Chapter 3 Exercise Hints and Solutions

Agent-based and Individual-Based Modeling: A Practical Introduction, 2nd Edition

Exercise 1

We attempted to find publications that are relatively easy to obtain and follow the ODD protocol relatively well. However, students are likely to find authors that did not follow it closely, or did not interpret protocol elements correctly. Critcal reviews—carefully comparing published ODD descriptions to the protocol as described in the book and template file—could be a good way to reinforce what information should be provided where and how easy it is to leave out important information.

Exercise 2

Encourage students to use the ODD template that is a supplement to the Grimm et al. (2010) paper "The ODD protocol: a review and first update". This template starts on page 29 of the PDF version of Grimm et al. (2010) provided on the public web site as supplementary material for Chapter 3. If students try to answer the questions posed in the template (starting with: What is the purpose of the model?) using information from the journal article describing a model, then it should be straightforward to complete the ODD as much as possible and to identify the information that is missing.

As an example, we prepared the following ODD description from a paper on the list provided for Exercise 2, that of Axelrod (1997. The dissemination of culture: a model with local convergence and global polarization. *Journal of Conflict Research* 41: 203-226).

Purpose

The model's purpose is stated as being "to show the consequences of a few simple assumptions about how people (or groups) are influenced by those around them." These assumptions are about how people learn culture from each other and, therefore, how culture spreads and how societies influence each others' culture. In particular, the model assumes that people or societies share culture locally, and share more with others that are more similar to themselves.

Entities, state variables, and scales

The entities in this model are agents that "can be thought of as homogeneous villages". The villages are represented by sites (patches) on a grid.

The sites have state variables for each of five cultural "features" (characteristics). Each of these five cultural feature variables has a value that is an integer between 0 and 9. A site's culture is defined as its set of values for the five feature variables, concatenated together as a five-digit string, e.g., 93209.

The grid of sites is 10 × 10 patches in extent. The distance between sites is not stated, and in fact it is not clear that the grid represents geographic space. Time is represented only by the number of "ticks" (times that the schedule is executed); each tick does not represent a specific amount of

time. Model runs continue until the system is stable (site state variables no longer change), which can take more than 80,000 ticks.

Process overview and scheduling

The schedule has only one action: a single cultural interaction of one site. On each tick, one of the 100 sites is chosen randomly, and that site then executes the cultural interaction trait described below at "Submodels".

This scheduling means that on each tick, only one agent may have its culture state variables changed.

(Output from the model was also scheduled, though exactly how was not explained.)

Design concepts

Basic principles: The author states that the study is based on three principles. One is agent-based modeling, so that consequences of simple mechanisms emerge. Second is the lack of central authority, so that changes in culture arise from local interactions instead of being imposed by central authority. Third is adaptive rather than rational agents, with agents making decisions simply in response to their neighbors instead of by attempting to calculate the best choice.

Emergence: The key results of the model are the presence or absence of regions of different, but stable, culture. These results emerge from the adaptive trait of the village sites.

Adaptation: The sites adapt their culture state variables to be more similar to neighbors, using the cultural interaction submodel described below. This trait does not explicitly seek to increase a measure of individual success; instead, the trait seems to implicitly assume that being more like a neighbor in culture is better.

Objectives: This concept is not relevant because the adaptive trait for cultural interaction does not seek a specific objective.

Learning, *prediction*: These concepts are not used.

Sensing: Village sites are assumed able to sense the culture variables of the one neighbor site that they interact with. Sites are assumed to simply know their neighbor's variable values.

Interaction: The model represents one kind of interaction: spreading of culture. These are direct interactions, with the culture of one site directly affecting the culture of another.

Stochasticity: Random processes are used to initialize the model (see "Initialization" below), presumably so that simulations start with no pattern of cultural similarity among neighbors. The cultural interaction trait is highly stochastic, with random choice of which site acts each tick, which neighbor it interacts with, and which cultural variable it changes. The reason why these processes were made stochastic was not provided, but presumably it was to minimize the level of mechanistic detail in the model.

Collectives: This model does not include collectives. Regions of culturally similar sites do emerge, but these regions do not affect the individual sites (because sites are affected only by neighbor sites).

Observation: Because this model is about the spread and similarity of culture, the key outputs from the model are not the values of the sites' culture variables but how similar these variables are over the grid of sites. These outputs are observed via a "map of cultural similarities" that displays the borders between all sites, shaded from black between highly dissimilar sites to white between sites with identical culture variables. (Calculation of cultural similarity is explained below at "Submodels".) This map therefore displays the boundaries between regions within which culture is similar or identical.

Initialization

The model apparently is initialize by setting the five culture variables of each site to a random digit between 0 and 9. (This method was implied but not stated explicitly.)

Input data

The model uses no input data.

Submodels

The single submodel is the trait a site uses to interact culturally with a neighbor site. It has these steps ("the site" refers to the site executing this trait):

1. Randomly select one neighbor site to interact with. These "neighbors" are the four (or fewer, for sites on the edge of the grid) sites to the north, east, south, and west.
2. Calculate the "cultural similarity" between the site and the selected neighbor. Cultural similar is the fraction of the five culture variables for which both sites have the same value. For example, if the cultures of the site and its neighbor are 64892 and 16852 then their similarity is 0.4 (two of the five digits are the same).
3. Decide whether to interact with the neighbor. This decision is made randomly with the probability of interacting equal to the culture similarity calculated in step 2. Hence, if culture similarity is zero, the sites never interact. If the sites are already similar (cultural similarity of 0.6 to 1.0), they are likely to interact.
4. If there is an interaction with the neighbor, randomly select one of the culture variables for which the site and its neighbor differ, and set the site's value to that of its neighbor. For example, a site and its neighbor could have cultures of 64892 and 16852 before the interaction and 66892 and 16852 after it.