LevelSpace: Constructing Models and Explanations across Levels

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Abstract

In this hands-on workshop, we will introduce participants to the recently released LevelSpace NetLogo extension. By using LevelSpace, it is possible to programmatically open NetLogo models from inside NetLogo, essentially treating models like agents. This has a wide and interesting applications for modellers, curriculum developers, and researchers interested in eliciting and studying complex systems and how people reason about them. We will introduce the LevelSpace extension's programming primitives and how to use them by building connected model ecologies. We will talk about the different kinds of ways that phenomena might be connected, and how to model that using LevelSpace. We will also discuss our experience with using LevelSpace in classrooms, and discuss best practices for using it as a tool for studying student reasoning *within* and *between* complex phenomena.

Keywords

Agent based modeling; NetLogo; complex systems thinking; Multi-Level Linked systems

Introducing LevelSpace

NetLogo (Wilensky, 1999) offers learners and modelers a low-threshold, high-ceiling environment for constructing models of, and reasoning about, complex phenomena. NetLogo is widely used in education and research on complex systems (Goldstone & Wilensky, 2008; Wilensky & Rand, 2015) and is one of the most often cited languages in social sciences research (Thiele, Kurth, & Grimm, 2012).

One question we have often been asked – and wondered ourselves – while building models is, "how does the phenomenon in this model relate to the phenomena in other models?" For instance, the NetLogo library already contains two models that seem closely related in the real world: The Wolf Sheep Predation model shows how we get stable ecosystems in which wolves, sheep, and grass interact in a complex food web. The Climate Change model shows how the greenhouse gas effect happens as the interactions between clouds, soil, CO2, and energy from the sun in either the shape of infrared light, or visible light. There are obvious ways in which these two phenomena interact in the real world. For instance, the Climate Change model has a temperature indicator which could affect how quickly grass grows back in the Wolf Sheep Predation model. The Wolf Sheep Predation model both produces greenhouse gases (animal flatulence) and absorbs them (respiration of grass), which would affect the amount of greenhouse gases in the atmosphere in the Climate Change model. But so far it has not been possible connect them computationally. That is, until now!

With LevelSpace (Hjorth, Head, & Wilensky, 2015), it is possible to connect the any number of models – we have run as many as a couple of thousand models simultaneously. LevelSpace is built as a NetLogo extension, using NetLogo's Extensions API and the Controlling API. It is

released as Open Source, and full documentation and source code are freely available on GitHub. It extends the NetLogo language with a set of primitives that allow modelers, learners, and curriculum designers to control NetLogo models from inside NetLogo models, essentially treating models like agents – "turtles all the way down."

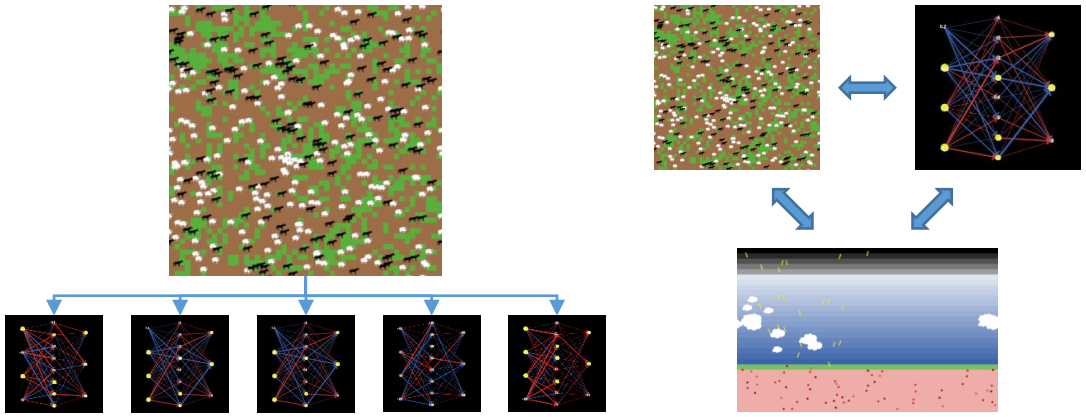

Figure 14: **Multi-Level Linked Systems**. **Each wolf and sheep run their own neural net model which acts as their 'brain'. [Left] An ecosystem, a polluting traffic system, and the environment interact [Right]**

By using LevelSpace it is possible to encourage and elicit thinking not just *within* complex phenomena, but also *between* them. We think this has interesting implications for modelling as a scientific method, and for modelling as a process of thinking-with external, manipulable representations. We have designed and implemented early prototypes of GUIs and curriculum activities using LevelSpace (Hjorth, Brady, Head, & Wilensky, 2015; Hjorth, Head, Brady, & Wilensky, 2015), and we will discuss our experiences with implementing LevelSpace-based curriculum and discuss best practices for using LevelSpace in classrooms, and for studying student reasoning.

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