The Social Emergence of Communication in Spatialized Arrays of Neural Nets

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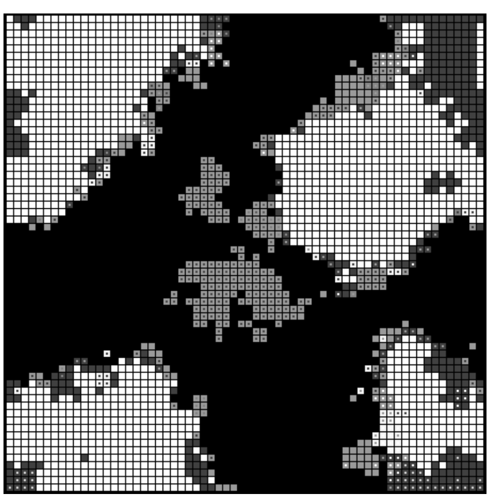
We build on a background of game-theoretic work regarding cooperation (Axelrod 1984, Nowak and Sigmund 1992), particularly the emergence of higher levels of cooperation in the Spatialized Prisoner's Dilemma (Grim 1995, Grim 1996, Grim, Mar, & St. Denis 1998). Here we extend that work to the larger topic of communication, exploring spatialized models with large arrays of agents in an environment of wandering food sources and predators.

Our individuals are simple neural nets; we use two species of neural nets in two series of runs. In each case we start with a spatialized cellular automata array of over 4,000 individuals with randomized weights and biases, and have them do a partial training on the behavior of more successful neighbors. In this environment each individual is capable of making arbitrary sounds and of responding to sounds from immediate neighbors by opening its mouth, hiding, or coasting in neutral. An individual whose mouth is open in the presence of a wandering food source is 'fed' and gains points; an individual who fails to hide in the presence of a predator is 'hurt' by losing points. But opening mouths, hiding, and making sounds each exact an energy cost. Our models differ from most of their predecessors in that (1) all action and neural net training is purely local, and (2) all gains are individual; there is no symmetrical reward for communication per se.



Emerging communities of two perfect communicators at generation 290, shown in black and white. Other strategies shown in shades of gray.

Can a community of neural nets in an environment this simple evolve a system for signaling food and predators? The answer is a resounding 'yes'. In initially randomized arrays of a range of different types of neural nets, simple patterns of signaling emerge and dominate using standard learning algorithms. In a simple spatial environment of wandering food sources and predators, pursuing purely individualistic gains and using partial training on successful neighbors, randomized arrays of neural nets can learn to communicate.

Background publications:

Grim, P., St. Denis, P., & Kokalis, K. (2002). Learning to communicate: The emergence of signaling in spatialized arrays of neural nets. *Adaptive Behavior* 10, 45-70.

Grim, P., Kokalis, T., Alai-Tafti, A., & Kilb, N. (2001). Evolution of communication with a spatialized genetic algorithm. *Evolution of Communication* 3, 105-134.

Grim, P., Kokalis, T., Alai-Tafti, A., & Kilb, N. (2000). Evolution of communication in perfect and imperfect worlds. *World Futures: The Journal of General Evolution* 56, 179-197.

Grim, P., St. Denis, P., & Kokalis, T. (2003). Information and meaning: Use-based models in arrays of neural nets. Forthcoming in *Minds and Machines*.

References:

Axelrod, R. (1984). *The evolution of cooperation*. New York: Basic Books.

Nowak, M., & Sigmund, K. (1992). Tit for tat in heterogeneous populations. *Nature* 355, 250-252.

Grim, P. (1995). Greater generosity in the spatialized Prisoner's Dilemma. *Journal of Theoretical Biology* 173, 353-359.

Grim, P. (1996). Spatialization and greater generosity in the stochastic Prisoner's Dilemma. *BioSystems* 37, 3-17.

Grim, P., Mar, G., & St. Denis, P. (1998). *The philosophical computer: Exploratory essays in philosophical computer modeling.* Cambridge, MA: MIT Press.