Chapter VI

Modeling Developmental Processes in MGS

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ABSTRACT

Biology has long inspired unconventional models of computation to computer scientists. This chapter focuses on a model inspired by biological development both at the molecular and cellular levels. Such biological processes are particularly interesting for computer science because the dynamic organization emerges from many decentralized and local interactions that occur concurrently at several time and space scales. Thus, they provide a source of inspiration to solve various problems related to mobility, distributed systems, open systems, etc. The fundamental mechanisms of biological development are now understood as changes within a complex dynamical system. This chapter advocates that these fundamental mechanisms, although mainly developed in a continuous framework, can be rephrased in a discrete setting relying on the notion of rewriting in a topological setting. The discrete formulation is as formal as the continuous one, enables the simulation, and opens a way to the
systematic study of the behavioral properties of the biological systems. Directly inspired from these developmental processes, the chapter presents an experimental programming language called MGS. MGS is dedicated to the modeling and simulation of dynamical systems with dynamical structures. The chapter illustrates the basic notions of MGS through several algorithmic examples and by sketching various biological models.

INTRODUCTION

The membrane paradigm, DNA computing, molecular computing, and aqueous computing are examples of unconventional models of computation inspired by molecular biology. In this chapter, we focus on a model inspired by biological development at both molecular and cellular levels. We are interested not only in the interactions between the molecules, but also by the assembling and the structural organization that is dynamically created.

Such biological processes are particularly interesting for a computer scientist because the dynamic organization of the involved entities emerges from many decentralized and local interactions that occur concurrently at several time and space scales. The development of biological organisms has for a long time inspired computer science (see, for instance, the notion of cellular automata noted in von Neumann, 1966). More recently, the emerging domains of amorphous computing (www.swiss.ai.mit.edu/projects/amorphous), self-healing systems, or autonomic computing (Kephart & Chess, 2003; Parashar & Hariri, 2003) are also directly inspired by developmental processes found at both molecular and cellular levels. Inspired by the description of various developmental processes as changes in a dynamical system, we propose a new computational paradigm that extends the idea of rewriting systems to a broader class of data structures. To investigate this model, we are developing an experimental programming language called MGS.

However, the fertilization of computer science by biological notions (Paton, 1994) is not a one-way process, and biology has imported many concepts developed within computer science such as the notion of programs, memory, information, control, and many others (Stengers, 1988; Keller, 1995). Obviously, new programming paradigms inspired by basic developmental mechanisms will be also an ideal framework to support and help the biologist in analysing and understanding these kinds of biological processes. We illustrate this cross-fertilization by using MGS to simulate various processes of pattern formation.
Development of Gelatin Films with Designed Antimicrobial Peptide and Silver Nanoparticles
