A cerebral framework for integrating biologically plausible mechanisms in large connectionist models

Nicolas Rougier
University of Colorado Boulder, Department of Psychology
Campus Box 345, Boulder, CO 80309
USA
rougier@psych.colorado.edu

Frederic Alexandre
LORIA-INRIA Lorraine
BP 329
F-54506 Vandoeuvre
France
falex@loria.fr

ABSTRACT

Researches in Computational Neurosciences have given rise to a variety of mechanisms which aim at integrating data and knowledge from Neurosciences in robust and efficient algorithms. Though this research is still very active to produce new and more precise models, it is today very tempting to try to use existing models for industrial purpose, especially in the field of robotics.

Designing a complex task in autonomous robotics on this basis implies to coordinate and integrate several computational neuroscience models, since each model is generally devoted to a single mechanism. It is also important that this integration might allow a tight coupling between the models, so that they can exchange parameters, share data and act in feedback loops one on the other.

We propose to describe here a cerebral framework, inspired from theoretical biology [2] and adapted to computer sciences [1]. At a macroscopic level, this framework corresponds to the definition of the main cerebral structures, their functions and the main information flows between them. The functions are generally defined on the basis of the kind of processing and memorization that is performed on received data. Information flows correspond to the integration of feed-forward, lateral and feed-back control between elementary units. It is hence a structural and functional framework, since it allows the integration of different memory and data processing mechanisms, through the implementation of cortical and extra-cortical (e.g: hippocampal) neuronal structures.

At the microscopic level, functioning and learning rules are defined at the level of the neuronal circuit. Here, the different kinds of information flows are implemented in activation rules and the conditions and ways of learning are defined. This hence allows an unified representation of activity propagation between the structures and a consistent view of memory interaction. At present, such an approach has already been used for the implementation of a robot navigation task, with the adaptive building of an internal representation of the external world [3].

We endly want to insist on the interest of such a systemic approach. First of all, it can lead to the realization of complex systems which are unfeasible with simple computational neuroscience models and also with classical automation techniques. This particularly gives very encouraging results from a purely robotic point of view.

Second, and perhaps more importantly here, it creates a new and deeper dialog between neuroscientists and computer scientists. Indeed, designing such a framework, and enriching and adapting it as we are still doing today, implies to discuss at different levels of abstraction, from the neuronal to the behavioral scale, which is fruitful for both communities. Particularly, it prevents from having a too narrow view of a neuronal mechanism, as it is too often the case in the modeling reasoning and requires to take several levels of abstraction and also a richer context into account to more deeply understand such mechanisms.

REFERENCES

[1] F. Alexandre. Connectionist Cognitive Processing for Invariant Pattern Recognition. In *International Conference on Pattern Recognition (ICPR'96)*, Vienna, August 1996.

[2] Y. Burnod. *An adaptive neural network: the cerebral cortex.* 2nd edition, Masson, Paris, 1993.

[3] H. Frezza-Buet, N. Rougier, and F. Alexandre. A cerebral framework for the integration of biologically inspired temporal mechanisms for sequence processing. In *Neural, Symbolic and Reinforcement Methods for Sequence Learning.* Springer, 2000.