Chapter 14
Computational Foundations of the Anticipatory Artificial Autopoietic Cellular Automata

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ABSTRACT

A survey of the Varela automata of autopoiesis is presented. The computation of the Varela program, with initial conditions given by a living cell, is not able to self-maintain the membrane of the living cell. In this chapter, the concept of anticipatory artificial autopoiesis (AAA) is introduced. In this chapter, the authors present a new algorithm of the anticipatory artificial autopoiesis, which extend the Varela automata. The main enhancement consists in defining an asymmetric membrane of the artificial lining cell. The simulations show the anticipatory generation of artificial living cells starting with any initial conditions. The new concept of anticipatory artificial autopoiesis is related to artificial life (Alife) and artificial intelligence (AI). This is a breakthrough in the computational foundation of autopoiesis.

INTRODUCTION

This chapter deals with the computational foundation of the concept of Autopoiesis, the organization of living systems, introduced by Varela et al. [1974].

The term "autopoiesis" comes from the Greek (auto-), meaning "self", and "poiesis", meaning "production", so an autopoietic system refers to a system capable of self-producing.

Furthermore, an original idea of the time was the computational model of an autopoietic living cell. In this seminal paper they further argue that living systems belong to the class of autopoietic systems.

The computational model of autopoiesis is based on automata.

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Autopoiesis and Cognition are related to the Game of Life [Beer, 2004], based on deterministic automata.

The concept of autopoietic automata is very innovative because it is open to the new technologies of information in the industry, management, organization and culture, in this new 21th century.

The personal computers, the tablets, and the smart phones, are based on programs that are more and more intelligent with the progress of artificial intelligence (AI).

In the definition of a program, the term "gram" meaning "written" and "pro" meaning "in advance", so a program means a script which is written in advance.

Consequently, computer programs and automata are computing anticipatory systems.

Moreover, a new revolution is emerging, with the increase of humanoid robots. The main quality of such humanoid robots is its similarity to the human being.

Research is very intense in the domain of artificial life (Alife).

The concept of autopoietic system, a system which is self-developing, is now introduced in AI and Alife.

Varela [1996, 2000] related autopoiesis to cognition, and proposed "a biology of intentionality" in relation to autopoiesis. Let us remark that any intention is linked anticipation.

A review and a reappraisal of autopoiesis were presented by Luisi [2003].

Bitbol et al. [2004] consider autopoiesis with or without cognition for defining life at its edge.

If we accept Rosen's [1985] quest that all living systems, even so artificial ones, are anticipatory systems, to what degree does the original model of Varela et al. [1974] represents the anticipatory properties of living systems?

In what ways is it possible to modify the original algorithm in order to highlight the role of anticipation in the development of new living structures in the simulated system?

These reflections would give some light on the relationship between autopoiesis and anticipation in artificial life (Alife) systems.

In this chapter, we will combine the research on autopoiesis and artificial life by Varela et al. [1974], McMullin and Varela [1997], Mingers and McMullin [1997], and McMullin [1997, 2004] with our own research on anticipatory modelling, simulation, and computing [Dubois, 2003; Holmberg, 1998]. We have already demonstrated that a highly creative and idea generating research milieu will emerge [Dubois and Holmberg, 2008].

Fractals can be generated by incursive and hyperincursive automata [Dubois, 1997, 1998].

Rosen [1991] asked: Why are living things alive ? Rosen [1985] believed that the distinction between matter and life is due to the property that living systems are anticipatory systems.

Dubois [2000] demonstrated that the fundamental origin of anticipation can be found in electromagnetism. Hence, anticipation will be a fundamental and included property in autopoietic biological and programmed physical artificial systems.

Palmer [2003] presented a study on the quantum weak measures and the reflexive autopoiesis.

Varela [1989] presented an essay on the living related to autonomy and knowledge.

Collier [2008] analyzed the Dubois conjecture in the simulating autonomous computing in bio-systems.

Moreover, autopoietic systems can be used for anticipatory computing. An important work was performed by Letelier, Marin, Mpodozis and Soto-Andrade [2002] on the anticipatory computing with autopoietic and (M, R) system.

Letelier, Marin and Mpodozis [2003] presented an interesting work on autopoietic and (M, R) systems.

Rosen [1985] proposed his Metabolic-Repair model (M, R), similar to the autopoietic model of Varela.