On Hierarchy of the Positioned Eco-grammar Systems

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Outline

Eco-grammar systems

- Attempt to describe interaction between evolving environment and the community of agents living within
- Agents – own evolution, act in the environment
- Environment – 0L system
- State of the environment affects the evolution of the agent
- State of the agent affects the evolution of the environment

PM colonies

- Bounded environment - special boundary markers
- Environment – static
- Agents – acts in the environment according to the context
  - delete the symbol
  - insert the symbol
  - substitute the symbol
  - movement
  - death of the agent

Our view

- Attempt to describe the interaction between the evolving environment and the community of the agents living within
- Focus on the embodiment of the agent in the environment
- presence of the agent is given by the special symbol
- We can study local changes - acting of the agent
- Evolution of the agent is suppressed; it can be described by the type of the agent
- Motivation - living tissue attacked by viruses

Positioned eco-grammar systems

- We go out from the eco-grammar systems and PM colonies
- Environment is a 0L scheme
- Presence of the agent is given by the special symbol

Positioned eco-grammar systems

Definition

Positioned eco-grammar systems (PEG system for short) $\Sigma = (V_E, N_B, E, B_1, \ldots, B_m)$ where

- V_E is finite nonempty alphabet of the environment
- $N_B = \{[j] : 1 \leq j \leq m\}$ is the set of identifiers of the agents, $[j]$ sets position of the $j-th$ type of agent in the environment
- $E = (V_E, P_E)$ is $0L$ scheme with alphabet V_E and evolution rules P_E - environment
- $B_j = ([j], Q_j)$, is the $j-th$ type of the agent for $1 \leq j \leq m$ and Q_j is the set of the rules of type $a[j]b \to u$ where $ab \in V_E$ is the symbol on the right or the left side of the agent $[j]$ and $u \in (V_E \cup N_B)^*$
- Axiom $\alpha \in (V_E \cup N_B)^*$

Positioned eco-grammar systems

Definition

- Agent can arise or die via rules
- Presence of the agent in the environment is given by the symbol from the set N_B
- In the environment can be several copies of one type of the agent
- Agents work parallel, untouched symbols are rewritten by the rules of the environment
- Language $L(\Sigma, \alpha) = \{\gamma(u) \in V_E^* : \alpha \Rightarrow_\Sigma^* u, u \in (V_E \cup N_B)^*\}$, where γ is morfism $\gamma(a) = a$ for $a \in V_E$ and $\gamma(b) = \varepsilon$ for $b \in N_B$

Types of Hierarchy

Positioned eco-grammar systems - Sequential components, agents, in parallel environment

- Local modifications of the environment - locations of agents affect generative power
  - Hierarchy based on number of agents presented in the environment
- Agent's context affects its generative power
  - Hierarchy based on the number of the types of the agents in the PEG system

Types of Hierarchy

Number of agents in the environment

- Denote by the PEG_n PEG system with at most n agents present in the environment
- Hierarchy $PEG_n \subseteq PEG_{n+1}$
- Need to find suitable languages

Types of Hierarchy

Number of agents in the environment

- $L = \{a^i b^i c^i : i \geq 0\} \notin 0L$
- $L = \{a^i b^i c^i : i \geq 0\} \notin PEG_1$
- $a[1]bc \Rightarrow aabb[1]c \Rightarrow aabb[1]cc$
- To generate $L = \{a^i b^i c^i : i \geq 0\}$ we need at least 2 agents in the environment

Types of Hierarchy

Number of agents in the environment

- Generally $L = \{a_1^i a_2^i \dots a_{2n}^i a_{2n+1}^i : i \geq 0\} \notin PEG_n$
  - $L = \{a_1^i a_2^i \dots a_{2n}^i : i \geq 0\} \in PEG_n$
  - $L = \{a_1^i a_2^i \dots a_{2n}^i a_{2n+1}^i : i \geq 0\} \notin PEG_n$
- So it holds $PEG_n \subseteq PEG_{n+1}$

Types of Hierarchy

Number of type of agents in the system

- Denote by the PEG^n PEG system with at most n types of the agents in the PEG system
- One-sided & one symbol context - limits in the interaction with the same symbol
- Hierarchy $PEG^n \subseteq PEG^{n+1}$
- Need to find suitable languages

Types of Hierarchy

Number of type of agents in the system

- $L = \{a^i b^i a^j b^j a^k : i, j, k \geq 1, i \neq j \neq k\} \notin 0L$
- $L = \{a^i b^i a^j b^j a^k : i, j, k \geq 1, i \neq j \neq k\} \notin PEG^1$
- Consider $L = \{a^i b^i a^j b^j a^k : i \geq 1, j = 2i, k = 3i\}$
- $a[1]abbaaaa[1]bbbb?aaaaaa?$
- $Q_1 = \{[1]a \to a[1]ab, [1]b \to aa[1]bbb\} \cup (\{a[1] \to aaaa[1]\}$ or $\{[1]b \to aaa[1]bbbb\})$
- To generate $L = \{a^i b^i a^j b^j a^k : i, j, k \geq 0, i \neq j \neq k\}$ we need at least 2 types of the agents

Types of Hierarchy

Number of type of agents in the system

- Generally
  - $L = \{a^{i_1}b^{i_1}a^{i_2}b^{i_2}\dots a^{i_{2n}}b^{i_{2n}} : i_j \geq 1, i_j \neq i_{j+1}, 1 \leq j \leq 2n\} \in PEG^n$
  - $L = \{a^{i_1}b^{i_1}a^{i_2}b^{i_2}\dots a^{i_{2n}}b^{i_{2n}}a^{i_{2n+1}} : i_j \geq 1, i_j \neq i_{j+1}, 1 \leq j \leq 2n\} \notin PEG^n$
- So it holds $PEG^n \subseteq PEG^{n+1}$

Conclusion

We have shown that the generative power of the PEG system depends on the number of the agents present in the environment and on the types of the agents in the PEG system. There are the hierarchies:

- $PEG_n \subseteq PEG_{n+1}, n \geq 0$
- $PEG^n \subseteq PEG^{n+1}, n \geq 0$

Thanks for your attention :-) Feel free to ask your questions!