Agent-based modelling INF-50806

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Build Complex Adaptive Systems

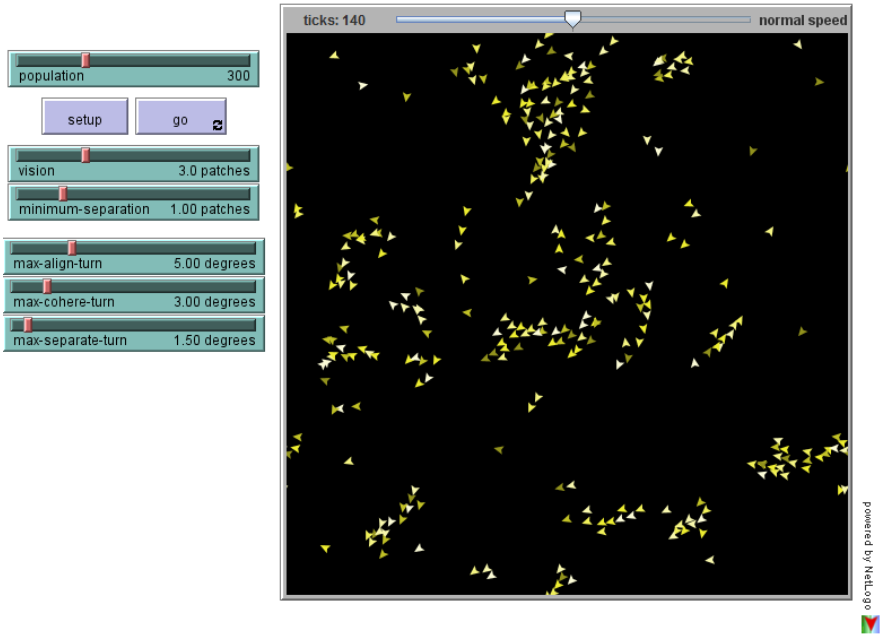
In all its application domains, Wageningen University researchers deal with complex adaptive systems. Whether plants, animals or people are the subject matter, they interact in systems in which changes in inputs lead to non-reversible changes in outputs. Consider pathogens infecting a population of plants, agricultural practices leading to land degradation, or the 2008 financial crisis. All involve path dependent complex adaptive systems. Both natural and social science can be incorporated in models that describe these systems.

Grow it to show it

One fruitful way to study these systems is by growing them in models. You do not calculate a system-level equilibrium, but you zoom in to the detail level, creating a world in which plants, animals or people live and do whatever they do; and then you investigate what emergent behaviour this yields for the overall system. You do this using the user-friendly language Netlogo, created specifically for researchers who want to concentrate on the model. A reference library of agent-based models in natural and social sciences can be found on the Netlogo site, http://ccl.northwestern.edu/netlogo/. The figure shows a simple flocking model in Netlogo, with control buttons and sliders on the left, and a toroid (doughnut-shaped) environment on the right. No central control is assumed, yet the virtual birds start to flock.

For whom?

Any clever student with initiative can take the course and get a lot out of it. It runs in period 4. So far, we have had students from social sciences (Management, Economics), from technological sciences (Biosystems engineering), from biological sciences (Biology, Plant Sciences). Typically, the projects lie at the intersection of these traditional disciplines.



Prepare for research projects

The course is a laboratory for those who want to get a feeling for what agent-based models can do for them, in their area of research. In four weeks you get acquainted with agent-based modelling and Netlogo, work with some existing models, and create your own application in small teams. PhD projects are now running in Wageningen and elsewhere that use this approach; master project can support them. Sensitivity analysis and validation, crucial for realistic research projects, are given full attention in the course.

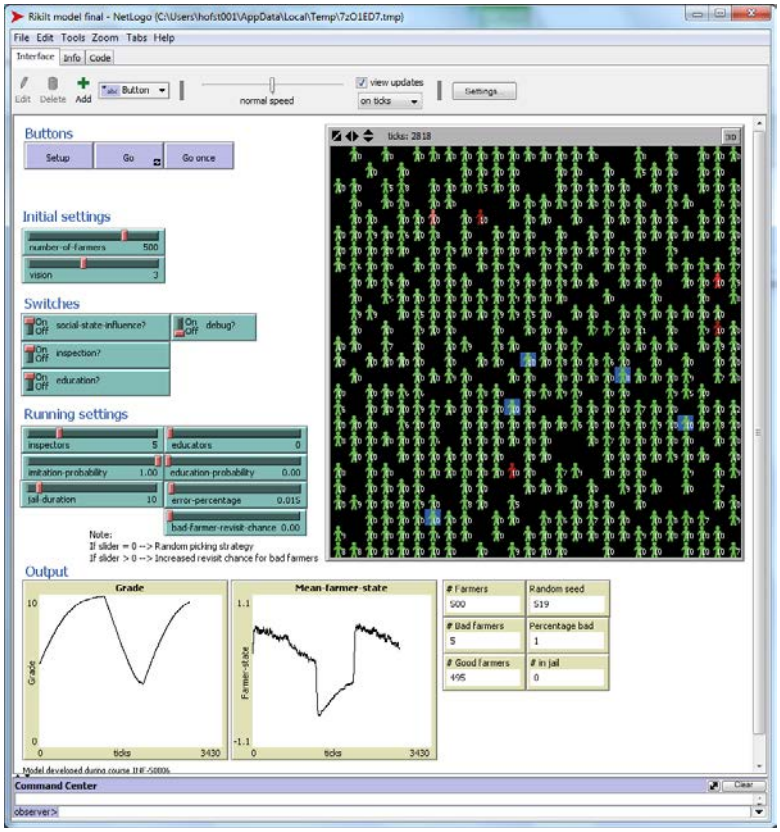
More information

The course guide can be found on our Web site www.wageningenur.nl/inf/. Information can also be obtained from the teachers: Gert Jan Hofstede, Mark Kramer, Sjoukje Osinga.

Example projects

Here are some projects carried out by students from previous years. The brief text does not do the projects justice, but it shows the range of issues that can be dealt with.

1. **Food safety strategies**. This is a model of farmers who imitate one another in pesticide use, and might thus tempt one another into misbehaving. But inspections correct them. The output, depending on the parameter settings, might be a system such as shown in the figure, with a periodic oscillation where the 'grade' or reputation of farmers slowly goes up across 1000 time ticks (= days; see left-hand graph), while their actual rule conformity deteriorates over time (right-hand graph), until there is an outbreak of rule breaking. Then, grade plummets, inspectors punish defectors, and it takes them a few hundred ticks to restore good behaviour. The question now is how the inspectors can be more proactive.



2. **Designing disease-resistant landscapes.** Phytophtora (late blight) is a devastating fungus that attacks potatoes. There are resistant varieties, but their yield is lower, and the disease mutates rapidly to beat resistance. Corridors of resistant varieties could allow to plant high-yield varieties and still control the infection. This will only work if all the farmers in an area collaborate. This model use both data on the spread of phytophtora, and data on the behaviour of farmers, to investigate the potential of resistant corridors. It is a preparation for a PhD project in the IP/OP CAS call, that started in early 2013.
3. **How plants attract the predators of their enemies**: Herbivore-induced plant volatiles. This model has plants (of which the figure shows a field; open places mean the plants in them have been eaten) emit volatile substances that attract the mites (two in the figure; the substance will attract the predator of the same colour as the louse that attacked it) that eat the lice (28 in the figure) that eat their leaves. Unexpectedly, the model showed that more volatile HIPVs work better, because they allow the mites to better localize the infected plants.