# Participatory, embodied, multi-agent simulation

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# Participatory, Embodied, Multi-Agent Simulation

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## ABSTRACT
We will demonstrate the integration of a software-based multi-agent modeling platform with a participatory simulation environment and real-time control over a physical agent (robot). Both real and virtual participants will be able to act as agents in a simulation that will control a physical agent. The backbone of this demonstration is a widely used, freely available, mature modeling platform known as NetLogo.

## Categories and Subject Descriptors
I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence – *coherence and coordination, intelligent agents, languages and structures, multiagent systems.*

## General Terms
Design, Experimentation, Human Factors, Languages.

## Keywords
multi-agent simulation, participatory simulation, embedded agents, robotics, sensors

## 1. WHY IS INTEGRATION GOOD?
Multi-agent simulation is a powerful technique used to encode real-world simple rules in virtual agents and then simulate their interactions [1]. Participatory simulations are similar to multi-agent simulation except individuals play the role of the virtual agents, sometimes in combination with the virtual agents [2]. In addition, an extensive amount of multi-agent research has gone into examining how to embody agent control within a physical entity [3]. All three of these areas are concerned with the creation, manipulation, and development of agents in one form or another. Thus combining these three disparate systems in to one unified platform would be useful. Of course, multi-agent simulation platforms, participatory simulation systems, and robotic systems have all been demonstrated to a large degree in the past. However many of these systems were not designed to be integrated, and thus combining these existing platforms is difficult if not impossible.


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We will demonstrate a single platform (NetLogo) that supports simulated agents, participatory agents and physical agents [4]. Moreover this platform is freely available, widely used, and easy to learn. By enabling all three types of interaction to be combined in one modeling environment NetLogo facilitates development of systems and simulations that combine these aspects without the need for learning multiple platforms and then attempting to connect them to each other.

## 2. A MULTI-AGENT MODELING PLATFORM (NETLOGO)
NetLogo is a mature multi-agent modeling platform. It has been developed for over 8 years at the Center for Connected Learning and Computer Based Modeling which is under the leadership of director Uri Wilensky and is currently located at Northwestern University [4]. NetLogo has an estimated twenty thousand current users. With NetLogo, one can model complex systems with thousands of interacting agents, and study the connection between the micro-level rules and the macro-level "emergent" patterns. Agents can be either moving entities or stationary cells as in a cellular automaton. Thousands of these agents follow rules in the simulated system, acting in parallel and affecting other agents, both moving and stationary. NetLogo has found use by many natural and social scientists as a research tool and has also been adopted as a successful element of curriculum by hundreds of educational institutions. The emergent phenomena modeled span a wide range of domains including ecosystems, economies, organizational change, and molecular interactions and reactions. Figure 1 illustrates a typical NetLogo model of flocking behavior.

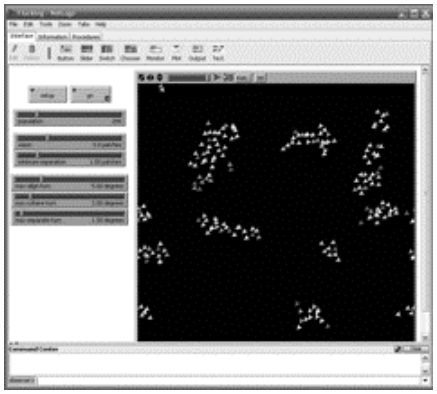

**Figure 1: A NetLogo Model of Flocking Behavior.**

## 3. PARTICIPATORY SIMULATION (HUBNET)

In a participatory simulation individuals act out the roles of agents in a complex system [2]. The behavior of the whole system is not defined ahead of time but instead emerges from the participation of various individuals in the simulation. This emergent behavior can then be displayed back to the group as a whole through a central server with the results usually projected on a screen at the front of the room. **HubNet** is the name we have given to the NetLogo architecture designed to enable individuals to participate in a simulation of a complex dynamic system. HubNet enables many users at individual computers or other devices to control the behavior of agents and to view the aggregated results on a joint display. The individual devices can be a mix of different hardware systems (programmable calculators, computers, or handheld devices) that are able to run the Java-based NetLogo platform. The network layer implements flexible communication protocols that include the ability to upload and download data sets, monitor key-presses at the individual level, support real-time interaction as in network computer games, and form collaborative groups of various sizes (e.g., peer to peer, small groups, and whole-group modes). Figure 2 illustrates a HubNet setup just before it was utilized in a classroom.

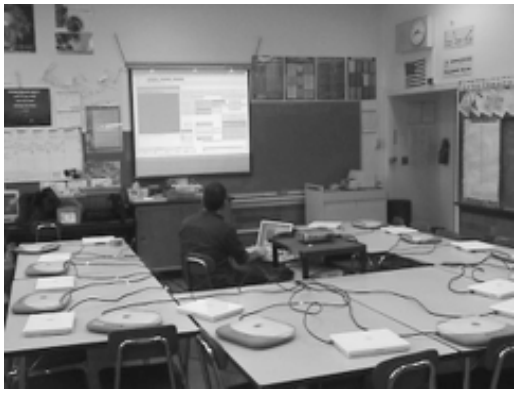

**Figure 2: A HubNet Setup About To Be Used.**

## 4. INPUT/OUTPUT TO THE REAL WORLD (NETLOGOLAB)

The **NetLogoLab** module enables users to perform real-time sensing and control, using a standard serial port robotics interface [3]. With various kinds of sensors (temperature, chemical composition, pH, humidity, light, distance, etc.), modelers can feed their models with environmental data, process it, and then control various kinds of actuators (motors, light bulbs, relays, LEDs). Being completely integrated into NetLogo, this module can make use of all the features of the modeling environment. Applications range from model calibration and validation to building robots, interactive simulations and autonomous vehicles. For this demonstration, we will connect a robot to the NetLogo model, and then let it be controlled in three scenarios: a self-contained pre-programmed agent-based model, a sensor-enable apparatus activated by environmental variables (such as human presence, light or temperature) and by humans interacting in a networked simulation, using HubNet. There will also be some basic construction and electronics materials for participants to modify the physical agents and try out different ideas for sensing and control. Figure 3 illustrates a typical NetLogoLab experiment.

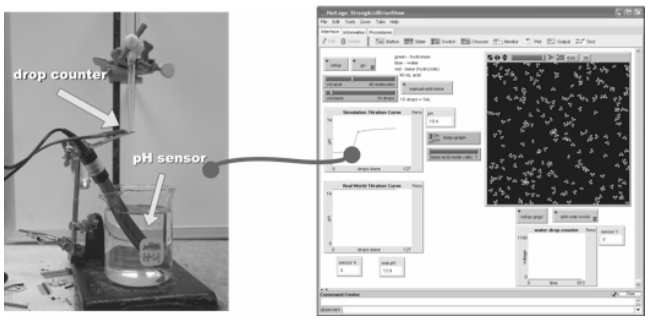


**Figure 3: A Typical NetLogoLab Experiment.**

## 5. INTEGRATION AND SUMMARY

The **NetLogo** platform provides the backbone for the integration and the place where the virtual agents are located. **HubNet** then provides a distributed interface into that platform for users to participate with the simulation. **NetLogoLab** then provides an output from the NetLogo platform to control robotic agents, as well as sensor input. In our demonstration we will begin by showing off NetLogo and a few of the hundreds of models that are built in to the NetLogo models library. From there we will progress to demonstrating both the HubNet and the NetLogoLab technologies independently. Finally, we will combine all of these aspects in a participatory simulation where people will work with virtual agents to control a robotic device.

To recapitulate, we plan to demonstrate all three aspects of the NetLogo modeling platform separately, then combine them in a simple proof-of-concept simulation to demonstrate the power behind a platform that seamlessly integrates virtual, participatory, and robotic agents in one package. We feel that this demonstration will excite and entertain a wide variety of researchers who are looking for an easy to learn, powerful multi-agent platform to utilize for experimentation within one of these three fields or any combination.

## 6. REFERENCES

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