Computational Primitives based on neighbouring rules to model stigmergy

M.T. Signes Pont, H. Mora, J. M. García

Specialized Processor Architectures Laboratory, Department of Computer Technology, University of Alicante
03690 San Vicente del Raspeig, Alicante, Spain
teresa@dtic.ua.es, hmora@dtic.ua.es, juanma@dtic.ua.es

Abstract
The study of the mechanisms that link global system behaviour to the interaction of its parts is an important issue in the field of complex systems. Such mechanisms are present everywhere in nature, from the development of an embryo to the organization of large animal populations and they have been successfully used to model computation in computer science [1], sociology [2], biology [3], ecology [4], physics [5] and many other fields. Cooperation in multicellular systems requires information sharing. Entities such as computers in the Internet, people in societies, cells in a multicellular body or social insects in a colony, do not generally obey commands from some central controller; they share information by indirect and distributed paths. Independent entities deposit long-lived cues in external structures that are subsequently sensed by others. The cues may be attached to connective tissue within one body, to surfaces of shared nests such as termite mounds, or placed in shared databases or web-sites as the case may be. The principle, called stigmergy [6] is that the trace left in the environment by an action triggers the performance of a next action, by the same or a different agent. The communication with cues provides information embedded in the stigmergy structure that can be read and written again many times. In addition to the intrinsic information cues also provide information inherent to their location in the stigmergy structure. So, cues have both message and location meaning.

In this research we define a set of neighbouring binary rules that can model the elementary action performed by an agent on its environment. The recursive application of the rule provides time sequences that have the capability to model realistic cues since they mimic both the interpretation of the message by an agent and its following behaviour triggered by the interpreted message. The analysis of the cues provides the key for the generation of social communication and so is able to mimic a stigmergy structure.

Findings – the set of 16 elementary binary rules define different interactions between an agent and the cue in the stigmergy structure.

Practical implications – this approach provides a satisfying search technique to approximate realistic scenarios such as complex pattern construction: ants are workers that build architectures. By pushing building block into others, they add their work to existing structures. We also mention the growing models of vertebrate limb development [7]: during early development, morphogen gradients generate different cell types in distinct spatial order (positional value) following the well-known French Flag model.

Originality/value – The use of a powerful primitive operation reproduces the behavioural features of different kinds of systems by calculating iteratively new values on previous ones.

Main references –