EEL 4818(H) : Coevolution and Evolutionary Game Theory Homework
The Evolution of Cooperation

http://ivan.research.ucf.edu/classes/EEL4818H_Fall2007/

Due: Friday, November 16, 2007

Ivan I. Garibay
School of Electrical Engineering and Computer Science
University of Central Florida

1 Objective

The objective is twofold. First to gain some familiarity with the Evolutionay Game Theoretical (EGT) concepts discussed in class. Second, to investigate the evolutionary of cooperation via computer simulations using a Genetic Algorithm (GA).

2 Preliminaries

For the first part you only need your class notes, but if you need a reference textbook please see *Evolutionary Game Theory* by Weibull [3]. Please read the attached description [1] of Axelrod's original work on using a genetic algorithm to evolve strategies for the Iterated Prisoner's Dilemma [2].

3 Part 1: Nash Equilibria and Evolutionary Stable States

Consider the following two-person (A and B) two-strategy (X and Y) game given by the payoff matrix below. It is called the *Coordination Game*.

		Player B X	Player B Y
Player A	X	(2,2)	(0,0)
	Y	(0,0)	(1,1)

1. Calculate its Nash Equilibria in pure strategies.

   Hint: Obtain first the best reply sets for both players.

2. Are all these Nash equilibria, calculated above, evolutionary stable strategies (ESS)? Please explain.

   Hint: test each of the Nash equilibria in the following way: (i) Assume there is a population consisting entirely of the Nash equilibrium strategy you are testing. (ii) Introduce few "mutant" strategies and determine if these "mutants" will take over the population (end up replacing all the incumbents).

4 Part 2: Evolution of Cooperation

Please go to the class page: http://ivan.research.ucf.edu/classes/EEL4818H_Fall2007/ and download the Genetic Algorithm code provided. This is the same code you used for your previous assignment, but it has been modified for this homework. You do not need to write any code for this homework, just to download the code, set the parameters, run it, create some plots, and analyze the results. For the specifics of how to use the code please refer to the readme.txt file included in the distribution.

This GA is set to search strategies to play the Iterated Prisoner's Dilemma. Each strategy is a GA individual. It uses the representation Axelrod used as described below [1]. Each strategy remembers the three previous turns with a given player. The fitness of a strategy in the population is defined as the average cumulative score the strategy will obtain after playing 100 times with itself and with every other member of the population. For instance, for a population size 20, it averages 20 cumulative scores obtained by playing against each of the 20 population members. Each one of these cumulative scores is obtained by adding the payoffs obtained over the 100 games played with a particular opponent. Use a population of 20 strategies, tournament selection with tournament size 4 and $P_t = 0.9$, two-point crossover with $P_c = 0.7$, and bit-flip mutation with $P_m = 0.001$.

1. See if you can replicate Axelrod's qualitative results: do 40 runs of 50 generations each and examine the results carefully to find out how the best-performing strategies work and how they change from generation to generation. Provide a detailed description.

2. Produce the standard GA plots (averages over the 40 runs) for best fitness, average fitness and standard deviation versus generations for the previous step. Record the overall best fitness obtained in each run and the generation on which was obtained. Use these values to compute the average overall best fitness and the average number of generations to reach the best fitness.

3. Turn off crossover (set $P_c = 0$) and repeat the experiment above. What is the effect on the average overall best fitness and the average number of generations to reach the best fitness?

4. Let the fitness of a strategy be its cumulative score in 100 games with TIT FOR TAT. Can the GA evolve strategies to beat TIT FOR TAT?

5 Deliverables

- Write up:
    1. answers to questions
    2. Include all the graphs/plots
    3. State your observations and conclusions about the strategies evolved by the GA in each of the settings.
- Output files for each scenario and parameter configuration files.

6 Grading

Part 1:	Answers to EGT questions	: 40%
Part 2:	Plots/graphs of different scenarios	: 30%
	Interpretation	: 30%

References

[1] Melanie Mitchell **An Introduction to Genetic Algorithms**, The MIT Press, 1996.

[2] Robert M. Axelrod **The Evolution of Cooperation**, Basic Books, 1984.

[3] Jörgen W. Weibull **Evolutionary Game Theory**, The MIT Press, 1995.