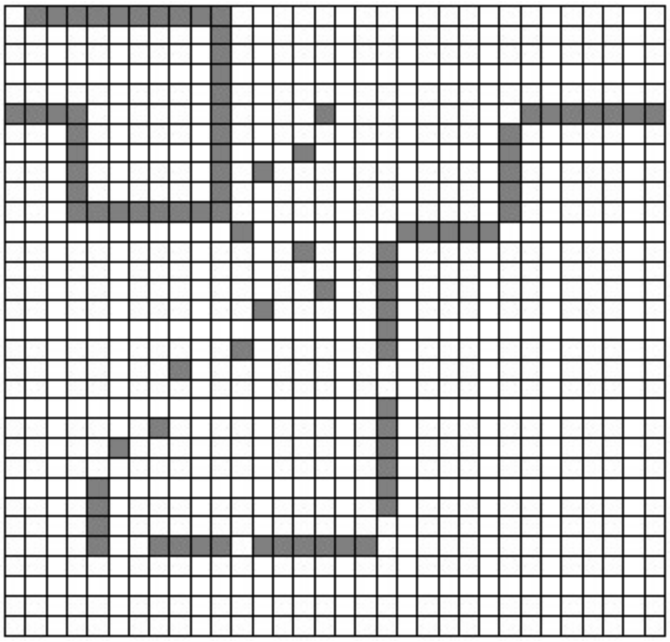
The deadline for submission is 4pm, Friday, 16 December, 2016 (end of week 10) and should be submitted electronically on Moodle. The cut-off deadline is 4pm, Monday 19 December, 2016 (with late submission incurring one grade penalty). Submissions after this deadline are not acceptable according to the University regulations. Submit your "cw1_lastname_firstname.m" file and your report on Moodle.

The length of the report should not exceed 6 pages

Task Description

You will implement a Genetic Algorithm (GA) to solve a specific problem, and show and analyse your results. These are to be done in MATLAB. GA will be introduced and discussed as part of the week 7 lecture. There will also be a lab about GA in week 7 to give you an initial understanding of the GA approach, but this task will be applying GA to a different problem than the one in the lab.

In this task, you will evolve a controller for a simulated ant. Each ant must survive on its own in a world represented by a 2D grid of cells by following trails of food. Each cell in the world either has a piece of food or is empty and the cells wrap-around (so, moving up when in the top row leaves the ant in the bottom row of the grid). Shown below is an environment (called the "John Muir" trail) that consists of a 32 by 32 grid containing 89 food cells (shown in grey).



The ant's position at any point in time can be specified by a cell location and a heading (north, south, east, or west). The ant always starts in the cell in the upper left corner, facing right (east). At the beginning of each time-step it gets one bit of sensory information: whether there is food in the cell in front of the cell it currently occupies (i.e., the cell it would move to if it moved forward). At each time-step it has one of four possible actions. It can move forward one cell; turn right ninety degrees without changing cells; turn left ninety degrees without changing cells; or do nothing. If an ant moves onto a food-cell, it consumes the food and the food disappears; when the ant leaves that cell, the cell is empty. The fitness of the ant is rated by counting how many food elements it consumes in 200 time-steps. (An ant that consumes 10 cells worth of food receives a fitness score of 10.)

The controller for our ant will consist of a 10-state finite state machine (FSM). At each time step, the ant takes the following actions:

1. Read the sensor value.
2. The controller changes state based on the sensor value.
3. The ant takes an action indicated by the new state (which may result in a change in position).
4. If the ant is in a cell with food, the ant eats the food.

Each of the ten states in the FSM controller has a unique identifier (a number ranging from 0 to 9) and the content of that state can be represented by three digits:

Digit #	Range	Meaning
1	1-4	The action that the ant takes upon entering this state, where 1 = move forward one cell 2 = turn right ninety degrees without changing cells 3 = turn left ninety degrees without changing cells 4 = do nothing
2	0-9	If the ant is in this state and the sensor value is **false** (there is no food in the square ahead of it), then the ant will transition to the state with the unique identifier indicated by this digit.
3	0-9	If the ant is in this state and the sensor value is **true** (there is food in the square ahead of it), then the ant will transition to the state with the unique identifier indicated by this digit.

The ant begins its life with the controller in state 0. The entire genetic material for an ant thus consists of 10 states, each of which is represented by three digits, for a total of 30 digits.

Simulator

We provide you with a simulator that takes as input the genetic encoding for an ant (i.e. the string of 30 digits) and a file containing an environment, and will produce as output the trail that the ant takes and an overall fitness value. The file called "simulate_ant.m" on Moodle does this. In the file, the variable "ant_ori" specifies the ant's orientation, and 1, 2, 3, 4 represents east, north, west, south respectively.

There is also a file called "muir_world.txt" containing the Muir world shown above. The numbers in this file describe the 32x32 grid world, where 0 represents no food and 1 represents food.

What you have to do here: Perform an example run of a test ant (with a string of your own choosing) on the Muir world. For the example, clearly state the genetic string representation of your test ant and the fitness it obtains. Copy the diagram of the Muir world above, and draw the trail that the ant takes on it.

Implement Genetic Algorithm

Your main task is to implement with MATLAB a genetic algorithm that attempts to build a better ant through evolution. You cannot use MATLAB's "ga" function, so you have to implement something similar to what you did in the lab in week 7. Write your own code in a separate .m file, and call it "cw2_lastname_firstname.m" (replace lastname and firstname with your names). There is no need to change the simulator .m file.

Your algorithm should make use of multi-point crossover and mutation. In each generation, you should test the fitness of each ant (individually) in the Muir world. Begin with an initial population of at least 10 ants and run your algorithm for at least 40 generations.

You will need to make many design decisions on how to implement the algorithm and what parameter values to use. Your mark will depend not only on the code that you write but also on how well you document your design decisions. In your report, you should also answer the following questions:

What was the fitness score of the most-fit individual in the first generation in the Muir world? What was the fitness score of the most-fit individual in the last generation? Plot the fitness score of the most-fit individual in each generation.

What path did the most-fit individual in the final generation take through the Muir world? Copy the diagram of the 32x32 grid above, and draw the trail in the diagram in your report.

What was the string of 30 digits of the most-fit individual in the final generation?

Marks allocation for different components of the course work:

Code efficiency	**5**
Code commenting and writing style	**3**
Presentation and writing of the report	**3**
Understanding	**5**
Using proximity matrix, higher dimension (n>1) distance and other elements of the algorithm correctly and fully	**4**
Total:	**20**

Appendix

Requirements for a Well Written Report

Each report should contain:

1. **Title,** name, student number, course, etc., followed by an abstract.
2. **Main part**: Introduction, review of the state of the art. The description of the algorithm and how it performs, including showing results with images. For instance: "This report describes development and application of the k-means clustering algorithm to image processing data…" Give the software code that you used to obtain the results in an Appendix. A very important part of your report is the analysis of the results. For instance, what are the advantages and limitations of the algorithms that you used? How can you characterize the results? Are they accurate?)
3. **Conclusions:** should describe briefly what has been done, with a summary of the main results and outline of the possible future work.

The objective of the assignment is to conduct data analysis on a set of data, and present conclusions on the results.

What a Mark Means in Lancaster University

A (Distinction)

Critical Understanding of Topic

Excellent understanding and exposition of relevant issues; insightful and well informed, clear evidence of independent thought; good awareness of nuances and complexities; appropriate use of theory.

Structure of Research

Substantial evidence of well implemented independent research and / or Substantial evidence of well selected evidence to support argument.

Use of Literature

Excellent use of literature to support argument /points.

Conclusion

Excellent; clear implications for theory and/or practice.

Language

Excellent; a delight to read.

Structure and Presentation

Arguments clearly structured and logically developed; sensible weighting of parts; meaningful diagrams; properly formatted references.

B (Very Good Pass)

Critical Understanding of Topic

Clear awareness and exposition of relevant issues; some awareness of nuances and complexities but tendency to simplify matters; based on appropriate choice and use of theory.

Structure of Research

Some evidence of independent research reasonably well implemented and / or some evidence of identification of suitable evidence to support argument.

Use of Literature

Good use of literature to support arguments.

Conclusion

Very good; draws together main points; some implications for theory and/or practice

Language

Carefully written; negligible errors.

Structure and Presentation

Arguments clearly structured and logically developed; good weighting of parts; meaningful diagrams; properly formatted references.

C (Good Pass)

Critical Understanding of Topic

Shows awareness of issues and theories; attempts at analysis but tendency to lapse into description

Structure of Research

Some evidence of independent research reasonably well implemented and / or some evidence of identification of suitable evidence to support argument.

Use of Literature

Use of standard literature to support arguments.

Conclusion

Reasonable conclusion that summarises essay; a few implications for theory and/or practice.

Language

A few errors; generally satisfactory.

Structure and Presentation

Arguments reasonably clear but undeveloped; some meaningless diagrams or poor structure.

D (Pass)

Critical Understanding of Topic

Work shows understanding of topic but at superficial level; no more than expected from attendance at lectures; some irrelevant material; too descriptive.

Structure of Research

Insufficient evidence of independent research and / or very limited evidence used to support argument.

Use of Literature

Use of secondary literature to support arguments.

Conclusion

Conclusion does not do justice to body of essay; too short; no implications.

Language

Some errors; grammar and syntax need attention.

Structure and Presentation

Arguments not very clear; poor organisation of material; poor use of diagrams; poor referencing.

F4 (Marginal Fail)

Critical Understanding of Topic

Establishes a few relevant points but superficial and confused; much irrelevant material; very little or no understanding of the issues raised by the topic or topic misunderstood; content largely irrelevant; no choice or use of theory; essay almost wholly descriptive; no grasp of analysis with many errors and/or omissions.

Structure of Research

No evidence of independent research and / or No attempt to identify suitable evidence to support argument.

Use of Literature

Relies on a superficial repeat of class notes.

Conclusion

No recognisable conclusion.

Language

Frequent errors; needs urgent attention.

Structure and Presentation

Arguments often confused and undeveloped; no logical structure; very poor organisation of material; many meaningless diagrams; negligible referencing.

F1-F3 (Clear Fail)

Critical Understanding of Topic

Establishes a few relevant points but superficial and confused; much irrelevant material; very little or no understanding of the issues raised by the topic or topic misunderstood; content largely irrelevant; no choice or use of theory; essay almost wholly descriptive; no grasp of analysis with many errors and/or omissions.

Structure of Research

No evidence of independent research and / or No attempt to identify suitable evidence to support argument.

Use of Literature

No significant reference to literature.

Conclusion

No recognisable conclusion.

Language

Frequent errors; needs urgent attention.

Structure and Presentation

Arguments often confused and undeveloped; no logical structure; very poor organisation of material; many meaningless diagrams; negligible referencing.