COMP 5660/6660 Fall 2023 Exam 2 Key

This is a closed-book, closed-notes exam. The sum of the max points for all the questions is 68, but note that the max exam score will be capped at 64 (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. Alice is writing an EA to solve the binary knapsack constraint satisfaction problem. The sum of the possible item costs is 37 while the total cost is constrained to be below 36. Should she: [4 pts]

   (a) Ignore the constraints under the motto: all is well that ends well.

   (b) Upon generating an infeasible solution, immediately kill it and generate a new solution; repeat this step until a feasible solution is generated.

   (c) Employ a penalty function that reduces the fitness of infeasible solutions, preferably so that the fitness is reduced in proportion to the number of constraints violated, or to the distance from the feasible region.

   (d) Employ a repair function that takes infeasible solutions and "repairs" them by transforming them into a related feasible solution, typically as close as possible to the infeasible one.

   (e) Employ a closed feasible solution space which guarantees that the initial population consists of feasible solutions only and all evolutionary operations on feasible solutions are guaranteed to result in feasible solutions. Typically a combination of custom representation, initialization, recombination, and mutation is employed to achieve this.

   (f) Employ a decoder function that maps genotype space to phenotype space such that the phenotypes are guaranteed to be feasible even when the genotypes are infeasible. Typically this involves mapping multiple different genotypes to the same phenotype.

   Select one of:

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

2. If we employ self-adaptation to control the value of penalty coefficients for an EA with an evaluation function which includes a penalty function, then: [4 pts]

   (a) the penalty coefficients will be self-adapted to cause fitness improvement just like, for instance, mutation step sizes

   (b) this cannot be done because it is inherently impossible to self-adapt any part of the evaluation function

   (c) the penalty coefficients will be self-adapted, but the increase in fitness achieved may not be correlated with better performance on the objective function

   Select one of:

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

3. The challenge when employing parameter control in order to reduce the number of EA strategy parameters which the practitioner has to configure is: [4 pts]

   (a) the introduction of “stealth” parameters, namely new parameters to control the parameter control, which may be as hard or harder to tune than the parameter(s) eliminated by the employment of the parameter control

   (b) the introduction of “stealth” parameters, namely new parameters to control the parameter control, which cause a dynamic derived variable associated with the eliminated EA strategy parameter to converge to a fixed value deterministically specified by the stealth parameters

   (c) the interaction between the parameter control of different operators, such as population sizing and offspring sizing, may be complex and hard to tune

   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]

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

   (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]

5. In Crowding: [4 pts]

   (a) new individuals replace similar population members, resulting in the population sharing the niches equally
   (b) the fitness of individuals immediately prior to selection is adjusted according to the number of individuals falling within some prespecified distance of each other
   (c) individuals share the fitness of similar population members immediately prior to selection, resulting in the number of individuals per niche being dependent on the niche fitness

   Select one of:

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

6. Fitness sharing differs from crowding in that fitness sharing: [4]

   (a) results in panmictic mating
   (b) results in niches sized proportional to fitness
   (c) implicitly requires fitness proportionate selection
   (d) implicitly requires fitness ranked selection

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

7. Speciation is: [4 pts]
   (a) when geographically separated sub-populations of a species adapt to their local environmental niches to the extent that they become mating-incompatible
   (b) when geographically separated sub-populations of a species adapt to their local environmental niches to the extent that they become mating-compatible
   (c) when sub-populations of different species in the same local environmental niche adapt homogeneously to the extent that they become mating-incompatible
   (d) when sub-populations of different species in the same local environmental niche adapt homogeneously to the extent that they become mating-compatible

   Select one of:

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

8. According to the concept of island model EAs in the context of Eldredge and Gould's theory of punctuated equilibria: [4 pts]
   (a) multiple populations of different species are run in parallel in some kind of communication structure
   (b) after a usually variable number of generations, a number of individuals are selected from each population to be exchanged with others from neighboring populations
   (c) **during the migration phase, the injection of individuals of potentially high fitness, and with possibly radically different genotypes, facilitates exploration**
   (d) the migratory injections interrupt periods of evolutionary stasis by rapid growth when the main population is invaded by individuals from a previously spatially isolated group of individuals of a different species.

   Select one of:

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

9. In Evolution Strategies with uncorrelated mutation with n step sizes, the conceptual motivation for updating the mutation step sizes with the formula $\sigma_i' = \sigma_i \cdot e^{\tau' \cdot N(0,1) + \tau \cdot N_i(0,1)}$ is: [4 pts]

   (a) the sum of two normally distributed variables is also normally distributed

   (b) the common base mutation $e^{\tau' \cdot N(0,1)}$ allows for an overall change of the mutability, guaranteeing the preservation of all degrees of freedom

   (c) the coordinate-specific $e^{\tau \cdot N_i(0,1)}$ provides the flexibility to use different mutation strategies in different directions

   Select one of:

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

10. Rechenberg's 1/5 success rule: [4 pts]

   (a) refers to the minimum successful mutation rate threshold necessary for an Evolution Strategy to reach the global optimum

   (b) refers to the ratio of offspring created by mutations versus recombination in Evolutionary Programming

   (c) refers to a rule of thumb for the optimal ratio of successful versus total mutations in Evolution Strategies where mutation step size is increased if the ratio is greater than 1/5 and decreased if the ratio is smaller than 1/5

   (d) refers to the minimum ratio of successful offspring creation versus total offspring creation in order for a parent to survive to the next generation

   Select one of:

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

11. In Multi-Objective problems a solution x is said to be dominated by a solution y when: [4 pts]

   (a) solution x is no better than y in all objectives

   (b) solution x is strictly worse than y in no more than one objective

   (c) only if both the above are true

   Select one of:

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

12. In the context of multi-objective problem solving, the term scalarisation refers to combining single objective fitness scores into a weighted cumulative fitness score. This approach suffers from the following drawbacks: [4 pts]

    (a) scalarisation commonly is a computationally expensive process
    (b) the implicit assumption that all the user's preferences can be captured before the range of possible solutions is known
    (c) for repeatedly solving different instances of the same problem, either the user's preferences are assumed to be static, or the user needs to repeatedly provide new weightings

    Select one of:

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

13. Modern Evolutionary Programming (EP) differs from classic EP in: [4 pts]

    (a) representation
    (b) parent selection
    (c) parameter control

    Select one of:

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

14. Say you want to purchase a new laptop where you maximize performance on your favorite benchmark, while keeping it as affordable as possible. 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	Performance	Affordability
1	8	2
2	4	1
3	2	3
4	1	2
5	9	1
6	4	7
7	2	5
8	1	3
9	10	7
10	5	5

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

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

(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: 1

Level 2: 2

After adding element 3:

Level 1: 1,3

Level 2: 2

After adding element 4:

Level 1: 1,3

Level 2: 2,4

After adding element 5:

Level 1: 1,3,5

Level 2: 2,4

After adding element 6:

Level 1: 1,5,6

Level 2: 2,3

Level 3: 4

After adding element 7:

Level 1: 1,5,6

Level 2: 2,7

Level 3: 3

Level 4: 4

After adding element 8:

Level 1: 1,5,6

Level 2: 2,7

Level 3: 3

Level 4: 8

Level 5: 4

After adding element 9:

Level 1: 9

Level 2: 1,5,6

Level 3: 2,7

Level 4: 3

Level 5: 8

Level 6: 4

After adding element 10:

Level 1: 9

Level 2: 1,5,6,10

Level 3: 2,7

Level 4: 3

Level 5: 8

Level 6: 4