COMP 5660/6660 Fall 2024 Exam 1 Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 70, but note that the max exam score will be capped at 66 (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. 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**

   The next two questions are about the following scenario:
   An experimenter has noticed that their EA is getting stuck in local optima on a problem, and suspects premature convergence. The EA is currently configured with k-tournament parent selection ($k = 20$), truncation survival selection, $\mu = 1{,}000$, and $\lambda = 200$, running for 1,000,000 evaluations.

2. Which changes to parent selection could reduce the chance of premature convergence? [4 pts]

   (a) Decrease k to 5

   (b) Increase k to 100

   (c) Switch to uniform random parent selection

   (d) Switch to exponential ranking parent selection

   Select one of:

   - a [2]
   - b [0]
   - c [2]
   - d [0]
   - a and b [1]
   - **a and c**; both reduce selection pressure
   - a and d [1]
   - b and c [0]
   - b and d [1]
   - c and d [1]
   - a, b, and c [2]

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

3. Which other changes could reduce the chance of premature convergence? [4 pts]

   (a) Switch to elitist survival selection
   (b) Switch to k-tournament survival selection with $k = 20$
   (c) Switch to fitness proportionate survival selection
   (d) Decrease λ to 50

   Select one of:

   - a [0]
   - b [2]
   - c [2]
   - d [0]
   - a and b [1]
   - a and c [1]
   - a and d [0]
   - **b and c**; both reduce selective pressure compared to truncation
   - b and d [1]
   - c and d [1]
   - a, b, and c [3]
   - a, b, and d [0]
   - a, c, and d [0]
   - b, c, and d [3]
   - a, b, c, and d [2]
   - none of a, b, c, nor d [0]

The following three questions use the following definition of the cutting stock problem:
The genotype is a fixed-length linear representation, with `len(shapes)` genes. Each gene is a 3-tuple `(x, y, r)` specifying the location & rotation of a specific shape. `x` and `y` are within the bounds of the stock, and `r` is within the range 0 to 3. The phenotype is a matrix indicating for each cell which shapes overlap it. Each individual cell corresponds to one phenotypic trait. This phenotype space includes every combination of shapes occupying every combination of cells. You may need to consider the existence of invalid solutions when answering the following questions.

4. Can this interpretation of the cutting stock problem exhibit pleiotropy? Why or why not? [4 pts]

   (a) No, because each gene affects the placement of one shape.
   (b) No, because shapes can have rotational symmetry.
   (c) Yes, because shapes can occupy multiple cells.
   (d) Yes, because shapes can overlap.

   Select one of:

   - a [1]

- b [0]
- c [4] One gene/shape can influence several phenotypic traits by occupying multiple cells.
- d [2]
- none of a, b, c, nor d [0]

5. Can this interpretation of the cutting stock problem exhibit polygeny? Why or why not? [4 pts]

   (a) No, because each gene affects the placement of one shape.
   (b) No, because shapes can have rotational symmetry.
   (c) Yes, because shapes can occupy multiple cells.
   (d) Yes, because shapes can overlap.

   Select one of:

   - a [1]
   - b [0]
   - c [2]
   - d [4] Multiple genes can influence the same phenotypic trait by overlapping each other.
   - none of a, b, c, nor d [0]

6. Is this interpretation of the cutting stock problem always injective? Why or why not? [4 pts]

   (a) No, because each gene affects the placement of one shape.
   (b) No, because shapes can have rotational symmetry.
   (c) Yes, because shapes can occupy multiple cells.
   (d) Yes, because shapes can overlap.

   Select one of:

   - a [2]
   - b [4] A shape with rotational symmetry means multiple alleles at that locus can occupy the exact same set of cells.
   - c [0]
   - d [1]
   - none of a, b, c, nor d [0]

7. Blend Recombination addresses the following issue(s) with recombination operators for real-valued representations: [4 pts]

   (a) Discrete Recombination has the disadvantage that only mutation can create new alleles.
   (b) Single Arithmetic Recombination has the disadvantage that as a result of the averaging process, the range of the alleles in the population is reduced.
   (c) Simple Arithmetic Recombination has the disadvantage that as a result of the averaging process, the range of the alleles in the population is reduced.
   (d) Whole Arithmetic Recombination has the disadvantage that as a result of the averaging process, the range of the alleles in the population is reduced.

   Select one of:

   - a [1]
   - b [1]
   - c [1]

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

8. n-point crossover exhibits: [4 pts]

   (a) distributional bias
   (b) convergence bias
   (c) positional bias

   Select one of:

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

9. What is the binary gray code for the standard binary number 0001000? [4 pts]

   0001100

10. What is the standard binary number encoded by the binary gray code 1110111? [4 pts]

    1011010

11. Given the following two parents with permutation representation:
    $p1 = (835269147)$
    $p2 = (314592768)$
    compute the first offspring with Order Crossover, using crossover points between the 1st and 2nd loci and between the 6th and 7th loci. Show your offspring construction steps. [4 pts]

    (a) $\cdot 35269 \cdot\cdot\cdot$
    (b) 435269781

12. Given the following two parents with permutation representation:
$p1 = (835269147)$
$p2 = (314592768)$
compute the first offspring with Cycle Crossover. Show first the cycles you've identified and then the construction of the offspring. [6 pts]

Cycle 1: 8-3-1-7
Cycle 2: 5-4-6-9-2
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: $83 \cdots \cdot 1 \cdot 7$
(b) Add cycle 2 from parent 2: 834592167

13. Given the following two parents with permutation representation:
$p1 = (835269147)$
$p2 = (314592768)$
compute the first offspring with PMX, using crossover points between the 2nd and 3rd loci and between the 7th and 8th loci. Show your offspring construction steps. [8 pts]

(a) $\cdot \cdot 52691 \cdot \cdot$
(b) $\cdot \cdot 526914 \cdot$
(c) $\cdot 7526914 \cdot$
(d) 375269148

14. Given the following parents with permutation representation:
$p1 = (835269147)$
$p2 = (314592768)$
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: [12 pts]

Edge Table:

Element	Edges

Construction Table:

Element Selected	Reason Selected	Partial Result

Original Edge Table:

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

Construction Table:

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

Edge Table After Step 1:

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

Edge Table After Step 2:

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

Edge Table After Step 3:

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

Edge Table After Step 4:

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

Edge Table After Step 5:

Element	Edges	Element	Edges
		6	2,9,7
2	6,9,7	7	2,6
		8	7,6
		9	6,2

Edge Table After Step 6:

Element	Edges	Element	Edges
		6	2,9
2	6,9	7	2,6
		9	6,2

Edge Table After Step 7:

Element	Edges	Element	Edges
		6	9
2	6,9		
		9	6

Edge Table After Step 8:

Element	Edges	Element	Edges
		6	9
		9	