COMP 5660/6660 Fall 2021 Exam 1 Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 92, but note that the max exam score will be capped at 86 (i.e., there are 6 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. Which of the following is not a pro for using an EA: [4 pts]

   (a) Ability to obtain satisfactory solutions for many hard problems
   (b) Solution availability while solving
   (c) Robustness when dealing with noisy problems
   (d) Inherent parallelism
   (e) Ability to feasibly optimize non-differentiable problem classes

   Select one of:

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

2. Would you expect in general a change in the performance of an EA if you change λ but maintain the same total number of fitness evaluations by making a compensatory change in the number of generations? [4 pts]

   (a) no, because the EA's performance depends on its representation (genotype) and its fitness function (environment/problem) which together determine its phenotype (expression of the genotype in a given environment)
   (b) yes, because increasing λ will decrease the generational gap and therefore lead to a better exploitation of the genetic knowledge encoded in the current population
   (c) yes, because this will change the ratio of exploitation versus exploration
   (d) no, because as long as the total number of fitness evaluations remains constant, the total number of recombinations as well as the total number of mutations remains per definition constant too and therefore the EA's performance remains unchanged

   Select one of:

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

3. Fitness proportional selection suffers from the following problems: [4 pts]
   (a) when fitness values are all very close together, mediocre individuals take over the entire population very quickly, leading to premature convergence
   (b) outstanding individuals cause the selection pressure to drop because they decrease the number of slots on the virtual roulette wheel from which individuals are selected
   (c) transposed versions of the fitness function all behave identically while they represent different problems which we obviously want to be able to differentiate between

   Select one of:

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

4. One advantage of implementing survivor selection by employing a so-called reverse k-tournament selection to select who dies is that: [4 pts]
   (a) you guarantee (k)-elitism
   (b) you guarantee ($k-1$)-elitism
   (c) the probability of surviving is proportional to your fitness rank
   (d) you guarantee 1-elitism (i.e., the fittest individual is guaranteed to survive)

   Select one of:

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

5. Genetic drift and natural selection: [4 pts]
   (a) are different terms for the same concept
   (b) are different non-related concepts
   (c) complement each other because natural selection without genetic drift would select based on phenotypes without regard for genotypes
   (d) complement each other because genetic drift without natural selection results in random search

   Select one of:

   - a [0] *(false because they are different concepts)*
   - b [1] *(false because while different, they are certainly related)*
   - c [1] *false because natural selection selects based on phenotype, whether or not there is genetic drift)*
   - **d**
   - none of a, b, c, nor d [0]

6. Parameter Control is important in EAs because: [4 pts]

   (a) it somewhat relieves users from parameter tuning as parameter control tends to make EAs less sensitive to its initial parameter values
   (b) left uncontrolled, parameters may experience drift
   (c) optimal EA strategy parameter values may change during evolution
   (d) it significantly reduces the EA parameter space

   Select one of:

   - a [2]
   - b [0]
   - c [2]
   - d [0]
   - a and b [1]
   - **a and c**
   - a and d [1]
   - b and c [1]
   - b and d [0]
   - c and d [1]
   - a, b, and c [3]
   - a, b, and d [1]
   - a, c, and d [3]
   - b, c, and d [1]
   - a, b, c, and d [2]
   - none of a, b, c, nor d [0]

7. What is the binary gray code for the standard binary number 100010110? [4 pts]

   110011101

8. What is the standard binary number encoded by the binary gray code 00101101? [4 pts]

   00110110

9. Given the following two parents with permutation representation:
   $p1 = (912853647)$
   $p2 = (493175628)$
   compute the first offspring with Order Crossover, using crossover points between the 3rd and 4th loci and between the 6th and 7th loci. Show your offspring construction steps. [6 pts]

   (a) $\cdots 853 \cdots$
   (b) **9 1 7 8 5 3 6 2 4**

10. Given the following two parents with permutation representation:
$p1 = (342715896)$
$p2 = (435689127)$
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: 3-4, cycle 2: 2-5-9, cycle 3: 7-6, cycle 4: 1-8
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: $34 \cdot\cdot\cdot\cdot\cdot\cdot\cdot$
(b) Add cycle 2 from parent 2: $345 \cdot \cdot 9 \cdot 2 \cdot$
(c) Add cycle 3 from parent 1: $3457 \cdot 9 \cdot 26$
(d) Add cycle 4 from parent 2: **3 4 5 7 8 9 1 2 6**

11. Given the following two parents with permutation representation:
$p1 = (912853647)$
$p2 = (285364791)$
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) $\cdot \cdot 2853 \cdot \cdot\cdot$
(b) $6 \cdot 2853 \cdot \cdot\cdot$
(c) $642853 \cdot \cdot\cdot$
(d) $642853 \cdot \cdot\cdot$
(e) **6 4 2 8 5 3 7 9 1**

12. Given the following parents with permutation representation:
$p1 = (342715896)$
$p2 = (435689127)$
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	2,5,7,9	6	3,5,8,9
2	1,4,7+	7	1,2+,4
3	4+,5,6	8	5,6,9+
4	2,3+,7	9	1,6,8+
5	1,3,6,8		

Construction Table:

Element selected	Reason	Partial result
1	Lowest	1
2	Tied shortest list, so lowest	1,2
7	Common edge	1,2,7
4	Only element	1,2,7,4
3	Only element	1,2,7,4,3
5	Shortlest list	1,2,7,4,3,5
6	Equal list sizes, so lowest	1,2,7,4,3,5,6
8	Equal list sizes, so lowest	1,2,7,4,3,5,6,8
9	Last element	**127435689**

Edge Table After Step 1:

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

Edge Table After Step 2:

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

Edge Table After Step 3:

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

Edge Table After Step 4:

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

Edge Table After Step 5:

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

Edge Table After Step 6:

Element	Edges	Element	Edges
		6	8,9
		8	6,9+
		9	6,8+
5	6,8		

Edge Table After Step 7:

Element	Edges	Element	Edges
		6	8,9
		8	9+
		9	8+

Edge Table After Step 8:

Element	Edges	Element	Edges
		8	9+
		9	

The last three questions are about this semester's GPac Map Generation assignment series.

13. In Assignment 1c, you're using a penalty function to minimize the bias of the provided repair function. Is this bias primarily due to: [4 pts]

    (a) the path between spawn points inherent to the genotype has a biased geometry

    (b) the repair function doesn't attempt to minimize the edit distance from the genotype

    (c) the repair function relies on a closed valid representation

    (d) the repair function randomly flips bits until a valid solution is generated

    (e) because punishment is sweeter than hard work

    Select one of:

    - a [1]
    - **b**
    - c [0]
    - d [0]
    - e [0]
    - a and b [3]
    - a and c [0]
    - a and d [0]
    - a and e [0]
    - b and c [2]
    - b and d [2]
    - b and e [2]
    - c and d [0]
    - c and e [0]
    - d and e [0]
    - none of a, b, c, d, nor e [0]

14. Explain whether the GPac map encoding is pleitropic and/or polygenetic, assuming the use of the provided repair function. [6 pts]

    Both, because, a gene indicating a wall location can affect multiple other locations by activating the repair function (pleitropy) and whether a location has a wall or not can be affected by multiple genes, namely the gene associated with that location as well as other genes causing the repair function to be activated (polygeny).

15. Explain whether the GPac map decoding function is surjective and/or injective, assuming the use of the provided repair function. [8 pts]

    It is surjective, because the actual placement of walls on the map (phenotype) always corresponds with the valid genotype where each gene specifies exactly that placement. It is not injective, because multiple genotypes can be decoded to the same phenotype; for example, if genotype g specifies an empty map which decodes to the actual empty map p, and genotype g' is identical to g except for the addition of a wall in the top-left corner, then g' will be repaired to p since Pac-Man needs to spawn there.