Title
Modeling Communicative Processes Using Connectionist Cellular Automata

Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 19(0)

Author
Claessen, Mark J. A.

Publication Date
1997

Peer reviewed

Modeling Communicative Processes Using Connectionist Cellular Automata

Mark J.A. Claessen (M.J.A.Claessen@exeter.ac.uk)
Department of Psychology, University of Exeter
Exeter, EX4 4QG, United Kingdom

Summary

I introduce a hybrid computational model to investigate cognitive processes that involve interaction and communication within a population of individuals. This model, the Connectionist Cellular Automaton (CCA), organizes a population of connectionist networks into the two-dimensional structure of a Cellular Automaton (CA). Using the phenomenon of 'ostensive teaching,' I show how this model extends traditional CA and allows one to study connectionist networks in a more dynamic environment than a fixed set of input-output patterns.

The Connectionist Cellular Automaton

A CA is a dynamic model in the form of a lattice containing a large number of cells. The lattice provides a topological organization, while the cells represent entities that are in a certain *state*. The cells interact locally, according to a simple algorithm, which leads to very complex behavior at the level of the system as a whole. Each *generation* of the automaton consists of all the cells changing their states on the basis of local interactions with neighboring cells. CAs are ideally suited to model communicative processes: they allow for messages to slowly spread through a population.

People's models of the world are shaped by their (social) environment. Although no two people's models are the same, we can effectively communicate through the use of language. Wittgenstein's (1958) Language Games are about how words become associated with objects: a teacher *points out* the objects to a pupil while naming them (ostensive teaching). Although this picture of language learning is grossly oversimplified, I will see how far one can extend it: a group of individual networks has to reach a consensus on the names of objects in their environment. Each neural network in the CCA is a backprop network; the input layer encodes the objects, while the output layer represents the words. The state of a cell corresponds to the weights of the connectionist network that occupies it. A cell changing its state therefore means a change in the weights of its network: in each generation of the simulation each network trains its neighbors on the names it gives to objects.

Not all individuals are equally coercive: the rules that determine what state the network is going take on next represent the amount of influence one network has on another. This can be moderated by adjusting the learning rates (λ) on the basis of the *similarity* between networks (*i.e.*, the words they give to objects in their environment). I use various λ *functions*, representing different theoretical notions about whether we are more inclined to communicate with like or differently minded people.

If there are two or more objects that have to be named, the networks collectively display *Smurfing behavior:* all objects become associated with the same name. It means that the simulations have to be limited to just one object. Smurfing is caused by the fact that there are two ways to globally optimize behavior. First, the networks in the automaton have to adjust their weights so as to find the minimum on an error surface. Second, behavior can be optimized by *reshaping the error surface itself.* When both forces are combined, Smurfing is the result.

With most λ functions the networks quickly converge to a single name for the object; with one function the automaton settles to a solution with multiple names. A consensus is reached faster if individuals mainly communicate with similar, rather than dissimilar neighbors. If we consider that communication is reciprocal this becomes understandable: the net balance of two individuals who *disagree* communicating with each other is normally that they reach a stand-off, whereas two individuals that already mostly *agree* might more easily reach a consensus. If these two effects are *combined* a global consensus is never reached, and minority groups are able to withstand the coercive influence of surrounding groups: individuals in the center of a group strengthen group cohesion, while communication at the border of different groups suffers from the stand-off effect.

References

Eiser, J.R., Claessen, M.J.A. & Loose, J.J. (1997). Attitude, beliefs and other minds: shared representations in self-organizing systems. In S.J. Read & L.C. Miller (Eds.), *Connectionist and PDP Models of Social Reasoning and Social Behavior.* Mahwah, NJ: Erlbaum.

Wittgenstein, L. (1958). *Philosophical Investigations.* Oxford: Blackwell.