Using Exact Sciences Modeling Tools to Understand Social Phenomena

Course #: 55772

Exercise #2: Axelrod model + Dynamic Optimization
Due: Sun May 6th, 11:50 pm, on Moodle

General Instructions:

- Unless stated otherwise, submission is done individually. We rely on trust. You may discuss assignments verbally, but do not share solutions with other students.
- You may use examples from the Internet, but use them as an inspiration and make them your own.
- Your homework should be submitted through Moodle. Please zip your files to ex_2_First_last.zip (with your first and last name). The zip should include: 1) a PDF document (no .docx and no jpg) with your responses, pseudo code, explanations, insights etc. 2) Your code files in case the exercise requires coding. Your code will not be tested, but we might use it as a reference in case we need clarifications. Please keep good coding standards, and document your code properly.
  You may use MatLab, Python, C/C++, or Java. If you want to use other programming language, please get our approval first.
- Please use proper language and correct grammar (Hebrew or English), explain clearly what you do, use graphs and charts if needed.
- No scanned handwritten works please.
- We respect the business etiquette: No late submission.

<u>Grading</u>
The homework grading will be based on the following parameters:

1. Correctness of the analytical response, clarity of presentation
2. Model compatibility: how does your model matches the description?
3. Implementation: Based on the pseudo-code (we might use the code if clarifications are needed).
4. Insights quality: Try to find non-trivial insights.
5. Creativity
6. Visualization: Your insights should pop-out of the figures you choose.

   Tips for visualization:

   - Label each figure
   - Explain each figure in the text
   - Label each axes + what are the units?
   - Clean figures: Avoid unnecessary details in figures.

Please choose either Task 1 OR Task 2. No need to do both.

Task 1 involves coding

Task 2 is more analytical and advanced and does not involve coding. It is especially suitable for the physicists and mathematicians in the group.

Task 1: Implementing Axelrod model

Please implement the Axelrod model of social norms as studied in class (you can use Axelrod's article if needed). For the sake of uniformity assume a population of 40 people. Implement the function with the metanorms.

Run 50 games, each of 500 generations. Total of 2500 populations.
Each generation - 40 individuals. When high-score individual reproduce - kill a low score individuals.
In each generation, each individual has 4 opportunities to defect.
Use the payoffs and punishment as stated in the model.

1) In each of the below conditions do the following analysis:
   - Each population is indexed with i=1,2,3,4…50 (the game) and the generation (j=1,2,…,500).
   - Calculate the average boldness and vengefulness for each population in each generation. This will give you 25000 data point.
   - Allocate data point to the nearest point on a boldness/vengefulness grid with a resolution of 0.25 (this is a sophisticated way to tell you so simply round up the numbers you get to a resolution of 0.25). Naturally, you will get many data points in the same location (boldness, vengefulness) on the grid. We will term such a group as "bin".
   - For each such bin, calculate the average boldness and vengefulness one generation later (remember, you are tracking populations, not individuals!).
   - Now, you have for each generation and each bin the initial (generation j) and final (generation j+1) boldness and vengefulness – and we would like to visualize it: the direction of change as a function of the initial state. Axelrod used 2-dimensional arrows to show the change (see figures 2 & 4 in the paper).
     Alternatively, you can represent this as graphs of the delta = final - initial, as a function of initial boldness and as a function of initial vengefulness in two separate graphs.
     Feel free to represent this the way you like: Explain your choice and make the figures clear. (e.g. What each the axes means.)

   a. First set the metanorm parameter/s to be zero. Do the analysis. Are social norms created?

b. Now set the metanorm parameters to their values as described in the paper. Could you see the creation of social norms?

2) Explain the figures you found. What insights about norms can you find in the figures? (you can use Axelrod's paper).
3) How does the value of the metanorms punishment influence the final boldness and vengefulness? What can you say about the critical value of the metanorms punishment cost from which we start observing social norms? Explain and show the appropriate graphs.

Task 2:

Axelrod's model is an agent-based model. Its principles are taken from theoretical biology and evolutional theory. However, it is only one option for creating norms. Try finding another, more analytical way to model the creation of social norms. For example, you can use game theory, if you are familiar with it; or apply ideas from solid state physics.
Please describe clearly your assumptions, variables, parameters, relationships.
Demonstrate (analytically or numerically) how social norms are created.
Do not feel that you need to come up with a finished product, but rather try coming up with something intelligent and creative that describes the phenomenon.

You can get inspired by the following lovely papers (all available online through the library on Google scholar scholar.google.com):

Castellano, Claudio, Matteo Marsili, and Alessandro Vespignani. "Nonequilibrium phase transition in a model for social influence." *Physical Review Letters* 85, no. 16 (2000): 3536.

Huang, Peter H., and Ho-Mou Wu. "More order without more law: A theory of social norms and organizational cultures." *JL Econ. & Org.* 10 (1994): 390.

Helbing, Dirk. "A mathematical model for the behavior of individuals in a social field." *Journal of Mathematical Sociology*19, no. 3 (1994): 189-219.

Be creative, use your modeler's mind, and have fun!