

Name: \_\_\_\_\_

Course (423 or 523): \_\_\_\_\_

**Complex Adaptive Systems**  
**Midterm**  
March 21, 2012

Answer all of the questions below in the space provided. You may not use books or notes for this exam. You may use the backs of the exam pages for scratch paper. The exam will be graded out of 100 points.

1. Given these 2 strings:

S1 = 110011001100

S2 = 101001010010

1.a (4 points) Which has greater Shannon entropy? Circle the correct answer.

a) S1

b) S2

c) S1 and S2 have the same Shannon entropy

1b. (6 points) Define algorithmic information content (which is the same as Kolmogorov complexity)

1c. (6 points) Define effective complexity

1d. (4 points) Which string has higher effective complexity?

a) S1

b) S2

c) S1 and S2 have the same effective complexity

1e. (6 points) Sketch a figure showing how effective complexity relates to Shannon entropy. Label the axes of your figure.

1f. (6 points) Provide 2 schemas (as defined in Forrest 1993) that represent the patterns shared by strings S1 and S2.

1. \_\_\_\_\_

2. \_\_\_\_\_

1g. (4 points) A high probability of crossover is better than a high mutation rate to prevent premature convergence on a string in a GA if

- a) the population of strings is very diverse
- b) the population of strings is very similar
- c) both a and b

2a. (5 points) Given Wolfram's Rule 134, and a 1 D CA with initial condition 0 0 0 0 1 (implemented as a torus) what is the state of the CA after one time step?

2b. (5 points) What is the state of the CA after 4 time steps?

2c. (5 points) To which of Wolfram's classes does rule 134 belong? Give the number and a one word description of the class.

2d. (5 points) What other Rule number would produce the same pattern from the same initial condition?

3a. (5 points) Given a CA with alphabet  $\{0,1,2\}$  and neighborhood size 5 (meaning neighbors are considered from a radius of 2), how many entries are needed in the rule table to specify every possible transition?

3b. (5 points) How many possible *different* rules can be specified?

4. (8 points) Sketch a bifurcation diagram. Label all axes. Provide a figure caption explaining the figure.

5. Provide short answers in the blanks provided based on readings from class.

5a. (4 points) In the Wilke and Adami 2001 article “Evolution of digital organisms at high mutation rates leads to survival of the flattest” which genotypes were favored by a high mutation rate?

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5b. (4 points) List two advantages of parallel GAs versus traditional GAs

1. \_\_\_\_\_

2. \_\_\_\_\_

5c. (4 points) List 2 ways Wiemer et al (2009) reduce the search space for program repair.

1. \_\_\_\_\_

2. \_\_\_\_\_

5d. (3 points) The three key ingredients for evolution by natural selection are:

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

5e. (3 points) List three characteristics of chaotic systems

1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

6. (8 points) Write a 3 sentence summary of one article you were assigned to read.