Math 378 Final

Due: *5pm Thursday May 6th*

Directions:

Answer any three of the following questions, completely and correctly. Opinions should be defended (with logic) or supported (by reference). When in doubt about the completeness of your answers, discuss them with the instructor. You may discuss you answers with other students but every word you write must be your own. If you use simulations to support your answers, include a source code listing. This listing may be given as a URL.

Problem 1 *Here is a data structure that an evolutionary algorithm for the Herbivore task could use. A creature in our population is an ordered list of patterns of the form "*$c_1c_2\ldots c_8A$*" where the first eight characters:*

$$\begin{array}{ccc} c_1 & c_2 & c_3 \\ c_4 & * & c_5 \\ c_6 & c_7 & c_8 \end{array}$$

in each pattern are matched, one after the other, against the area around the cowdozer until one fits. The patterns is oriented with the cowdozer which is facing c_2. The action A is the move to make, left, right, forward, or eat. The characters c_i are "empty", "box", "wall", or "", with the latter being a wild card that matches anything. Answer all three of the following questions.*

(i) What constraints are there on the patterns to make them correspond to situations that could arise in practice?

(ii) What use is the "" character in the patterns? Give an example of a pattern corresponding to a sensible move that uses *'s.*

(iii) For the Herbivore task is this pattern matching gene superior to, worse than, or similar to GP-Autoamta? Remember to defend your answer.

Problem 2 *Design and implement, using existing code or writing your own, an evolutionary algorithm that locates hard or impossible Tartarus boards for an 8x8 board with 8 boxes. Tartarus code has been placed on the projects link of the class web page. Give the algorithm and several boards located by it. There are several possible answers: minimize coding time not algorithm efficiency, subject to the need to have an answer by the time the test is due.*

Problem 3 *Suppose that we are running an evolutionary algorithm with two fitness functions. For each creature we generate two different fitness numbers. Assume we wish to simultaneously make both functions large and do not know how to combine them into a single meaningful number for selection. Describe a model of evolution that will tend to let creatures high in both numbers be found.*

Problem 4 *A fitness function is* deceptive *if genes "close to" the global optima have below average fitness. Closeness is measured by computing the minimum number of mutations required to turn one gene into another. Create a deceptive fitness function on binary genes of length n, relative to a mutation operator that you choose. Having done this, give a second mutation operator that makes the function non-deceptive.*

Problem 5 *Review the sunburn task. Suppose we use a limited number of shots for each type of weapons system and have an initial range of 20. Assuming we have sensibly designed fire/no fire controllers, would the competitiveness of the starbase design against all other designs be enhanced or degraded? Explain. Include details of the fire/no fire controllers you would use if these details matter to your argument.*

Problem 6 *Suppose that we have a gene that stores the position of n points in the plane, stored as a vector of real values:*

$$(x_1, y_1, x_2, y_2, \ldots, x_n, y_n).$$

For fitness we join all pairs of points with line segments and count the number of intersections. As a function of the number of points n compute the maximum possible fitness.

Problem 7 *Non-aligned crossover between two strings does crossover by exchanging two chunks of the gene the same length but which start at different points. For the standard string evolver problem with a reference string of* $S = 01101001001101100101$ *defend a choice of non-aligned or standard two point crossover. Doing an experiment is not the worst choice you could make.*

Problem 8 *One problem we experience in the grid robot tasks, such as Tartarus and North Wall Builder, is that a population will get stuck on a particular fitness value. Assume for the sake of discussion this is because most of the population diversity is gone and so most of the population is either made of idiots or minor variations on the current best strategy. Let us consider a new mutation operator for GP-Automata that renumbers the states and the transition function so that the automata is exactly the same* except *that the states are listed in a different order. If we were looking at a diagram all that would happen is that the labels on the states would change. This operator would not change the behavior (and hence fitness) of a GP-Automata it was applied to. Such mutations are called* neutral mutations*. Answer the following questions:*

(i) What would the short term effect of this operator on fitness be?

(ii) What would the effect of the operator on fitness be?

(iii) Can this crossover operator break local optima?

Problem 9 *Give a tree that uses the minimal number of nodes to generate the number 75 in the PORS language and prove that it is in fact, minimal.*

Problem 10 *In class we discussed range and domain niche specialization: reducing the fitness of a creature if its gene is near other genes or reducing its fitness value if its fitness value is near that for other genes. For the various grid robot tasks both of these have problems. Give a method for computing if two robotic agents for the Herbivore task have similar* behaviors *thus enabling a new form of niche specialization.*