ODD for the decision-making model

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1 Purpose

This model illustrates how ABM can be used to explore decision making in the context of a heterogeneous environment. In particular, we will examine how variations in agents' mobility can produce the emergence of a tragedy of the commons (Hardin, 1968).

2 Entities, state variables, and scales

2.1 Agents

Each agent is defined by a spatial location x, y, its current level of $energy$ and the $energyCost$ it consumes every time step.

2.2 Environment

Agents move within a spatial grid with dimensions $xDim \times yDim$. The grid represents a heterogeneous resource landscape where the cell in each set of coordinates x, y is defined by the current level of resources it contains $resources$ and a maximum level $maxResources$.

3 Process overview and scheduling

The simulation proceeds with a discrete number of time-steps, each where the following process updates the population of agents and the resources in the environment.

1. Decision making
2. Collection
3. Cloning
4. Energy expenditure
5. Resource growth

   The order of agents' execution is shuffled every time step, and each phase is simultaneously executed for all agents before moving to the next one.

4 Design concepts

4.1 Basic principles

The basic principles for this model are agents exist in a landscape of cells whereby they attempt to obtain resources from these cells. Cell resources grow at constant rates, while agents are able to view some distance within a space and can move to areas where they seem benefit in consuming resources from cells.

4.2 Emergence

Tragedy of the commons will emerge from the system if all agents have access to the same environmental information (i.e. high $radius$ values). In other words, agents are likely to over consume if they see the entire space or simulated region.

4.3 Adaptation

Agents do not adapt.

4.4 Objectives

The objective of each agent is to collect the highest value of *resources* per time step.

4.5 Learning

Agents do not learn.

4.6 Prediction

Agents do not predict.

4.7 Sensing

Agents sense *resources* within a neighbourhood of Chebyshev distance *radius*.

4.8 Interaction

Agents directly interact with environment collecting *resources*. Competition between agents indirectly emerge from resource exploitation.

4.9 Stochasticity

Stochastic elements include the initial distribution of resources and agents, the order of execution of agents, and the choice of cell to move if two (or more) cells have maximum *resource* value in the search neighbourhood.

4.10 Collectives

Agent operate independently.

4.11 Observation

The number of agents is calculated at each time-step.

5 Initialization

These are provided in the main text and in the model input files included in each model. A parameter sweep is applied to a search radius for cell resources, whereby this parameter is varied for agents.

5.1 Agents

This model is initially populated by $nAgents$ located at random spatial coordinates.

5.2 Environment

The value of $maxResources$ of each cell is sampled from a uniform distribution $U(0, maxEnergy)$. Current *resources* of each cell is then copied from its $maxResources$ value.

6 Input data

The model uses data files, which are included in the git repository for the models.

7 Submodels

7.1 Decision making

All agents move to a new location based on a greedy decision making process: each agent will move to the cell with highest resources within *radius* of its current location x, y. Chebyshev distance is used to define the list of candidates (i.e. the greatest distance of the two dimensions, x and y).

7.2 Collection

All agents collect resources up to $maxEnergy$ and the collected amount is removed from cell's $resources$.

7.3 Cloning

Agents whose $energy$ equals $maxEnergy$ produce offspring. These have the same spatial location x, y than their parents, and the $energy$ of both (parent and offspring) is updated to $energy = maxEnergy/2$.

7.4 Energy expenditure

Agents decrease their $energy$ level by $energyCost$. Offpsring do not decrease their $energy$ levels the time step they are created. If $energy \leq 0$ the agent dies and is removed from the simulation.

7.5 Resource growth

The $resources$ of each cell will increase every time step by the parameter $resourceGrowthRate$ up to the local $maxResources$.

8 References

References

Hardin, G. (1968). The tragedy of the commons. *science*, 162(3859):1243–1248.