COMP 5660/6660 Fall 2023 Final Exam Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 98, but note that the max exam score will be capped at 94 (i.e., there are 4 bonus points, but you can't score more than 100%). You have exactly two hours 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**

2. Which of the following inherent characteristics of an EA makes it belong to the family of "embarrassingly parallel" algorithms: [4 pts]

   (a) fitness evaluations within a generation can be computed independently

   (b) runs of an EA can be computed independently

   (c) individual fitness evaluations contain independent and parallelizable operations

   Select one of:

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

3. 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]

4. 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

   Select one of:

   - 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**

5. The phenomenon of bloat in GP occurs most likely because: [4 pts]

   (a) individuals with bigger genomes have a larger chance of survival (also known as "survival of the fattest")

   (b) the variable length aspect of GP causes a natural tendency for the population to reflect the different possible sizes

   (c) the ratio of alleles to genes in bloated individuals is higher than non-bloated individuals which gives them an evolutionary advantage

   Select one of:

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

6. Over-selection is employed in GP because: [4 pts]

   (a) GP typically uses large trees which suffer from bloat
   (b) GP typically uses fitness proportionate selection which suffers from premature convergence
   (c) GP typically uses large populations which cause excessively high selective pressure

   Select one of:

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

7. A Competitive Coevolutionary Algorithm is a CoEA: [4 pts]

   (a) with two or more competing populations
   (b) where each individual competes with one or more individuals in the competing population
   (c) where individuals compete with each other to gain fitness at each others expense

   Select one of:

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

8. Mediocre stability in a competitive CoEA occurs when: [4 pts]

   (a) the convergence of the system is not very stable
   (b) the system stabilizes in a suboptimal equilibrium
   (c) cycling causes instability in the system

   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]

9. Your Assignment 2c Ms. Pac-Man versus The Ghosts problem: [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 competitive coevolution problem because the ghosts cooperate with each other

   Select one of:

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

10. A multi-population cooperative CoEA is a CoEA where: [4 pts]

    (a) each population tries to solve its own problem without harming the fitness of any of the other populations
    (b) the populations are symbiotic species
    (c) each population is a different species representing part of a larger problem

    Select one of:

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

11. What is the motivation for the automated design of crossover operators for EAs employing self-adaptation: [4 pts]

    (a) EA performance is sensitive to the choice of crossover operator
    (b) identifying & configuring best traditional crossover operator is time consuming
    (c) existing crossover operators may be suboptimal for the problem at hand
    (d) the optimal crossover operator may change during evolution

    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]

12. In Learning Classifier Systems (LCS), the Bucket Brigade algorithm is a: [4 pts]

    (a) multi-step credit allocation method to distribute reward to members of previous action sets

    (b) multi-step credit allocation method to distribute reward to members of previous match sets

    (c) multi-step credit allocation method to distribute reward to individuals of previous populations

    (d) LCS for optimizing human chain formation to pass buckets of water to put out fires

    Select one of:

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

13. On a computer system with 200 computing cores and given a population size of 100 and an offspring size of 500, employing an Asynchronous Parallel EA (APEA) for evolving GP controllers for Pac-Man: [4 pts]

    (a) may be expected to reduce run-time versus a Synchronous Parallel EA (SPEA) because a SPEA cannot utilize more cores than the offspring size while an APEA can *(while the reason given is true, it doesn't apply here because* $\lambda = 500 \geq 200 = \#$ *computing cores)*

    (b) may be expected to increase run-time versus a SPEA because an APEA cannot utilize more cores than the population size while a SPEA can

    (c) may be expected to reduce run-time versus a SPEA because a SPEA has to wait for the longest evaluation to complete while an APEA can exploit the heterogeneous evaluation times common to GP

    Select one of:

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

14. Say you want to purchase a new house and care most about maximizing space and affordability. You execute a multi-objective EA and the final population contains the solutions listed in the following table, where you're maximizing both objectives:

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

(a) List for each element which elements it dominates; indicate elements with their IDs. [4 pts]

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

(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. [12 pts]

After adding element 1:
- **Level 1:** 1

After adding element 2:
- **Level 1:** 2
- **Level 2:** 1

After adding element 3:
- **Level 1:** 3
- **Level 2:** 2
- **Level 3:** 1

After adding element 4:
- **Level 1:** 4
- **Level 2:** 3
- **Level 3:** 2
- **Level 4:** 1

After adding element 5:
- **Level 1:** 4,5
- **Level 2:** 3
- **Level 3:** 2
- **Level 4:** 1

After adding element 6:
- **Level 1:** 4,5
- **Level 2:** 3,6
- **Level 3:** 2
- **Level 4:** 1

After adding element 7:
- **Level 1:** 4,5
- **Level 2:** 3,6
- **Level 3:** 2,7
- **Level 4:** 1

After adding element 8:
- **Level 1:** 4,5
- **Level 2:** 3,6
- **Level 3:** 2,7
- **Level 4:** 1,8

After adding element 9:
- **Level 1:** 4,5
- **Level 2:** 3,6
- **Level 3:** 2,7
- **Level 4:** 1,8
- **Level 5:** 9

After adding element 10:
- **Level 1:** 4,5
- **Level 2:** 3,6
- **Level 3:** 2,7
- **Level 4:** 1,8
- **Level 5:** 10
- **Level 6:** 9

15. The n-bit multiplexer function consist of k address bits a_i followed by 2^k data bits d_j where $n = k+2^k$ and the function is defined as $a_{k-1}, \ldots, a_1, a_0, d_{2^k-1}, \ldots, d_1, d_0$. Assume a Michigan-style Learning Classifier System (LCS) to solve a 6-bit multiplexer problem with the following rule set:
Rule 1: 1##### : 0 → 50
Rule 2: 11###0 : 0 → 20
Rule 3: 0#1010 : 1 → 10
Rule 4: #11##0 : 1 → 30
Rule 5: #00100 : 0 → 60
Rule 6: ###1#0 : 1 → 50

    If the input string 111100 is presented to this LCS:

    (a) which rules will the match set consist of? [2 pts]
    Rules 1, 2, 4, 6

    (b) which rules will the action set consist of and what action will the LCS execute? Show how you computed this. [6 pts]
    Group them by advocated action and compute predicted action payoff:
    Action 0: Rules 1 & 2: Mean predicted action payoff: (50+20)/2=35
    Action 1: Rules 4 & 6: Mean predicted action payoff: (30+50)/2=40
    Highest predicted payoff action: Action 1
    Action set: Rules 4 & 6
    LCS executes Action 1

16. Given the following two parents with permutation representation:
$p1 = (475318692)$
$p2 = (524836971)$
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: 4-5, Cycle 2: 7-2-1-3-8-6-9
    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: $4 \cdot 5 \cdot \cdots$

    (b) Add cycle 2 from parent 2: 425836971

17. Given the following two parents with permutation representation:
$p1 = (475318692)$
$p2 = (524836971)$
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. [10 pts]

    (a) $\cdot\cdot 5318 \cdot \cdot$

    (b) $4 \cdot 5318 \cdot \cdot$

    (c) $4 \cdot 5318 \cdot 6$

    (d) 425318976

18. Given the following two parents with permutation representation:
$p1 = (475318692)$
$p2 = (524836971)$
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: $\cdots 3186 \cdot \cdot$

    (b) Child 1: **249318675**