Chapter 6.10

Forward and Backward Chaining with P Systems

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ABSTRACT

One of the concepts that lie at the basis of membrane computing is the multiset rewriting rule. On the other hand, the paradigm of rules is profusely used in computer science for representing and dealing with knowledge. Therefore, establishing a “bridge” between these domains is important, for instance, by designing P systems reproducing the modus ponens-based forward and backward chaining that can be used as tools for reasoning in propositional logic. In this paper, the authors show how powerful and intuitive the formalism of membrane computing is and how it can be used to represent concepts and notions from unrelated areas.

1. INTRODUCTION

The use of rules is one of the most common paradigms in computer science for dealing with knowledge. Given two pieces of knowledge $V$ and $W$, expressed in some language, the rule $V \rightarrow W$ is usually considered as a causal relation between $V$ and $W$. This representation is universal in science. For example, in chemistry, $V$ and $W$ can be metabolites and $V \rightarrow W$ a chemical reaction. In this case, $V$ represents the reactants which are consumed in the reaction and $W$ is the obtained product. In propositional logic, $V \rightarrow W$, with $V = v_1 \lor v_2 \lor \ldots \lor v_n$ and $W = w_1 \lor w_2 \lor \ldots \lor w_m$, is a representation of the clause $-v_1 \lor v_2 \lor \ldots \lor v_n \lor w_1 \lor w_2 \lor \ldots \lor w_m$.

An important problem is deriving new knowledge: given a knowledge base $KB = (A, R)$, where...
A knowledge base is a construct $KB = (A, R)$ where $A = \{a_1, a_2, \ldots, a_n\} \subseteq U$ is the set of known atoms and $R$ is the set of rules of the form $V \rightarrow W$, with $V, W \subseteq U$.

In propositional logic, the derivation of a proposition is done via the inference rule known as Generalized Modus Ponens:

$$ P_1, P_2, \ldots, P_n, \ P_1 \land P_2 \land \ldots \land P_n \rightarrow Q $$

The meaning of this is as follows: if $P_1 \land P_2 \land \ldots \land P_n \rightarrow Q$ is a known rule and $\{P_1, P_2, \ldots, P_n\} \subseteq A$ then, $Q$ can be derived from this knowledge. Given a knowledge base $KB = (A, R)$ and an atomic formula $g \in U$, we say that $g$ can be derived from $KB$, denoted by $KB \vdash g$, if there exists a finite sequence of atomic formulas $F_1, F_2, \ldots, F_k$ such that $F_k = g$ and for each $i \in \{1, 2, \ldots, k\}$ one of the following claims holds:

- $F_i \in A$;
- $F_i$ can be derived via Generalized Modus Ponens from $R$ and the set of atoms $\{F_j, F_2, \ldots, F_{i-1}\}$.

It is important to remark that for rules $V \rightarrow W$ we can require $|W| = 1$ without losing generality (Lloyd, 1987).

This definition of derivation provides two algorithms to answer the question of knowing if an atom $g$ can be derived from a knowledge base $KB$. The first one is known as forward chaining and it is an example of data-driven reasoning, i.e., the starting point is the known data. The dual situation is the backward chaining, where the reasoning is query-driven (Bratko, 2001).

A deep study of both algorithms is out of the scope of this paper. We briefly recall their basic forms.

In this paper we present several different transformations of a tuple $\langle A, R, g \rangle$ into P systems and prove that forward chaining and backward
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