Chapter XVIII
A Simulation of Temporally Variant Agent Interaction via Belief Promulgation

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ABSTRACT

This chapter concludes a two part series which examines the emergent properties of multi-agent communication in "temporally asynchronous" environments. Many traditional agent and swarm simulation environments divide time into discrete "ticks" where all entity behavior is synchronized to a master "world clock". In other words, all agent behavior is governed by a single timer where all agents act and interact within deterministic time intervals. This discrete timing mechanism produces a somewhat restricted and artificial model of autonomous agent interaction. In addition to the behavioral autonomy normally associated with agents, simulated agents should also have "temporal autonomy" in order to interact realistically. This chapter focuses on the exploration of a grid of specially embedded, message-passing agents, where each message represents the communication of a core "belief". Here, we focus our attention on the how the temporal variance of belief propagation from individual agents induces emergent and dynamic effects on a global population.

INTRODUCTION

In the chapter entitled *A Simulation of Temporally Variant Agent Interaction via Passive Inquiry*, we examined a mechanism of agent interaction where each agent – in a specially embedded two-dimensional grid – periodically examines the states of neighboring agents and modifies its own state according to an inherent set of rules. In those experiments, the agents did not attempt to actively influence their neighbors in any way. In this chapter, we give agents the ability to send events to neighboring agents in attempt to influence their behavior. Here, we outline two approaches: The first approach extends the previous *Game of Life* simulations by eliminating autonomous agent vivification and replacing it with event triggered vivification. The second approach

abandons the *Game of Life* inspired rule-set and instead implements a world of agents, each possessing a simple belief with a corresponding strength. In this last model, agents "compete" to alter the belief of neighboring agents. Finally, we conclude with some details relevant to the implantation of the simulation environment; including a brief overview of agent behavior customization and the data logging techniques used throughout these simulations.

MESSAGE DRIVEN COMMUNICATION

Thus far, we have focused on the exploration of the globally emergent behaviors in passive agent interaction systems. The agents reacted to their environment, but did so in a manner where each agent's vivification was independent of neighboring vivifications. In the message based version of this simulation, the focus shifts from agents behaving passively within the environment into a model where each agent actively attempts to exert influence over the environment. The emergent behaviors observed in previous sections resulted from agents examining their immediate surroundings and updating themselves accordingly. Global behavior arose from the non-deterministic agent vivification order and the asynchronous nature of the updates. In this set of experiments, global emergence is driven by the exchange of messages.

In this section, we expanded our simulation to accommodate *active* agents which directly communicate—albeit in a primitive manner. Information is exchanged as simple messages which are reflective of an agent's internal state. Though agents may take on many states during a simulation, each agent communicates its active state with its spatially embedded neighbors. The active model is divided into two distinct subtypes. The first subtype, discussed in Section "*Message Driven* Game of Life", is a direct extension of the previous "Conway" model; but agents respond to events generated by neighbors rather than vivificating autonomously. The second subtype, discussed in Section "*Fuzzy 'Belief' Promulgation*", is a completely new model based upon temporally variant "belief" interaction. The models in both subtypes display interesting and rather unique behavioral characteristics.

Message Driven *Game of Life*

In this mode, each agent begins in a random Boolean state conforming to the basic "Conway" life/death (active/inactive) rules. As with the threaded model discussed in Section "Threaded Model", the agents behave autonomously within a global mean vivification delay time dm of 500ms with delay variances dv chosen to produce dm/dv ratios rmv ranging from 0.0 to 2.0. However, instead of agents simply examining their neighborhood at intervals which are independent of the environment, the agents

Table 1. This table shows a sampling of data (5 trials for each r_{mv} tested) taken from our complete database of trials for sorted by age_{avg}

r_{mv}	μ_d	μ_a	μ_m	$\hat{\sigma}_d$	$\hat{\sigma}_a$	$\hat{\sigma}_m$
0.15	0.407	4.44	35.5	0.00055	0.030	0.217
0.25	0.409	4.54	36.3	0.00045	0.024	0.217
0.50	0.411	4.72	37.8	0.00055	0.031	0.278
0.75	0.415	5.14	41.1	0.00045	0.059	0.464
1.00	0.417	5.33	42.6	0.00055	0.019	0.167
1.25	0.420	6.00	48.1	0.00045	0.061	0.501
1.50	0.421	6.17	49.3	0.00045	0.066	0.534
1.75	0.423	7.02	56.2	0.00045	0.103	0.850
2.00	0.424	7.12	56.9	0.00110	0.137	1.163

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