String-Object Transduction with Dogmatic P systems

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Thank you !!

Questions ?
Abstract

In this work, we approach the translations of strings to strings in the framework of P systems. We use a variant of P systems with string objects in the regions and transduction rules to transform them. Here, our source of inspiration comes from the “Central Dogma” in Computational Biology which establishes the following transformation of biological sequences in living beings

DNA $\rightarrow$ RNA $\rightarrow$ proteins

We will show how these transformations can be captured in order to simulate finite-state transducers.
The Central Dogma in Computational Biology

**Replication** makes a copy of a DNA strand

**RNA Transcription** makes a complementary DNA strand and substitutes the thymine (T) by the uracil (U) to obtain a RNA strand

**Splicing** (tRNA is compacted into significant units)

**Transduction** (every triplet of RNA nucleotides encodes a protein amino acid)
The Central Dogma in Computational Biology

DNA $\rightarrow$ RNA $\rightarrow$ proteins

• Different processes in different regions
• Different alphabet sizes and symbols
• Finite transduction-like operations
• Different products at every stage

Our Goal: Propose a model to catch the main features of the Central Dogma in the living cell (hence in a membrane structure) to transduce string languages
Dogmatic P systems

Main ingredients

• string objects instead of multisets of symbol objects

• \(\text{here, out, in}_j\) addressing

• Language transducers (explicit input/output regions, or skin output)

• New transduction rules (with priorities)
Introducing transduction-like rules in the regions

\[ u : V_{pos} \rightarrow W_{ad_1, ad_2, \ldots, ad_k} \quad \text{pos} \in \{l, r, *\} \quad \text{ad}_i \in \{\text{here, out, in}_j\} \]

The rule is applied whenever there exists string objects \( u \) and \( x \) such that \( x \) contains the substring \( v \) at position established by \( pos \). Then \( v \) is replaced by \( w \) in \( x \) and the resulting string is sent to the regions established by \( ad_j \).

\[ eee : a_l \rightarrow bb_{\text{here}} \]
Dogmatic P systems

\[
\Pi = (V, \mu, A_1, A_2, \ldots, A_m, (R_1, \rho_1), (R_2, \rho_2), \ldots, (R_m, \rho_m), i_0)
\]

Note: The \texttt{in}_j address in any rule of region k sends the resulting string object directly from region k to region j (RNA migration)
Simulating Transducers by Dogmatic P systems

A Transducer is defined by the tuple \((Q, \Sigma, \Gamma, q_0, E, F)\) where the transitions in \(E\) take the form \(qx \rightarrow yp\)

\[
\begin{array}{c}
q \\
\xymatrix{ 
& x/y & p \\
\ar[rr]^{} & & \\
}
\end{array}
\]

\[
T(x) = \{ y \in \Gamma^* : q_0x \rightarrow yp, p \in F \}
\]

\[
T(L) = \bigcup_{x \in L} T(x)
\]

A normal form

\[
F=\{q_f\} \\
E \subseteq Q - \{q_f\} \times (\Sigma \cup \{\lambda\}) \times (\Gamma \cup \{\lambda\}) \times Q - \{q_0\}
\]
Simulating FTs by Dogmatic P systems

An small example: (formal proposal in the abstract)

\[
\begin{align*}
R_0 & \quad \#a_l \rightarrow \hat{b}\hat{b}_{in_1} \\
R_1 & \quad \hat{b}a_l \rightarrow \hat{b}\hat{b}\hat{b}_{here} \\
R_2 & \quad \hat{b}_r \rightarrow b_{out} \\
\text{skin} & \quad \hat{b}_l \rightarrow b_{here} \\
\end{align*}
\]
Future Research

• Exploring the generation power of the *dogmatic* P Systems with a restricted number of regions (IFTs hierarchy collapses at 4 states)

• Exploring the effects of different transductions (rational, recognizable, (sub)sequential, etc.) over the model

• Use of general context in the transduction rules?

• Computing by carving with dogmatic P systems
Thank you (again)!!

Questions?