

CONTEXT MATTERS: HOW CONTEXT SENSITIVITY IMPROVES COMPUTATIONAL POWER IN MEMBRANE SYSTEMS

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It is well known that context sensitivity plays an important role in the theory of formal languages. In my presentation, I discuss how different forms of context sensitivity influence the computational power of a bio-inspired computing model known as P systems with active membranes [3]. These abstract models are parallel computing devices inspired by the structure and functioning of living cells. Such a system consists of hierarchically organized regions, each bounded by membranes that possess specific polarizations. The regions contain multisets of objects. Both membranes and objects are manipulated by means of developmental rules, including evolution rules (objects can be transformed into other objects), communication rules (objects can be transported across membranes), division rules (objects can divide elementary membranes, duplicating the contents of the original membrane), and dissolution rules (objects can dissolve membranes). All of these rules are initiated by a single object; hence, context sensitivity is not explicitly incorporated into the rule set itself. However, context sensitivity arises implicitly through the capacity of objects to obtain information about the presence of other objects within the same membrane. The most direct mechanism to achieve this is the use of polarizations. Alternatively, an object may dissolve a membrane, causing all the objects contained in that membrane to be moved into the parent membrane. Any object that thus ends up in the parent membrane receives information that the object that dissolved the membrane was present alongside it in the now-dissolved membrane.

It is known that polynomial-time P systems with active membranes characterize the complexity class $P^{\#P}$, that is, the class of decision problems that can be solved in polynomial time by Turing machines equipped with $\#P$ oracles—and this holds even when dissolution rules are not allowed [2]. On the other hand, if membrane polarizations are omitted, it is conjectured that these P systems can efficiently solve only problems in P. The P lower bound in this conjecture is straightforward, and notably, it still applies even in the restricted case when only dissolution rules are permitted [1].

In my presentation, I will explore this topic in more detail and discuss some methods described in the literature for replacing the context sensitivity provided by membrane polarizations with other mechanisms.

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- [3] GH. PĂUN, P systems with active membranes: attacking NP-complete problems. *Journal of Automata, Languages and Combinatorics* **6(1)** (2001), 75–90.