Dynamics of Continuous, Discrete and Impulsive Systems
Series **B:** *Applications & Algorithms* **26 (2019)** 135-152
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OPTIMAL CONTROL OF ANTIGEN-ANTIBODY INTERACTIONS FOR CANCER IMMUNOTHERAPY

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Abstract. In this paper, we propose a dynamic model to represent the population of antigens and antibodies in cancer patients; in particular the antigen-specific-antibody interactions to elicit immune response that leads to the death of cancer cells. The antibodies are known to be powerful medications for cancer immunotherapy. We formulate a terminal control problem where the schedule and doses of these antibodies are considered as control variables. The objective functional is defined as a measure of antigen population at the end of treatment period. Pontryagin minimum principle is used to obtain the optimal treatment policies. For illustration, a series of numerical results is presented showing the effectiveness of immune therapy for cancer treatment corresponding to the different choices of parameters and treatment periods. This approach is potentially applicable to determine and prescribe the optimal doses and schedules for cancer patients.

Keywords. Antigen, Antibody, Immune system, Cancer Immunotherapy, Optimal control.

AMS (MOS) subject classification: 49J15, 93A30, 90C52, 92D25.

1 Introduction

Mathematical modelling of bio-chemical processes has been widely used to analyse the dynamic behavior of biological phenomena. This analysis can also be applied in both clinical and experimental settings [20]. In the era of intense and rapid development of cancer immunotherapy, such efforts can prove to be significant in developing effective and efficient drug administration regimes [14]. Currently, immunotherapy is the most promising cancer treatment approach since the development of other therapies [12]. It was first introduced by William B. Coley in 1890 [23]. The idea behind this breakthrough is the immune system of human body, which can be described as a network of cells, tissues, and organs, naturally works to defend the body against attacks by foreign invaders (pathogens) [16]. Researchers are training the immune system to recognise cancer cell and destroy them. Following this, if the interactions of the immune system with cancer cells or tumor cells