Agent Based Modelling with Applications in Economics

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Overview

Essay

- 5 – 10 pages long (appendix does not count)
- should contain:
  - scientific problem (goal) description
  - background literature – depends on a model selected
  - description of the experiment – BehaviorSpace
  - results – correlation and/or regression analysis
  - conclusions
- only models not covered during the class may be selected (one model can be selected by at most one student)
- describe only code changes (if any) and present your code snippets in the appendix
- the deadline is 16th of March - upload on the moodle platform

Few potentially useful reporters

mean [area-count] of turtles
max [area-count] of turtles
count turtles with [area-count $\leq$ 0]
[area-count] of turtle 0
[area-count] of turtles with [color = red]
item 0 sort-by [[a b] $\rightarrow$ a > b] [area-count] of turtles
item 1 sort-by [[a b] $\rightarrow$ a > b] [area-count] of turtles
any? turtles-on patch 0 0
any? turtles-on (patch-set patch 0 0 patch 1 0 patch -1 0 patch 0 1 patch 0 -1)
[area-count] of turtles

Game of Life – Conway

- Any live cell with fewer than two or more than three live neighbours dies.
- Any live cell with two or three live neighbours lives on.
- Any dead cell with exactly three live neighbours becomes a live cell.

Sugarscape

Models library $\rightarrow$ Social science $\rightarrow$ Economics $\rightarrow$ Sugarscape $\rightarrow$ Sugarscape 1 Immediate Growback

Problem: What do we need such model for?

Sugarscape - we start simple

Agents (turtles) features – fields

- sugar – the amount of sugar this turtle has
- metabolism – the amount of sugar that each turtles loses each tick
- vision – the distance that this turtle can see in the horizontal and vertical directions
- ...

Environment (patches) features – fields

- (p)sugar – the amount of sugar on this patch
- max-(p)sugar – the maximum amount of sugar that can be on this patch
- ...

Sugarscape - rules

G_α – Sugarscape grow-back

- at each lattice position sugar grows back at a rate of α units per time interval up to the capacity at this position

G_∞ – immediate growback

M – Agent movements

- Look out as far as vision permits in each of the four lattice directions: north, south, east and west (in a random order) and identify the unoccupied site(s) having the most sugar
- If the greatest sugar value appears on multiple sites then select the nearest one (if more than one the first considered)
- Move to this site
- Collect all the sugar at this new position

If sugar level is lower or equal zero agent dies.

Sugarscape

Models library $\rightarrow$ Social science $\rightarrow$ Economics $\rightarrow$ Sugarscape $\rightarrow$ Sugarscape 2 Constant Growback

Problem: How do the agent movements change?

Sugarscape - rules

$R_{[a,b]}$ – Agent replacement rule

- Each agent has maximum age – selected randomly at the agent birth from the range $[a, b]$
- When an agent dies it is replaced by an agent of age 0 having random genetic attributes, random position on the sugarscape, random initial endowments,and a maximum age randomly selected from the range $[a, b]$

Sugarscape

Models library $\rightarrow$ Social science $\rightarrow$ Economics $\rightarrow$ Sugarscape $\rightarrow$ Sugarscape 3 Wealth Distribution

Problem: How do the agent movements change?

Sugarscape - rules

$P_{\alpha\beta}$ – Pollution formation rule

- When sugar quantity s is gathered from the sugarscape, an amount of production pollution is generated as a quantity αs. When sugar amount m is consumed (metabolized), consumption pollution is generated according to βm. The total pollution on a site at time t, p^t, is the sum of the pollution present at the previous time, plus the pollution resulting from production and consumption activities that is $p^t = p^{t-1} + \alpha s + \beta m$.

M – Agent movements

- Look out as far as vision permits in each of the four lattice directions: north, south, east and west (in a random order) and identify the unoccupied site(s) having the **maximum sugar to pollution ratio**.

Sugarscape - rules

D_α – Pollution diffusion rule

- Each α time periods and at each site, compute the pollution flux – the average pollution level over all von Neumann neighbouring sites
- Each site's flux becomes its new pollution level

Sugarscape - rules

S – agent sex rule

- Select a neighbouring agent at random
- If the neighbour is fertile (in a given age range and having at least the same amount of sugar as at birth) and of opposite sex and at least one of the agents has an empty neighbouring site (for the baby), then a child is born
- Repeat for all neighbour

Sugarscape - rules

K – cultural transmission rule

- An agent is endowed with cultural string – "00100100111"
- For each neighbour a tag is randomly selected
- If the neighbour agrees with an agent at that tag position, no change is made; if they disagree, the neighbour's tag is flipped to agree with the agent's tag
- Agents are defined to be the members of the Blue group when 0s outnumber 1s on their tag strings, and the members of the Red group in the opposite case

Sugarscape - rules

Two resources – 1 is sugar and 2 is spice

- An agent is endowed with a fixed metabolism (m_1, m_2) and a changing wealth (w_1, w_2).
- We can calculate amount of time until death given no further resource gathering" $\tau_1 = w_1/m_1$ and $\tau_2 = w_2/m_2$.
- We define agent welfare function as $W(w_1, w_2) = w_1^{m_1/m_T} w_2^{m_2/m_T}$ and $m_T = m_1 + m_2$

M – Agent movements

- Look out as far as vision permits in each of the four lattice directions: north, south, east and west (in a random order) and identify the unoccupied site(s) producing the maximum welfare.
- Move to this site
- Collect all resources at this new position

Sugarscape - rules

Internal resources valuation

$$MRS = \frac{dw_2}{dw_1} = \frac{\frac{\partial W(w_1,w_2)}{\partial w_1}}{\frac{\partial W(w_1,w_2)}{\partial w_2}} = \frac{m_1 w_2}{m_2 w_1} = \frac{\frac{w_2}{m_2}}{\frac{w_1}{m_1}} = \frac{\tau_2}{\tau_1}$$

Agent may trade, let us consider the case $MRS_A > MRS_B$. Who trades what?

Sugarscape - rules

Internal resources valuation

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Actions:

- A buys sugar and sells spice
- B buys spice and sells sugar

At what price?

Sugarscape - rules

Internal resources valuation

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At what price?

$$p(MRS_A, MRS_B) = \sqrt{MRS_A MRS_B}$$

Sugarscape - rules

T - agent trade rule

- Agent and neighbour compute their MRSs; if they are equal the end, else continue
- The direction of exchange is as follows: spice flows from the agent with higher MRS to the agent with lower MRS while sugar goes into opposite direction
- The geometric mean of the two MRSs is calculated – this will serve as the price, p
- The quantities to be exchanged are as follows; if $p > 1$ then p units of spice is for p unit of sugar, if $p < 1$ then $1/p$ units of sugar for 1 unit of spice
- If this trade will a) make both agents better off (increases the welfare of both agents), and (b) not cause the agents MRSs to cross over one another, then the trade is made and return to start, else end