COMP 5660/6660/6666 Fall 2020 Exam 1 - Canvas Quiz Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 84, but note that the max exam score will be capped at 80 (i.e., there are 4 bonus points, but you can't score more than 100%). You have exactly 50 minutes to complete this exam. Keep your answers clear and concise while complete. Good luck!

1. Mutation has the potential to modify an individual's: [4 pts]

   (a) genotype

   (b) phenotype

   (c) alleles

   (d) fitness

   Select one of:

   - a [1]
   - b [1]
   - c [1]
   - d [1]
   - **a, b, c, and d**
   - a, b, and c, but not d [3]
   - none of a, b, c, nor d [0]

2. Mutation has the potential to increase population diversity by: [4 pts]

   (a) increasing the number of unique fitness values without increasing the number of unique alleles *(true, a different distribution of the same set of alleles over the genes can result in a different phenotype and fitness value)*

   (b) increasing the number of unique alleles without increasing the number of unique phenotypes *(true, for instance if the decoder function skips a particular gene then changing that gene's allele to a unique value will not effect the phenotype)*

   (c) increasing the number of unique phenotypes without increasing the number of unique genotypes *(true, for instance if two different genotypes decoded to the same phenotype, then replacing one of those genotypes with a unique genotype which decodes to a unique phenotype doesn't increase the number of unique genotypes but does increase the number of unique phenotypes)*

   Select one of:

   - a [1]
   - b [1]
   - c [1]
   - a and b, but not c [2]
   - **a, b, and c**
   - none of a, b, nor c [0]

3. To increase selective pressure for an EA employing tournament parent selection one can: [4 pts]

   (a) switch from truncation survivor selection (i.e., deterministically replacing the worst individuals) to an elitist stochastic survivor selection

   (b) decrease the tournament size used in parent selection

   (c) increase the mutation rate

   - a [2]
   - b [2]
   - c [2]
   - a and b [1]
   - b and c [1]
   - a and c [1]
   - a, b, and c [0]
   - **none of a, b, nor c**

4. In an EA which utilizes truncation survival selection: [4 pts]

   (a) the chance of premature convergence is lower than other elitist EAs *(false because truncation survival has the highest selective pressure of all the regular elitist survival mechanisms)*

   (b) the parent selection must not be elitist because that would cause premature convergence *(elitist means that the fittest solution is guaranteed to survive so doesn't apply to parent selection and also doesn't necessarily cause premature convergence)*

   (c) the parent selection should be stochastic to decrease the chance of premature convergence

   - a [1]
   - b [1]
   - **c**
   - a and b [0]
   - b and c [2]
   - a and c [2]
   - a, b, and c [1]
   - none of a, b, nor c [2]

5. What is the binary gray code for the standard binary number 010011011? [4 pts]

   011010110

6. What is the standard binary number encoded by the binary gray code 1110001? [4 pts]

   1011110

7. Given the following two parents with permutation representation:
   $p1 = (435792168)$
   $p2 = (623571489)$ compute the first offspring with Order Crossover, using crossover points between the 2nd and 3rd loci and between the 6th and 7th loci. Show your offspring construction steps. [6 pts]

   (a) $\cdot \cdot 5792 \cdot \cdot\cdot$

   (b) **3 1 5 7 9 2 4 8 6**

8. Given the following two parents with permutation representation:
$p1 = (542176839)$ $p2 = (295463871)$ compute the first offspring with Cycle Crossover. Show first the cycles you've identified and then the construction of the offspring. [8 pts]

Cycle 1: 5-2, cycle 2: 4-9-1, cycle 3: 7-6-3, cycle 4: 8
Construction of first offspring by scanning parents from left to right, starting at parent 1 and alternating parents:

(a) Add cycle 1 from parent 1: $5 \cdot 2 \cdots\cdots$
(b) Add cycle 2 from parent 2: $5924 \cdots\cdot 1$
(c) Add cycle 3 from parent 1: $592476 \cdot 31$
(d) Add cycle 4 from parent 2: **5 9 2 4 7 6 8 3 1**

9. Given the following two parents with permutation representation: $p1 = (542176839)$ $p2 = (425913876)$ compute the first offspring with PMX, using crossover points between the 2nd and 3rd loci and between the 6th and 7th loci. Show your offspring construction steps. [12 pts]

(a) $\cdot\cdot 2176 \cdot\cdot\cdot$
(b) $\cdot 52176 \cdot\cdot\cdot$
(c) $\cdot 52176 \cdot 9 \cdot$
(d) $\cdot 52176 \cdot 93$
(e) **4 5 2 1 7 6 8 9 3**

10. Given the following parents with permutation representation: $p1 = (435792168)$
$p2 = (623571489)$ compute the first offspring with Edge Crossover, except that for each random choice you instead select the lowest element. Show how you arrived at your answer by filling the following templates: [16 pts]

Edge Table:

Element	Edges

Construction Table:

Element Selected	Reason Selected	Partial Result

Original Edge Table:

Element	Edges	Element	Edges
1	2,6,7,4	6	1,8,9,2
2	9,1,6,3	7	5+,9,1
3	4,5+,2	8	6,4+,9
4	8+,3,1	9	7,2,8,6
5	3+,7+		

Construction Table:

Element selected	Reason	Partial result
1	Lowest	1
4	Tied shortest list, so lowest	1,4
8	Common edge	1,4,8
6	Shortest list	1,4,8,6
2	Equal list sizes, so lowest	1,4,8,6,2
3	Equal list sizes, so lowest	1,4,8,6,2,3
5	Only element	1,4,8,6,2,3,5
7	Only element	1,4,8,6,2,3,5,7
9	Last element	**148623579**

Edge Table After Step 1:

Element	Edges	Element	Edges
1	2,6,7,4	6	8,9,2
2	9,6,3	7	5+,9
3	4,5+,2	8	6,4+,9
4	8+,3	9	7,2,8,6
5	3+,7+		

Edge Table After Step 2:

Element	Edges	Element	Edges
		6	8,9,2
2	9,6,3	7	5+,9
3	5+,2	8	6,9
4	8+,3	9	7,2,8,6
5	3+,7+		

Edge Table After Step 3:

Element	Edges	Element	Edges
		6	9,2
2	9,6,3	7	5+,9
3	5+,2	8	6,9
		9	7,2,6
5	3+,7+		

Edge Table After Step 4:

Element	Edges	Element	Edges
		6	9,2
2	9,3	7	5+,9
3	5+,2		
		9	7,2
5	3+,7+		

Edge Table After Step 5:

Element	Edges	Element	Edges
2	9,3	7	5+,9
3	5+		
		9	7
5	3+,7+		

Edge Table After Step 6:

Element	Edges	Element	Edges
		7	5+,9
3	5+		
		9	7
5	7+		

Edge Table After Step 7:

Element	Edges	Element	Edges
		7	9
3			
		9	7
5	7+		

The last three questions are about the Light Up Puzzle assignment assuming that the genotype representation is any set of coordinate pairs (coordinates merely need to map to the dimensions of the grid) for bulb placements and the decoder function maps these sets to bulb placements in white cells on Light Up puzzle grids where no two bulbs shine on each other, black cell adjacency constraints are met, and fitness is determined by the number of cells lit up.

11. Given a mutation operator which is restricted to moving bulbs to adjacent cells, is this problem: [4 pts]

    (a) unimodal

    (b) multimodal

    (c) either unimodal or multimodal depending on the neighborhood structure

    (d) either unimodal or multimodal depending on the recombination operator

    - a [0]
    - **b** [For example, given a 3 by 3 board of all white cells except for center cell (2,2) and corner cell (3,1) which are black but without any number constraints and a single bulb has been placed in (1,1), then that start position is a local optimum and there are additional local optima such as placing the bulb in (1,3), so therefore the problem is multimodal.]
    - c [2]
    - d [0]

12. Explain whether this encoding is pleitropic and/or polygenetic. [6 pts]

    Both, because, for example, a bulb has the potential to light up multiple cells (pleitropy) and a cell has the potential to be lit up by different bulbs (polygeny).

13. Explain whether this decoding function is surjective and/or injective. [8 pts]

    It is surjective, because the placement of bulbs in a phenotype always is a valid genotype which will be decoded to that phenotype. It is not injective, because multiple genotypes can be decoded to the same phenotype; for example, if genotype g decodes to a phenotype where all cells are lit, and g' is created by adding a uniquely placed bulb coordinate pair to g, then the decoder may decode g' to the same phenotype as g because the added bulb either is on a black cell or is shining on another bulb.