CS301 SP2007 Exam 3 Key

This is a closed-book, closed-notes exam. The only items you are allowed to use are writing implements. Mark each sheet of paper you use with your name and the string “cs301sp2007 exam3”. 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 43, but note that the max exam score will be capped at 39 (i.e., there are 4 bonus points but you can’t score more than 100%). While this exam has been designed to be doable in 60 minutes, you have up to 75 minutes to complete this exam. Keep your answers clear and concise while complete. Good luck!

Multiple Choice Questions - Circle the letter indicating your choice

1. Countermeasures to Bloat in Genetic Programming include: [1]
   (a) increasing mutation rate to maintain genetic diversity
   (b) reducing the number of alleles to prevent disproportional tree growth
   (c) increasing parsimony pressure to penalize the fitness of large chromosomes
   (d) all of the above

2. The scope of change in parameter control can be at the level of the: [1]
   (a) gene
   (b) individual
   (c) population
   (d) all of the above

3. Panmictic mating (aka panmictic mixing) is: [1]
   (a) mating between genotypically similar individuals
   (b) mating between any individuals in a population
   (c) mating between phenotypically similar individuals
   (d) mating between parents and their offspring

4. Punctuated Equilibria is the theory that: [1]
   (a) highly fit individuals cause a virtual puncture in the equilibria associated with population dynamics
   (b) periods of evolutionary stasis are interrupted by rapid change whenever speciation occurs
   (c) geographically separated sub-populations of the same species show adaptations to their local environments
   (d) none of the above

5. A Coevolutionary Algorithm (CoEA) is an EA: [1]
   (a) where the fitness of each individual depends on one or more other individuals
   (b) with exactly two populations
   (c) where the fitness of each individual depends on individuals from a second population
   (d) with multiple populations
6. Disengagement in a CoEA occurs when: [1]
   (a) the individuals in one population stop competing with the individuals in another population
   (b) population A outevolves population B to the point where every individual in A utterly defeats all individuals in B
   (c) individuals who are selected to mate with each other (virtually engaged so to speak) determine they are not a good match and select alternative mates
   (d) none of the above

7. In multi-objective problems a solution $x$ is said to dominate a solution $y$ when: [1]
   (a) solution $x$ is no worse than $y$ in all objectives
   (b) solution $x$ is strictly better than $y$ in no more than one objective
   (c) both of the above are true
   (d) one but not all of the above are true

Regular Questions

8. List three technical drawbacks to parameter tuning. [3]
   (a) Parameters are not independent and systematically trying all combinations is infeasible.
   (b) Even when disregarding dependencies, the process of tuning all parameters is very time consuming.
   (c) Optimal parameter values are typically not constant during the evolutionary process.

9. Explain the difference between (1) deterministic parameter control, (2) adaptive parameter control, and (3) self-adaptive parameter control. [5]
   Deterministic parameter control modifies a strategy parameter in a predetermined way without using search feedback, while adaptive and self-adaptive parameter control do use search feedback. Adaptive parameter control uses an externally supplied updating mechanism, while self-adaptive parameter control genetically encodes parameters so the updating mechanism is implicitly embedded in the evolutionary cycle.

10. Describe concisely the concept of the island model EA. [4]
    An island model EA evolves multiple populations of the same species in parallel with some type of communication structure which repeatedly after a (usually fixed) number of generations exchanges a number of individuals with neighboring populations.

11. Explain the difference between fitness sharing and crowding. [4]
    In fitness sharing the fitness of individuals immediately prior to selection is adjusted according to the number of individuals falling within some prespecified distance of each other, while in fitness crowding new individuals replace similar population members; the resulting difference is that in fitness sharing the number of individuals per niche is dependent on the niche fitness, while in fitness crowding the population is equally distributed over the niches.

12. Describe briefly the difference between a cooperative CoEA and a competitive CoEA. [2]
    In cooperative CoEAs each population is a different species representing part of a larger problem, the populations need to cooperate to solve the larger problem; in competitive CoEAs individuals compete which each other to gain fitness at each other’s expense.

13. List two metrics for assessing the performance of a MOEA and explain each metric very briefly. [3]
    **Convergence** A measure of how close a solution set is to the Pareto-optimal front
    **Diversity** A measure of how evenly distributed the solutions in a solution set are

The Baldwin Effect is the positive effect obtained by evaluating an individual based on its genetic potential (achieved for instance through local search), rather than on the phenotype associated with its pure genetic expression without any form of learning.

15. Given the following bit strings \( v_1 \) through \( v_5 \) and schema \( S \)

\[
\begin{align*}
 v_1 &= (01001110101011) \quad \text{fitness}(v_1) = 0.8 \\
 v_2 &= (10110010011001) \quad \text{fitness}(v_2) = 0.1 \\
 v_3 &= (00001010011010) \quad \text{fitness}(v_3) = 1.0 \\
 v_4 &= (01001110101001) \quad \text{fitness}(v_4) = 1.2 \\
 v_5 &= (01001011100011) \quad \text{fitness}(v_5) = 1.9 \\
 S &= (01*11101*100*) 
\end{align*}
\]

(a) Compute the order of \( S \). [1] 
\[ 10 \]
(b) Compute the defining length of \( S \). [1] 
\[ 13-1=12 \]
(c) Compute the fitness of \( S \). [2] 
\[ \frac{12}{2} = 1.2 \]
(d) Do you expect the number of strings matching \( S \) to increase or decrease in subsequent generations? Explain your answer! [4]

Average population fitness: 
\[
\frac{0.8+0.1+1.0+1.2+1.9}{5} = 1.0
\]
Increase, because the fitness of \( S \) is higher than the average population fitness.

16. Select an EA strategy parameter/operator of your choice and explain a reasonable approach to unburdening the user from having to select it for the problem at hand. Simply fixing a parameter without regard for the problem at hand is NOT a reasonable approach. A truly ingenious approach may be rewarded with an extra point. [4]

Self-adaptation allows evolving parameters rather than having them tuned manually. A classic example is self-adaptation of mutation rates in Evolutionary Strategies, but note that this introduces a new parameter, namely learning rate. A more sophisticated example is self-adaptation of mate selection by genetically encoding individual mate selection operators in expression trees.