# CS5401 FS2018 Exam 3 Key

This is a closed-book, closed-notes exam. The only items you are allowed to use are writing implements. Write your name in the designated spot on the top left of each of the exam pages. If you are caught cheating, you will receive a zero grade for this exam. The max number of points per question is indicated in square brackets after each question. The sum of the max points for all the questions is 42, but note that the max exam score will be capped at 40 (i.e., there are 2 bonus points, but you can't score more than 100%). This exam consists of 16 multiple-choice questions followed by two multi-part open questions. You have exactly 75 minutes to complete this exam. Good luck!

## Multiple Choice Questions - circle the letter of your choice on the exam pages

1. In Learning Classifier Systems (LCS), the Bucket Brigade algorithm is a: [2]
   (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 [1]
   (c) multi-step credit allocation method to distribute reward to individuals of previous populations [$\frac{1}{2}$]
   (d) LCS for optimizing human chain formation to pass buckets of water to put out fires [0]
   (e) none of the above [0]

2. "Intelligent" initialization in a memetic algorithm can be performed by: [2]
   (a) Seeding [$\frac{1}{2}$]
   (b) Selective Initialization [$\frac{1}{2}$]
   (c) Locally Optimized Random Initialization [$\frac{1}{2}$]
   (d) Mass Mutation [$\frac{1}{2}$]
   (e) **all of the above**
   (f) none of the above [0]

3. The Baldwin Effect is: [2]
   (a) **improved EA performance obtained by applying local search prior to fitness calculation**
   (b) improved EA performance obtained by applying local search after fitness calculation [1]
   (c) improved EA performance obtained by combining local search with Lamarckian evolution [$\frac{1}{2}$]
   (d) none of the above [0]

4. A Competitive Coevolutionary Algorithm is a CoEA: [2]
   (a) with two or more competing populations [$\frac{1}{2}$]
   (b) where each individual competes with one or more individuals in the competing population [1]
   (c) **where individuals compete with each other to gain fitness at each others expense**
   (d) all of the above [1]
   (e) none of the above [0]

5. A cooperative CoEA is a CoEA where: [2]
   (a) each population tries to solve its own problem without harming the fitness of any of the other populations [1]
   (b) the populations are endosymbiotic species [1]
   (c) each population is a different species representing part of a larger problem [$1\frac{1}{2}$]
   (d) **all of the above**
   (e) none of the above [0]

6. Mediocre stability in a competitive CoEA occurs when: [2]
   (a) the convergence of the system is not very stable [0]
   (b) **the system stabilizes in a suboptimal equilibrium**
   (c) both of the above [1]
   (d) cycling causes instability in the system [0]
   (e) none of the above [0]
7. Your Assignment Series 2 Ms. Pac-Man versus The Ghosts problem: [2]
   (a) is technically not a competitive coevolution problem because it is a single population problem [0]
   (b) is technically not a competitive coevolution problem because it is a single species problem [0]
   (c) both of the above [0]
   (d) **none of the above**
8. The Limiting Cases in the Greedy Population Sizing EA (GPS-EA) are those instances when: [2]
   (a) both populations are stuck in a local minimum and the average fitness of the larger population is higher than the average fitness of the smaller population [1]
   (b) the larger population is stuck in a local minimum but the average fitness of the smaller population is larger than the average fitness of the larger population [$1\frac{1}{2}$]
   (c) **both populations are stuck in a local minimum and the average fitness of the larger population is lower than the average fitness of the smaller population**
   (d) none of the above [0]
9. A shortcoming of the GPS-EA + ELOOMS hybrid in terms of population size control is: [2]
   (a) the lack of support for dynamic population size control [1]
   (b) that it can overshoot the optimal population size because of the stochastic nature of the doubling criterion [$\frac{1}{2}$]
   (c) its inability to reuse the high-quality individuals identified in preceding populations [$\frac{1}{2}$]
   (d) **all of the above**
   (e) none of the above [0]
10. A hyper-heuristic is: [2]
   (a) **a metaheuristic which searches algorithm space employing algorithmic primitives**
   (b) a type of Genetic Programming to automate the design of algorithms employing a Turing complete set of primitives [1] *(it can be a different type of metaheuristic than GP and typically should use higher order primitives than a Turing complete set to avoid an infeasibly large search space)*
   (c) a type of EA which employs algorithmic primitives extracted typically from existing algorithms to automate the design of algorithms [$1\frac{1}{2}$] *(it can be a different type of metaheuristic than an EA)*
   (d) all of the above [1]
   (e) none of the above [0]

11. In order for a hyper-heuristics to target not only a specific class of problems (e.g., SAT) but also a specific computational architecture (e.g., Intel Xeon processor with lots of cache): [2]
    (a) this is not possible because hyper-heuristics work independent from the computational architecture [0]
    (b) they need to reflect the efficiency of the evolved algorithm in the fitness function [1]
    (c) they need to be supplied with algorithmic primitives which not only are suited to the specific class of problems being targeted, but also allow the differences between computational architectures to be exploited [1]
    (d) **answers b and c**
    (e) none of the above [0]
12. What is the motivation for the automated design of crossover operators for EAs: [2]
    (a) EA performance is sensitive to the choice of crossover operator [$\frac{1}{2}$]
    (b) identifying & configuring best traditional crossover operator is time consuming [$\frac{1}{2}$]
    (c) existing crossover operators may be suboptimal for the problem at hand [$\frac{1}{2}$]
    (d) the optimal crossover operator may change during evolution [$\frac{1}{2}$]
    (e) **all of the above**
    (f) answers a, b, and c [$1\frac{1}{2}$]
    (g) answers a, b, and d [$1\frac{1}{2}$]
    (h) answers a, c, d [$1\frac{1}{2}$]
    (i) answers b, c, d [$1\frac{1}{2}$]
    (j) none of the above [0]
13. A CIAO plot: [2]
    (a) **visualizes the progress of two populations in competitive coevolution where the luminance of each pixel $(x, y)$ indicates the relative performance of the y-axis population's fittest individual in generation $y$ versus the x-axis populations fittest individual in generation $x$**
    (b) visualizes the relative performance of two populations in competitive coevolution where the luminance of each pixel $(x, y)$ indicates the average performance of individual $y$ from the y-axis population versus all its ancestors fittest opponents [1]
    (c) isn't a plot, "ciao" is Italian for "hello" [0]
    (d) none of the above [0]
14. A CIAO plot which becomes predominantly uniform gray, neither particularly dark nor light, is indicate of: [2]
    (a) **mediocre stability**
    (b) cycling [0]
    (c) disengagement [0]
    (d) answers a and b [1]
    (e) answers a and c [1]
    (f) answers b and c [0]
    (g) answers a, b, and c [$\frac{1}{2}$]
    (h) none of the above [0]

15. On a computer system with 400 computing cores and given a population size of 200 and an offspring size of 300, employing an Asynchronous Parallel EA (APEA) for evolving GP controllers for Pac-Man: [2]

    (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 [1]

    (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 [0]

    (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 [1]

    (d) answers a and b [$\frac{1}{2}$]

    (e) answers b and c [$\frac{1}{2}$]

    (f) **answers a and c**

    (g) answers a, b, and c [1]

    (h) none of the above [0]

16. NeuroEvolution – evolving artificial neural networks (ANNs) – is a hot trend. For real-world use it is: [2]

    (a) impractical, because similar to meta-EAs, it can take exponentially more time to run [0]

    (b) impractical, because ANNs and EAs implement very different types of machine learning, ANNs at the individual level and EAs at the population level, which are not compatible [0]

    (c) practical, because the EAs can be run a priori (i.e., the training phase), with the resulting ANN run in production/real-time (i.e., the testing/validation phase) [1]

    (d) practical, because the high computational cost of NeuroEvolution can be amortized over repeated uses of the resulting ANN [1]

    (e) answers a and b [0]

    (f) **answers c and d**

    (g) none of the above [0]

## Regular Questions - write your answer under the question on the exam page

17. Given the following bit strings $v_1$ through $v_5$ and schema $S$
$v_1 = (01101110101001)$ $fitness(v_1) = 0.8$
$v_2 = (10110010011001)$ $fitness(v_2) = 0.1$
$v_3 = (00001010011010)$ $fitness(v_3) = 1.0$
$v_4 = (01001110111001)$ $fitness(v_4) = 1.2$
$v_5 = (01001011100011)$ $fitness(v_5) = 1.9$
$S = (01 * *11101 * 100*)$

    (a) Compute the *order* of $S$. [1]
    10

    (b) Compute the *defining length* of $S$. [1]
    13-1=12

    (c) Compute the fitness of $S$. [1]
    $\frac{0.8+1.2}{2} = 1.0$

    (d) Do you expect the number of strings matching $S$ to increase or decrease in subsequent generations? Explain your answer! [3]
    *Average population fitness:* $\frac{0.8+0.1+1.0+1.2+1.9}{5} = 1.0$
    *Decrease, because the fitness of S is equal to the average population fitness and S has a high-order and defining length so large destruction chance.*

18. 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? [1]
    **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. [3]
    **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**