Networks of Genetic Processors: From Universality to a Formal Language Characterization

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Networks of Bio-inspired Processors (NBP) [3] are a family of models of computation inspired by different biological processes over biomacromolecules (mainly, DNA and RNA molecules). These operations can be applied over strings to define formal languages. Any bio-inspired processor contains a multiset of strings, where every string can be found in an arbitrarily large number of copies. The processors apply the operations that they have defined over the strings in a massively parallel and non-deterministic manner, and they obtains a (probably) new multiset of strings. A network model arranges the connection of a finite number of bio-inspired processors. The processors can be equipped with input/output filters to receive/send the strings from/to other processors connected to it. The network computes by alternating two kind of computation steps: operation application and string communication. These models have been formulated as accepting and generating devices.

The first model of NBPs was formulated by V. Mitrana (the founder of this research topic) as Networks of Evolutionary Processors (NEP) [1]. There, the operations in the processors were inspired by point mutation over the nucleotides in DNA. Later, the splicing biological process during the DNA transcription and RNA translation inspired the Networks of Splicing Processors (NSP) [2].

The Networks of Genetic Processors (NGP) were inspired by NEPs and NSPs, by using some operations previously defined over them. At every processor, only symbol substitutions or full string *crossover* are applied. Hence, the model can be easily related to classical Genetic Algorithms. It has been proved that NGPs are computationally complete given that they can simulate any Turing machine, if an accepting version of the model is defined [4]. The generating version of this model can be used to introduce a descriptive complexity measure of formal languages defined according to the classical Chomsky's hierarchy: three, four, six or eight processors can be used to characterize the regular, context-free, context-sensitive and recursively enumerable languages [6].

In addition, the NGPs can be used to formally prove the computational completeness of Genetic Algorithms, if some restrictions are imposed [4], and they have been fruitfully used to solve hard optimization combinatorial problems efficiently [5].

References

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