COMP 5660/6660 Fall 2022 Final Exam Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 130, but note that the max exam score will be capped at 124 (i.e., there are 6 bonus points but you can't score more than 100%). You have exactly two-and-a-half hours to complete this exam. Keep your answers clear and concise while complete. Good luck!

1. When using k-tournament without replacement for survival selection: [4 pts]

   (a) the k fittest individuals are guaranteed to survive
   (b) the most fit individual is guaranteed to survive
   (c) the k least-fit individuals are guaranteed to not survive
   (d) the $k-1$ least-fit individuals are guaranteed to not survive

   Select one of:

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

2. A (1+1) EA is equivalent to: [4 pts]

   (a) random search
   (b) hill climber
   (c) simulated annealing
   (d) stochastic universal sampling

   Select one of:

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

3. Stochastic Universal Sampling can augment Fitness Proportional Selection by: [4 pts]

   (a) reducing sampling error
   (b) accounting for negative fitness
   (c) facilitating even selective pressure
   (d) reducing the likelihood of premature convergence

   Select one of:

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

4. In Evolutionary Strategies, the purpose of uncorrelated mutation with $n\sigma's$ rather than just one σ is: [4 pts]

   (a) to ensure proportionality between the different coordinates while allowing for an overall change of the mutability
   (b) the sum of n normally distributed variables is also normally distributed thus guaranteeing Gaussian mutation
   (c) coordinate specific step sizes provide the flexibility to use different mutation strategies in different directions

   Select one of:

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

5. Some Interactive EAs allow the user to directly modify the evolving genes and place the modified individuals back in the population. This is an example of: [4 pts]

   (a) Lamarckian Evolution
   (b) Baldwin Effect
   (c) Hyper-heuristics
   (d) Self-generating Memetic Algorithms

   Select one of:

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

6. In the context of Assignment 2c, the risk of evaluating a Pac-Man controller against a single Ghost controller is: [4 pts]

   (a) As this undersamples the opposing population in the most extreme, the Pac-Man controller's fitness estimation is almost guaranteed not representative of the true value.
   (b) There may be another Ghost who is better than the Ghost sampled against, yet Pac-Man does better against that Ghost, violating the transitive property of the Ghost fitness function.
   (c) While it does undersample the opposing population, the greatly reduced evaluation time allows for many more generations to be run, and this is always a beneficial tradeoff.

   Select one of:

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

7. Is the phenotype to fitness mapping for the Assignment 2 Series of Pac-Man vs. the Ghosts: [4 pts]

   (a) surjective
   (b) injective
   (c) bijective

   Select one of:

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

8. Which of the following statements about transitivity in competitive coevolutionary games are true: [4 pts]

   (a) Tournament-based pairing schemes are ineffective for intransitive games, because eliminated strategies might still be dominant against the champion.
   (b) Raw fitness is meaningless for intransitive games, and needs to be replaced by a surrogate fitness function.
   (c) Competitive fitness sharing is effective for intransitive games, because it rewards strategies specialized to beat otherwise undefeated opponents.
   (d) The Elo rating system is a good choice to model intransitive games, because it predicts winners based on differences in skill ratings.

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

9. In the hybridization of the GPS-EA and ELOOMS, the Limiting Cases are detected by: [4 pts]

   (a) none of the individuals desiring to mate with any individual who reciprocates that desire
   (b) the average fitness of the mating pool being higher than the average population fitness
   (c) the average fitness of the mating pool being lower than the average population fitness
   (d) none of the individuals desiring to mate with any other individual

   Select one of:

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

10. The current GP practice of strongly limiting the role of mutation in favor of recombination is because: [4]

    (a) recombination tends to increase genetic diversity in GP, unlike mutation which contrary to in standard EAs which employ a linear representation, has a tendency to destroy critical alleles
    (b) the generally shared view that in GP, crossover has a large shuffling effect, acting in some sense as a macromutation operator
    (c) mutation tends to cause excessive bloat in GP, unlike recombination which has a natural parsimony pressure effect

    Select one of:

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

11. Countermeasures to bloat in GP include: [4 pts]

    (a) increasing mutation rate to maintain genetic diversity
    (b) increasing parsimony pressure to penalize the fitness of large chromosomes
    (c) reducing the number of alleles to prevent disproportional tree growth

    Select one of:

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

12. Koza states that a parameterized topology in GP is: [4 pts]

    (a) a general solution to a problem in the form of a graphical structure whose nodes or edges represent components and where the parameter values of the components are specified by mathematical expressions containing free variables
    (b) a search landscape for tree representations whose terminal nodes take the values of input parameters
    (c) a graph representation where the terminal node input values are determined employing parameter control

    Select one of:

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

13. Panmictic mate selection in EAs has the following properties: [4 pts]

    (a) strategy parameters are fixed during an EA run
    (b) no genotypic restrictions on mating
    (c) more fit individuals mate more often
    (d) process of tuning mate selection parameters for each problem is time-consuming

    Select one of:

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

14. In Multi-Objective EAs employing levels of non-domination, increasing the number of conflicting objectives, generally will: [4 pts]

    (a) not impact the number of levels of non-domination
    (b) increase the number of levels of non-domination
    (c) decrease the number of levels of non-domination
    (d) either increase or decrease the number of levels of non-domination, depending on the amount of selective pressure

    Select one of:

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

15. A CIAO plot which is grayish (i.e., predominantly either a uniform gray or grainy gray mix of light and dark) is indicative of: [4 pts]

   (a) mediocre stability
   (b) cycling
   (c) disengagement

   Select one of:

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

16. The Iterated Prisoner's Dilemma is a game where in successive rounds, two individuals without means of communication must decide whether to defect or cooperate; this game: [4 pts]

   (a) is technically not a competitive coevolution problem because it is a single population problem
   (b) is technically not a competitive coevolution problem because it is a single species problem
   (c) is technically not a cooperative coevolution problem because it is a single population problem
   (d) is technically not a cooperative coevolution problem because it is a single species problem

   Select one of:

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

17. What is the binary gray code for the standard binary number 1000001? [3 pts] *1100001*

18. What is the standard binary number encoded by the binary gray code 0111110? [3 pts] *0101011*

19. Given the following bit strings v_1 through v_5 and schema S
$v_1 = (11101110111101)$ $fitness(v_1) = 0.3$
$v_2 = (10110010001101)$ $fitness(v_2) = 0.1$
$v_3 = (00001010011010)$ $fitness(v_3) = 1.0$
$v_4 = (01001110111001)$ $fitness(v_4) = 1.9$
$v_5 = (11001011110101)$ $fitness(v_5) = 1.7$
$S = (**************)$

   (a) Compute the *order* of S. [1 pt]
   0
   (b) Compute the *defining length* of S and show your computation. [2 pts]
   Strictly per the definition of defining length, it cannot be computed, but it has to be 0 to be consistent with the concept.
   (c) Compute the fitness of S and show your computation. [2 pts]
   $\frac{0.3+0.1+1.0+1.9+1.7}{5} = 1.0$
   (d) Do you expect the number of strings matching S to increase or decrease in subsequent generations? Explain your answer! [3 pts]
   Because S matches all possible strings, the number of strings matching S will never increase nor decrease.

20. Given the following two parents with permutation representation:
$p1 = (829137465)$
$p2 = (986375421)$
compute the first offspring with Order Crossover, using crossover points between the 3rd and 4th loci and between the 7th and 8th loci. Show your offspring construction steps. [6 pts]

   (a) Child 1: $\cdots 1374 \cdot\cdot$
   (b) Child 1: **865137429**

21. Given the following two parents with permutation representation:
$p1 = (829137465)$
$p2 = (986375421)$
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: 8-9-6-2, cycle 2: 1-3-7-5, cycle 3: 4
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: $829 \cdots \cdot 6 \cdot$
   (b) Add cycle 2 from parent 2: $829375 \cdot 61$
   (c) Add cycle 3 from parent 1: 829375461

22. Given the following two parents with permutation representation:
$p1 = (829137465)$
$p2 = (986375421)$
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) $\cdot\cdot 9137 \cdot \cdot\cdot$
   (b) $6 \cdot 9137 \cdot \cdot\cdot$
   (c) $6 \cdot 9137 \cdot\cdot 5$
   (d) 689137425

23. Given the following two parents with permutation representation:
$p1 = (829137465)$
$p2 = (986375421)$
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	9+,3,2	6	4,5,8,3
2	8,9,4,1	7	3+,4,5
3	1,7+,6	8	5,2,9,6
4	7,6,5,2	9	2,1+,8
5	6,8,7,4		

Construction Table:

Element selected	Reason	Partial result
1	Lowest	1
9	Common edge	19
2	Shortest list	192
8	Shortest list	1928
5	Equal list size, so lowest	19285
4	Equal list size, so lowest	192854
6	Equal list size, so lowest	1928546
3	Only element	19285463
7	Last element	**192854637**

Edge Table After Step 1:

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

Edge Table After Step 2:

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

Edge Table After Step 3:

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

Edge Table After Step 4:

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

Edge Table After Step 5:

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

Edge Table After Step 6:

Element	Edges	Element	Edges
		6	3
		7	3+
3	7+,6		
4	7,6		

Edge Table After Step 7:

Element	Edges	Element	Edges
		6	3
		7	3+
3	7+		

24. Say you want to purchase a new house and care most about maximizing space and affordability. You collect square footage data and pricing on ten different houses and then you normalize both the square footage data and the pricing which results in the following table, where higher space numbers indicate greater square footage and higher affordability numbers indicate lower prices:

ID	Space	Affordability
1	7	4
2	2	10
3	8	5
4	1	7
5	10	4
6	2	7
7	10	1
8	1	10
9	9	6
10	3	5

(a) List for each element which elements it dominates; indicate elements with their IDs. [3 pts]

ID	Dominates
1	None
2	4,6,8
3	1,10
4	None
5	1,7
6	4
7	None
8	4
9	1,3,10
10	None

(b) Show the population distributed over non-dominated levels, like some multi-objective EAs employ, after each addition of an element, starting with element 1 and ending with element 10 increasing the element number one at a time; indicate elements with their IDs. So you need to show ten different population distributions, the first one consisting of a single element, and the last one consisting of ten elements. [7 pts]

After adding element 1:

Level 1: 1

After adding element 2:

Level 1: 1,2

After adding element 3:

Level 1: 2,3

Level 2: 1

After adding element 4:

Level 1: 2,3

Level 2: 1,4

After adding element 5:

Level 1: 2,3,5

Level 2: 1,4

After adding element 6:

Level 1: 2,3,5

Level 2: 1,6

Level 3: 4

After adding element 7:

Level 1: 2,3,5

Level 2: 1,6,7

Level 3: 4

After adding element 8:

Level 1: 2,3,5

Level 2: 1,6,7,8

Level 3: 4

After adding element 9:

Level 1: 2,5,9

Level 2: 3,6,7,8

Level 3: 1,4

After adding element 10:

Level 1: 2,5,9

Level 2: 3,6,7,8

Level 3: 1,4,10