Chapter VI
Recent Methodology in Connectionist Systems

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ABSTRACT

The Artificial NeuroGlial Networks, which try to imitate the neuroglial brain networks, appeared in order to process the information by means of artificial systems based on biological phenomena. They are not only made of artificial neurons, like the artificial neural networks, but also they are made of elements which try to imitate glial cells. An important glial role related with the processing of the brain information has been recently discovered but, as the functioning of the biological neuroglial networks is not exactly known, it is necessary to test several and different possibilities for creating Artificial NeuroGlial Networks. This chapter shows the functioning methodology of the Artificial NeuroGlial Networks and the application of a possible implementation of artificial glia to classification problems.

INTRODUCTION

Recently Connectionist Systems (CSs) which pretend to imitate the neuroglial nets of the brain were built. These systems were named Artificial NeuroGlial Networks (ANGNs) (Porto, 2004). These ANGNs are not only made of neuron, but also from elements which imitate the astrocytes of the Glial System. During the last decades Neuroscience has advanced remarkably, and increasingly complex neural circuits, as well as the Glial System, are being observed closely. New discoveries are now unveiling that the glia is intimately linked to the active control of neural activity and takes part in the regulation of synaptic neurotransmission (Perea & Araque, 2005). In that case, it may be useful to integrate into the artificial models other elements that are not neurons.

Despite the latest achievements about the astrocytes, there is not exact information about their influence on brain processing or about the regulation of the astrocyte-neuron communication and its consequences.

Artificial models of neuroglial circuits have been developed as an attempt of studying the effects of the neuroglial activity that have been observed until now at the Neuroscience laboratories (Pasti et al., 1997; Araque et al., 1999; Araque et al., 2001; Perea & Araque, 2002; Perea & Araque, 2005, Martin & Araque, 2006), as well as of giving expression to the hypothesis and phenomena of these activity. In that way, the initially performed works have involved the elaboration of a ANGNs building methodology (Porto, 2004). The essence of this methodology, its application to classification problems and the latest results achieved after mimicking different functioning options of the Artificial NeuroGlial Networks are shown in the present chapter. The implementation of the mentioned options enables the study of these networks from the Artificial Intelligence viewpoint and the application of the ANGNs for solving real problems.

BACKGROUND

The specific association of processes with synapses and the discovery of two-way astrocyte-neuron communication (Perea & Araque, 2005) have demonstrated the inadequacy of the previously held view regarding the purely supportive role for these glial cells. Instead, future progress requires rethinking how the dynamics of the coupled neuron-glial network can store, recall, and process information.

It is a novel research field that is here covered from the Artificial Intelligence viewpoint; no CS considering the glial system had been developed ever before.

In this regard, the RNASA (Artificial Neural Networks and Adaptive Systems) laboratory, our group from the University of A Coruña performs two interrelated research works from the viewpoint of Computer Science. One of these types involves the elaboration of "biological" computational models to reach a better understanding of the structure and behaviour of both neurons (LeRay et al., 2004, Fernández et al., 2007), and astrocytes (Porto, 2004). The second type of works considers behaviour observed in the brain circuits and the studied biological phenomena in order to create CSs; these systems should test if the presence of such phenomena provides advantages for information processing (Porto et al., 2005; Porto et al. 2006, Porto et al. 2007). No actualised publications of other research groups have been found regarding the later works, although some first attempts of incorporating the astrocyte functions are appearing, as the work of Xi Shen & Philippe De Wilde (2006). These authors model the increase of the blood flow within the brain capillary vessels according the neuronal activity and the neuron-astrocyte pairing; however, it is only a mathematical modelling that does not use the knowledge about astrocytes on the implementation of CSs.

Also Nadkarni et al. (2007) elaborated a mathematical framework, apart from the connectionist models, for modelling the synaptic interactions between the neurons and the astrocytes, bearing in mind the tripartite synapse concept (Araque et al., 1999). This model also includes the quantitative description of the experimental conclusions related to the synaptic boosting and to the increase of spontaneous postsynaptic currents that occur when astrocyte activity is involved (Liu et al., 2004) (Fiacco et al., 2004). This model tries to provide a conceptual basis for more complex experimental protocols, as it quantifies an adaptive synapses that changes its reliability depending on the astrocyte behaviour. The intervention of the astrocytes can modulate a neuron network and its subsequent activity by providing other capabilities and an additional plasticity that it would not exist in absence of the glial cells.

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