Use of a Genetic Algorithm to Evolve an Extended Artificial Regulatory Network for Cell Pattern Generation

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ABSTRACT

Cell pattern formation has a crucial role in both artificial and natural development. We present results from experiments in which a genetic algorithm was used to evolve an extended artificial regulatory network to produce predefined 2D cell patterns through the selective activation and inhibition of genes.

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General Terms: Algorithms

Keywords: Genetic Algorithm, Artificial Regulatory Network, Cell Pattern.

1. ARTIFICIAL REGULATORY NETWORK

Artificial Regulatory Networks (ARNs) are computer models whose objective is to emulate to some extent the gene regulatory networks found in nature. The ARN implemented in this work is an extension of the model presented in [3], which in turn is based on the model proposed by Banzhaf [1]. The model was extended because in previous work we encountered limits in the number of regulatory genes that could be reliably synchronized under the conditions tested [3]. The original model only considered one inhibitor and one enhancer site for each regulatory gene [1]. However, in the present work the number of regulatory sites can be more than two with no predefined function; they can behave either as an enhancer or an inhibitor, depending on the configuration of the defining bits associated with the regulatory site (Figure 1). The ARN was evolved by means of a genetic algorithm (GA) that used tournament selection with single-point crossover and mutation as genetic operators. In order to test the functionality of the ARN found by the GA, the chromosomes representing the ARN were applied to a cellular growth model that we have successfully used in the past to develop simple 2D and 3D geometrical shapes [2].

2. RESULTS

Under the conditions tested, the values for the number of function defining bits and the number of regulatory sites that gave the best results were 12 and 8, respectively. However, there is no definite proof that they correspond to the optimal values for these parameters, since these results are based on single-trial experiments. In order to test the extended ARN, a French flag with a flagpole pattern was grown using a tandem of two identical series of the four structural genes that produced the desired pattern. Figure 2(a) shows the 21×7 French flag with a flagpole produced by the expression of the protein concentration pattern shown on 2(b).

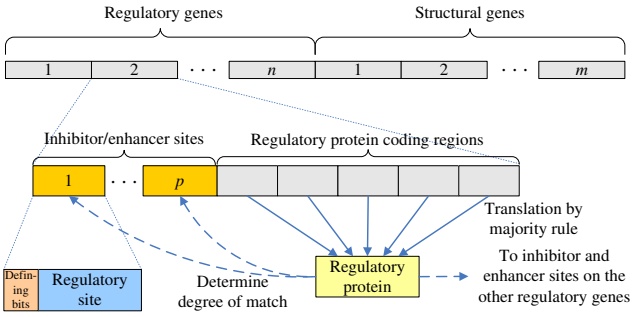

Figure 1: Genome structure.

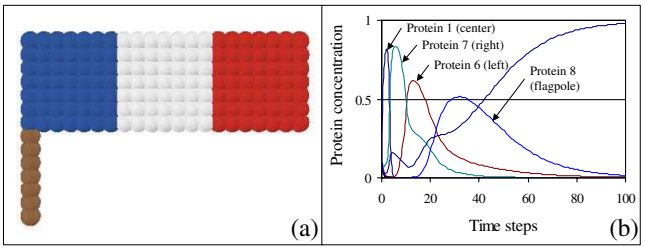

Figure 2: (a) French flag with a flagpole; (b) corresponding protein concentration graph.

3. REFERENCES

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