

## A REINFORCEMENT LEARNING INTELLIGENT CONTROLLER BASED ON PRIMARY-SECONDARY RESPONSE MECHANISM OF IMMUNE SYSTEM

Bao Liu<sup>1</sup>, Yongsheng Ding<sup>1,2,\*</sup> and Da Ruan<sup>3</sup>

<sup>1</sup>College of Information Sciences and Technology

<sup>2</sup>Engineering Research Center of Digitized Textile & Fashion Technology, Ministry of  
Education

Donghua University, Shanghai 201620, P. R. China.

<sup>3</sup>The Belgian Nuclear Research Centre (SCKoCEN)

Boeretang 200, B-2400 Mol, Belgium

**Abstract.** Reinforcement learning control is one of the important approaches in intelligent control. The immune system can recognize the invaded antigen and eliminate it rapidly, and will be more stable when the antigen invades again. This is the primary-secondary response mechanism of the immune system, and can be regarded as a process of reinforcement learning. Based on this mechanism, a novel reinforcement learning intelligent controller (RLIC) is presented in this paper. The RLIC has the abilities of learning, memory, and evolution. The control system has no control antibodies (CABs) when the control error appears for the first time. The RLIC can learn and produce the CABs automatically during the period of eliminating the control error, and the CABs store the final changing control output after the error is eliminated. When the control error appears again, the RLIC can eliminate it rapidly and stably by using the stored CABs and combining the conventional control algorithm. After the control error is eliminated, a new CAB is produced and stored. Repeating the above process, the RLIC's learning ability and system response become stronger and stronger. Consequently, the control performance of the RLIC can be improved. In order to examine the effectiveness of the RLIC, the simulation experiments are carried out by choosing a second-order plant with a time delay and a third-order plant. Simulation results demonstrate that system response ability and stability of the RLIC are better than those of the conventional PID controller.

**Keywords.** immune system, primary-secondary response mechanism, reinforcement learning, memory, evolution, intelligent controller.

## 1 Introduction

The learning control has appeared since 1960s, and has become an important approach in intelligent control research. The learning control system can learn some unknown-information of a certain process and control the process by using the knowledge learned [1]. Since the early 1970s, several structures of learning control have been presented, which include pattern