

Methodology to Solve Combinatorial Optimization Problems with the Artificial Immune System

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Abstract. This paper presents an approximation to the Methodology to solve Combinatorial Optimization Problems (CO) using the Artificial Immune System (AIS). This Methodology is based principally in the **performance** of the Natural Immune System (NIS), which one consist in the cell creation until the elimination of the antigen and the recirculation of the different cells trough the organism, this with the objective to find the best solution to a OC problem.

Keywords: Natural Immune System, Artificial Immune System, Combinatorial Optimization Problems

1 Introduction

The Natural Immune System is the responsible for maintain is a health state the organism, it means, to save from illness, infections, etc. caused for the presence of harmful agents like microorganism, called antigens.

The NIS is divided by the innate immunity and the adaptive immunity. The last one have been an object of deeper study in the AIS because it has characteristics that are desirables in any intelligent or optimization system.

The work of NIS follows a methodology, in which the active and passive cells are defined, the interactions between each component of the system and even so the defense mechanisms that will be used, this will depend of the antigen that attack the organism. This NIS is active even when there is not a detected threat, or the threat is unknown, and for this reason the NIS is in alert and in vigilance of the different parts of the organism that can be affected by the strange harmful antigens.

This methodology can be translated to the AIS to be simulated and used to solve diverse problems like the NIS do.

2 Natural Immune System

The Word immune means protection to face the illness and, more specifically, to face the infectious illness. The cells and molecules responsible of the immunity constitute the Immune System, and the global coordinated response to the introduction of stranger substances is the immune response. [1]

2.1 Innate Immunity

The defense face to the microorganism is realized by the first reactions of the innate immunity and for the later reactions of the adaptive immunity. The innate immunity is constituted by mechanisms that exist before the infection was developed, which are capable to establish fast responses to the microorganism and react of the same way to repeated infections. [1]

2.2 Adaptive Immunity

It is conformed by mechanisms of defense more evolved that are stimulated after de exposition to the infectious agents y of which intensity and defense capacity grow after the subsequent exposition to a determined microorganism. This is called Adaptive Immunity because is developed like a response to an infection.

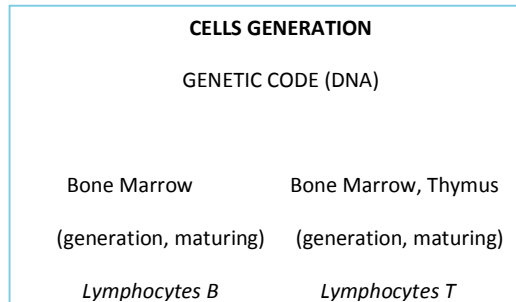
Some of its characteristics are the specificity to different macromolecules and the capacity to remember and response with greater intensity after repeated expositions to the same microorganism. Due to this capacity to differentiate between the microorganisms and macromolecules, even they are closely related; the adaptive immunity is called too Specific Immunity, or Acquired Immunity to highlight the fact that is based in strong protector responses acquired with the experience.

The components are the lymphocytes B and T and the products of them. [1]

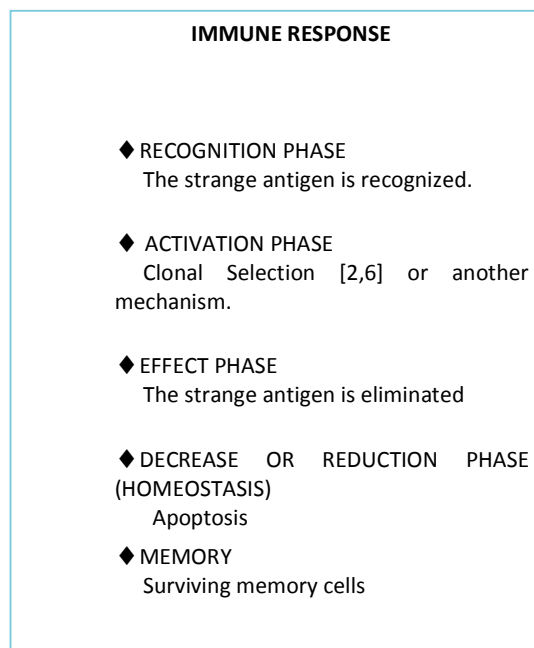
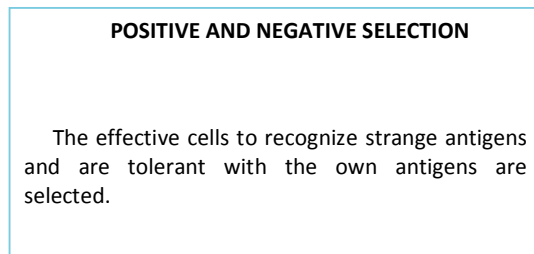
2.3 Estimated Model of the performance of the Natural Immune System

The next is the model in which is described briefly the work of the NIS, in which is considered since the NIS cells generation phase until the recirculation.

In the Immune Response is only considered the mechanisms that work in the adaptive immunity.



There is a stimulation to generate continually new cells and maintain the lymphocytes population.



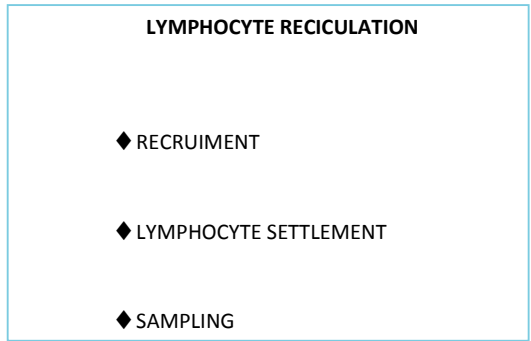


Fig. 1. Estimated Model of the performance of the Natural Immune System

2.3 AIS Methodology

Considering the model of the work of the NIS, the simulation of the generation cells phase is shown, that in the AIS is the feasible solution generation for OC problem.

Even though the NIS begins with the generation of lymphocytes T and B (bone marrow and thymus), whose receptors will have affinity to one antigen. This cells have a maturation process in which have changes a genetic level to be able of take part of the NIS. Some of this mechanism that are used to achieve the maturation are shown.

REVERSAL



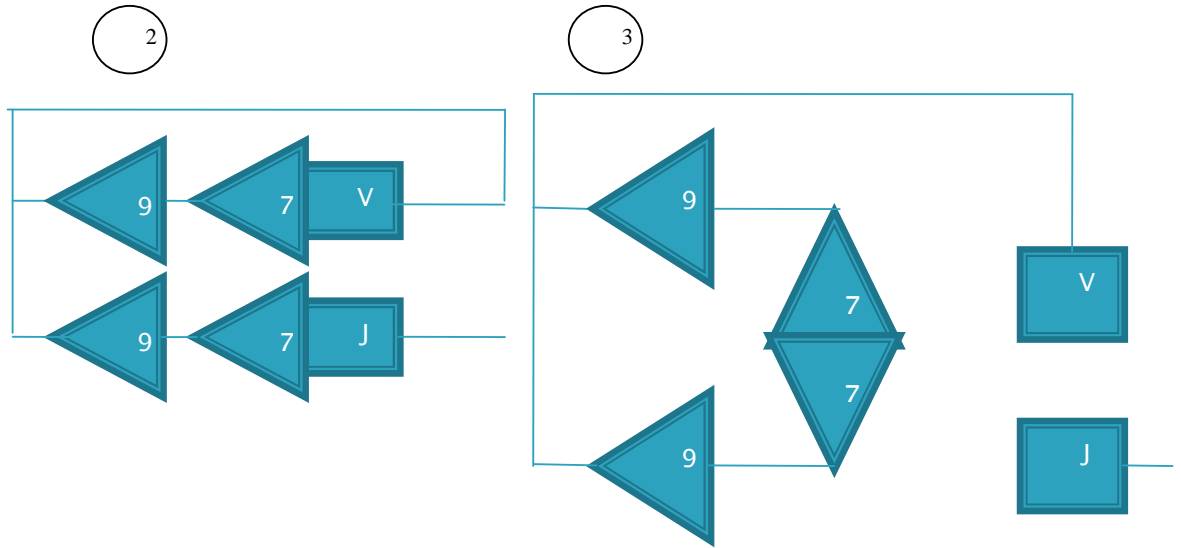
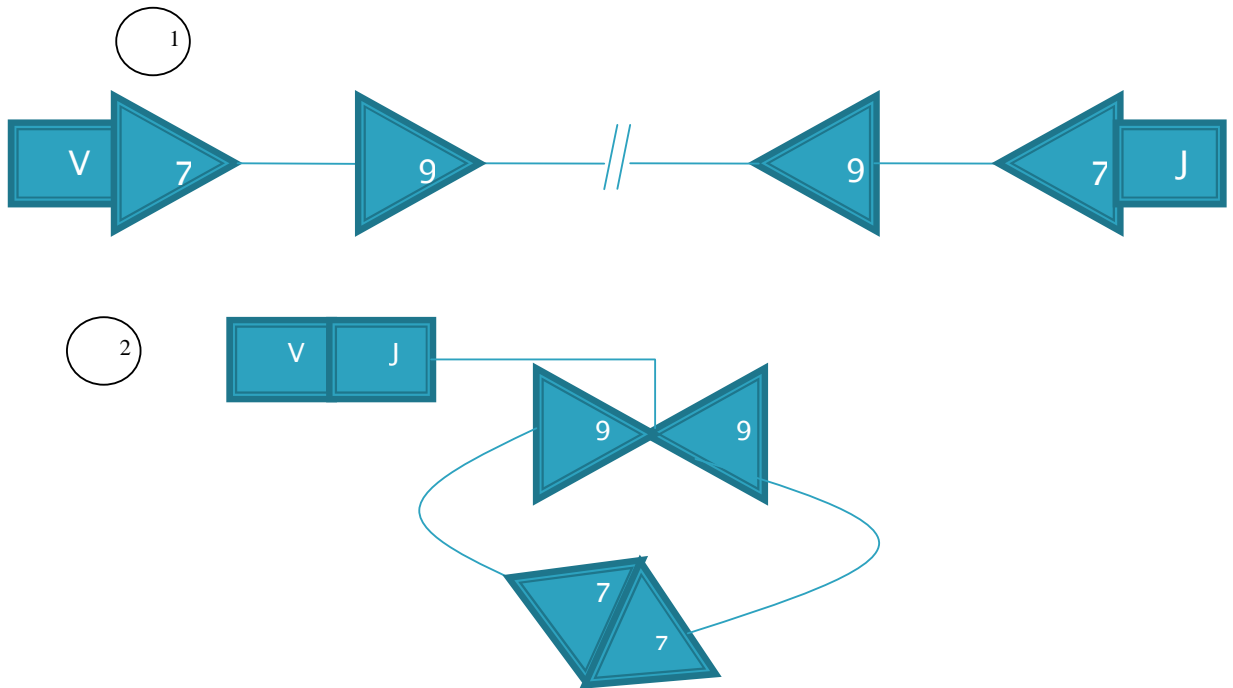


Fig. 2. Reversal Operator

DELETION



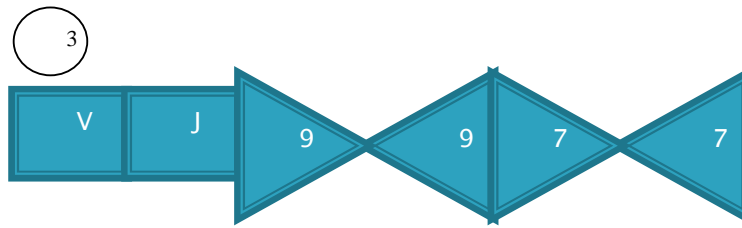


Fig. 3. Deletion Operator

The generated feasible solutions are equivalents to the lymphocytes.

The next pseudocode shows how the simulation of the first phase (generation cells) and how the solutions are modified in the maturation process.

Generate population

 Generate the initial population of solutions (lymphocytes)

 Generate each one of the sub solutions that will be part of the solution

 Evaluate the affinity

Define the J, V, 7 and 9 solutions.

End of Generate population

Maturation process

 Apply Reversal Operator

 Evaluate affinity

 If the solution improve

 If the improvement is low (less than 10%) go to the Deletion operator only the modified solution

 Else

 End maturation process

 Else

 Go to Deletion operator the original and modified solution

 Only the best solution go to the population

End Maturation process

Fin del proceso de maduración.

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