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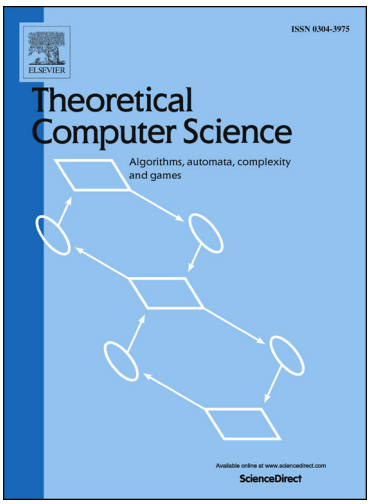


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# Denotational Semantics of Membrane Systems by using Complete Metric Spaces

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**Abstract**

In this paper we present a mathematical model for a class of membrane systems, emphasizing on constructions of the denotational semantics as fixed points over complete metric spaces (to describe the semantics of multiset rewriting) and metric powerdomains (to describe the nondeterministic behaviour). We use the continuation-passing style, a technique providing enough flexibility for handling the concept of maximal parallelism and for describing the specific interactions in a membrane system. An important feature of the denotational approach is that it provides a compositional view of the membrane systems. Moreover, such a semantics can be implemented naturally in a functional programming language; such an implementation in Haskell is provided, and it is freely available for software experiments.

*Keywords:* membrane systems, complete metric spaces, continuation-passing.

## 1. Introduction

Membrane computing is a branch of the natural computing inspired by the architecture and behaviour of living cells. Membrane computing was introduced in [19] by Gheorghe Păun, a former PhD student of Professor Solomon Marcus who was himself a promoter and active supporter of the membrane systems [10]. Membrane systems represent a class of computing devices inspired by living cells which are complex hierarchical membrane structures with a flow of materials and information which underlies their functioning, involving parallel application of rules, communication between membranes and membrane dissolution [19]. The structure of the cell is represented by a set of hierarchically embedded regions, each delimited by a surrounding boundary called membrane and all contained inside a skin membrane. Multisets of objects are distributed inside these regions, and they can be modified or communicated between adjacent regions. Objects represent the formal counterpart of molecular species

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