GoGoBot: Group Collaboration, Multi-Agent Modeling, and Robots (Demo Paper)

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1. HUMANS, ROBOTS, AND AGENTS
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 virtual agents, sometimes in combination with these virtual agents [2]. Finally, the bifocal modeling framework has enabled the examination of agents embodied in physical entities using sensors and actuators [3]. All three of these technologies 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. Multi-agent simulation platforms, participatory simulations, and bifocal modeling have all been demonstrated separately in the past. However many extant systems are difficult if not impossible to integrate.

We will demonstrate a single platform (NetLogo) that supports simulated agents, participatory agents and physical agents [5]. 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 unite these aspects without the need for learning multiple platforms and then attempting to connect them to each other. We place this particular technological platform within a more general framework that we call Human, Embedded and Virtual agents in Mediation (HEV-M). This framework facilitates general discussion about the components of the overall system and their interaction across particular technologies and instantiations.

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In previous work we have shown that the NetLogo platform allows this unification [4]. The newest version of our platform includes a more rugged robot and uses Bluetooth to communicate wirelessly. Both the communication hardware and the robot effectors have been improved to facilitate low latency, high bandwidth communication (see Figure 1).

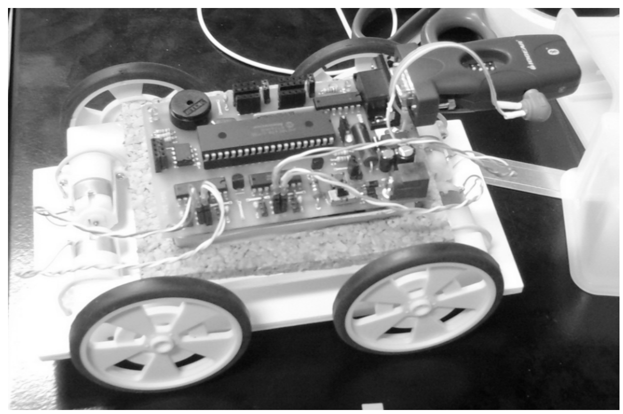

Figure 1: The Robot.

We have run four studies using a robot-car with four motors, each connected to a robotics interface (the GoGo Board, [6]), which communicates to the server. Each user is assigned a motor to control, and activating, deactivating, or reversing the correct wheels turns the car. Participants were given the task of moving the robot toward a goal while avoiding obstacles.

Initial results were intriguing, and demonstrate the potential of the platform for capturing tacit collective behaviors. In our first studies, with university professors [4, 7], participants were confident that they could easily accomplish the task. However, as soon as the first turn was necessary, participants started to report increasing frustration with their ability to solve the problem, and we observed the emergence of strategies for optimizing the process, such as delegating leadership to one participant, or formation of two groups acting independently. However, in a recent study with computer science students, results were more diverse: they did not delegate leadership; on the contrary, they ignored the other participants and adopted a strategy solely based on localized trial-and-error, with feedback coming exclusively from the car [8].

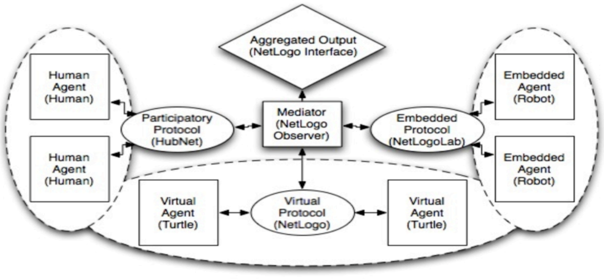

Figure 2: HEV-M Framework.

2. THE THEORETICAL FRAMEWORK

From one perspective, virtual, human, and robotic (embedded) agents can be viewed as equivalent: all of these agents have properties (i.e., descriptions of themselves, and knowledge about the world) and methods (i.e., actions that they can take to achieve goals). In all three cases, the agents examine the world around them and their own internal state and decide what action to take on the basis of this input. Each of these three systems, virtual, human, and robotic, present their own challenges. For instance, with respect to virtual agents, low-level rules often do not result in the anticipated emergent patterns. In the case of humans, the logic that connects the input to the output may not be known, and thus the actions taken may be unpredictable. Robots can also have noisy sensors that affect their perception of the world, and their actuators, also subject to a noisy environment, may not be working perfectly. Nonetheless, there are many reasons to motivate the combination of these systems into one integrated platform.

In this demonstration, we will explore the combination of all these agents within one integrated technological platform [4, 7]. We place this demonstration within a unified conceptual framework, which is the HEV-M framework. **HEV-M** stands for the integration of **H**uman agents, **E**mbedded sensory-enabled robotic agents, and autonomous **V**irtual agents, which communicate via a central **M**ediator. Within this framework, the three different agent groups may have different goals and tasks. The mediator receives messages from any of the agents, transforms the messages, and transmits the information within a well-established protocol.

3. THE TECHNOLOGY

NetLogo is a mature multi-agent modeling platform. It has been developed for over 11 years at the Center for Connected Learning and Computer Based Modeling which is under the leadership of director Uri Wilensky and is located at Northwestern University [5]. 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. **HubNet** is the name given to the NetLogo architecture designed to enable individuals to participate in a simulation of a complex dynamic system [2]. 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). The **NetLogoLab** module enables users to perform real-time sensing and control, using a standard serial port robotics interface, within the framework of bifocal modeling [3]. With various kinds of sensors (temperature, 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, NetLogoLab can make use of all the features of the modeling environment. Applications of NetLogoLab range from model calibration to building robots, interactive simulations, and autonomous vehicles.

4. INTEGRATION AND DEMO

The **NetLogo** platform provides the backbone for the integration and a world for the virtual agents. **HubNet** provides a distributed interface for users to participate in the simulation, and **NetLogoLab** provides an output that controls the 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 in 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 technologies in a participatory simulation where participants will work to control a robotic device. We will demonstrate all three aspects of the NetLogo modeling platform separately, then combine them in a simulation to demonstrate the power behind a platform that seamlessly integrates virtual, participatory, and robotic agents in one package. This integrated platform holds potential to increase understanding of phenomena from collaborate learning to human-robot coordination

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