

Chapter 7.4

Neuroglial Behaviour in Computer Science

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ABSTRACT

This chapter presents a study that incorporates into the connectionist systems new elements that emulate cells of the glial system. More concretely, we have considered a determined category of glial cells known as astrocytes, which are believed to be directly implicated in the brain's information processing. Computational models have helped to provide a better understanding of the causes and factors that are involved in the specific functioning of particular brain circuits. The present work will use these new insights to progress in the field of computing sciences and artificial intelligence. The proposed connectionist systems are called artificial neuroglial networks (ANGN).

INTRODUCTION

The analysis of the computational models developed up to the present day show that the artificial neural networks (ANN) have certain limits as information processing paradigms. We believe that these limitations may be due to the fact that the existing models neither reflect certain behaviours of the neurons nor consider the participation of elements that are not artificial neurons. Since the ANN pretend to emulate the brain, researchers have tried to represent in them the importance the neurons have in the nervous system (NS). However, during the last decades, research has advanced remarkably in the field of neuroscience, and increasingly complex neural circuits, as well as

the glial system (GS), are being observed closely. The importance of the functions of the GS leads researchers to think that their participation in the processing of information in the NS is much more relevant than previously assumed. In that case, it may be useful to integrate into the artificial models other elements that are not neurons. These assisting elements, which until now have not been considered in the artificial models, would be in charge of specific tasks, such as the acceleration of the impulse transmission, the establishment of the best transmission routes, the choice of the elements that constitute a specific circuit, the “heuristic” processing of the information (warning the other circuits not to intervene in the processing of certain information), and so forth.

NEUROSCIENCE AND CONNECTIONIST SYSTEMS

In order to create ANN that emulate the brain and its tremendous potentiality, we must know and thoroughly understand its structure and functioning; unfortunately, and in spite of numerous discoveries in the course of the last decades, the NS remains a mystery, as Cajal (1904) already predicted a century ago.

Many studies on specialised knowledge fields led to the NS. In biology, for instance, we can study the different forms of animal life and its astounding diversity without realizing that all these shapes depend on a corresponding diversity in NS. The study of the behavioural models of animals in their natural habitat, whose most renowned researcher Lorenz (1986) created hundreds of behavioural models that can be implanted into computers, is known as ethology, and the interrelation of these models and the nervous mechanism is called neuroethology. As such, the study of biological behaviour from a computational point of view could be called “computational neuroethology” or “computoneuroethology”. In general psychology, relevant studies from the perspective of

computational neuroethology will raise many questions on the mechanisms in the brain which determine human behaviour and abilities. Recently, neuroscientists have disposed of a wide array of new techniques and methodologies that proceeded from the fields of cellular and molecular biology and genetics. These research fields have contributed significantly to the understanding of the NS and the cellular, molecular, and genetic mechanisms that control the nervous cells; they also constitute the first step toward the processing and storage of the NS’s information.

It is commonly known that many fields of the learning process imply the NS. Neuroscience can therefore be seen as the intersection of a wide range of overlapping interest spheres. It is a relatively new field that reflects the fact that, until recently, many of the disciplines that compose it had not advanced sufficiently to be intersected in a significant manner: behavioural sciences (psychology, ethology, etc.), physical and chemical sciences, biomedical sciences, artificial intelligence, and computational sciences.

In neuroscience, the study of the NS of vertebrates is increasingly compelled to take into account various elements and points of view. Until a few decades ago, these studies were mainly focused on the analysis of the neurons, but now that the relevance of other cellular types such as the glial cells is being reconsidered, it becomes obvious that the focus must be widened and the research orientation renewed.

Astrocytes: Functions in Information Processing

Since the late 1980s, the application of innovative and carefully developed cellular and physiological techniques (such as patch-clamp, fluorescent ion-sensitive images, confocal microscopy, and molecular biology) to glial studies has defied the classic idea that astrocytes merely provide a structural and trophic support to neurons and suggests that these elements play more active

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