TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI

VUW **VICTORIA** UNIVERSITY OF WELLINGTON

**EXAMINATIONS – 2021**

**TRIMESTER TWO**

**AIML 426**

**EVOLUTIONARY COMPUTATION AND LEARNING**

**Time Allowed:** ONE HOUR

**CLOSED BOOK**

**Permitted materials:** Only silent non-programmable calculators or silent programmable calculators with their memories cleared are permitted in this examination.
Non-electronic foreign language translation dictionaries may be used.

**Instructions:** You have one hour to work on the test paper.
There are a total of 60 marks on this test.
Attempt all questions, skip to the next question if the current one is hard.

# Questions

| | **Marks** |
|---|---|
| 1. Introduction to Evolutionary Computation | [5] |
| 2. Genetic Algorithms | [10] |
| 3. Genetic Programming | [15] |
| 4. Evolutionary Computation for Computer Vision | [23] |
| 5. Performance Evaluation | [7] |

1. **Introduction to Evolutionary Computation** **(5 marks)**

(a) **(3 marks)** Briefly describe *two* real-world examples of using evolutionary computation to solve problems.

(b) **(2 marks)** State an advantage of evolutionary computation over hill climbing.

2. **Genetic Algorithms** **(10 marks)**

(a) **(4 marks)** Briefly describe the *one-point crossover* and *flip mutation* operator in Genetic Algorithm (GA).

(b) **(2 marks)** Given a GA with *population size of 20* and *size-7 tournament selection* for parent selection, the population is found to converge very quickly and get stuck into poor local optima. How to change the parent selection to improve the GA performance?

(c) **(4 marks)** A company is selling toys. Its inventory has $Q$ toys. It receives $N$ quotes, where quote $i$ is to buy $q(i)$ toys with a total payment of $c(i)$. The company is to develop a GA to decide which quotes to accept and which quotes to decline.

The **objective** is to maximise the total payment received from the accepted quotes.

The **constraint** is that the total number of toys sold to the accepted quotes cannot exceed the inventory $Q$.

**(i)** Design and briefly describe the GA *individual representation*.
**(ii)** Design and briefly describe the GA *fitness function*.

3. **Genetic Programming** **(15 marks)**

(a) **(3 marks)** Briefly describe *three* ways to use GP to do *multi-class* classification.

(b) **(2 marks)** GP can be used as a hyper-heuristic to automatically evolve/design heuristics. Give two real-world applications of GP hyper-heuristcs.

(c) **(3 marks)** Given the terminal set $\{x_1, x_2\}$ and the function set $\{+, -, *, /\}$, which of the following symbolic regression problems can be solved by these terminal and function sets?

**(i)** $y = x_1 + x_2 * (x_1 - x_2)$

**(ii)** $y = x_1^2 - 1$

**(iii)** $y = e^{x_2} + \sin(x_1)$

(d) **(7 marks)** Chris is designing a GP to solve the following symbolic regression problem (*the true model is unknown to him, and he was only given a numeric table of $x$ and $y$ values of sufficient instances*):

$$y = x^{20} + x^{8} - x^{2}$$

The following are the parameters set by Chris ($C$ in the terminal set is a random constant):

| **Parameter** | **Value** |
|---|---|
| Terminals | $\{x, C\}$ |
| Functions | $\{+, -, *\}$ |
| Population size | 1000 |
| Number of generations | 50 |
| Maximal tree depth | 3 |
| Crossover rate | 80% |
| Mutation rate | 10% |
| Reproduction rate | 0% |
| Elitism | Top 5 |

**(i)** Identify an issue in the parameter setting.

**(ii)** It is found that the GP-evolved programs have large training errors. Explain the reason, and suggest two ways to improve the training error.

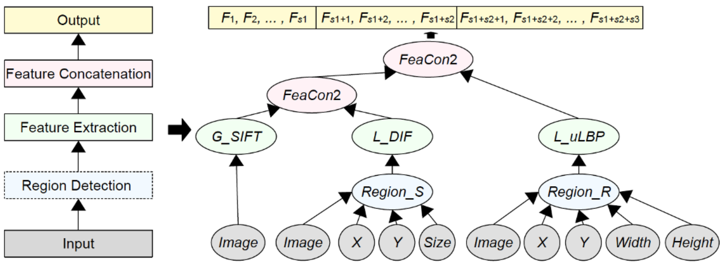
4. **Evolutionary Computation for Computer Vision** **(23 marks)**

(a) **(5 marks)** Design a $3 \times 3$ convolution kernel that can enhance brightness change along the main diagonal direction in a greyscale image.

(b) **(5 marks)** List and briefly explain all the key steps of the Canny edge detection algorithm.

(c) **(5 marks)** Draw a diagram to illustrate the neighbourhood structure used to extract the Local Binary Pattern (LBP) features when the radius parameter $r = 2$ and the pixel parameter $p = 4$. What is the dimensionality of the corresponding LBP feature vector?

(d) **(8 marks)** FLGP (feature learning GP) can evolve a GP tree that serves as an image feature extractor. Extend the GP tree representation (see the figure below) supported by FLGP such that the evolved GP tree can not only extract image features but also use the extracted features to make image classification decisions. That is, the input to the GP tree is an image with its raw pixel values and the output from the GP tree is the class label for the input image. Identify and briefly explain one potential difficulty for the GP system to evolve effective GP trees following your new tree representation.



5. **Performance Evaluation** **(7 marks)**

(a) **(7 marks)** Suppose a classifier is applied to a two-class object classification problem: **class1** and **class2**. There are a total of 200 objects for class1 and 300 objects for class2. The classifier correctly classified 160 objects for class1 and 210 objects for class2. Calculate respectively the accuracy, the error rate, the True Positive Rate (TPR), the False Positive Rate (FPR), the True Negative Rate (TNR) and the False Negative Rate (FNR) of the classifier. Assume that class1 is the positive class and class2 is the negative class.

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