Bilinear controlled model in adaptive cancer therapy

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Most patients diagnosed with prostate cancer are cured with surgery or radiation therapy. However, patients who have already started the process of metastasis or develop a relapse after local therapy usually require additional hormonal therapy aimed at systemic treatment. The report examines the interaction between a population of androgen-dependent cancer cells and two populations of androgen-independent cancer cells in prostate cancer both with and without hormonal therapy. This interaction is modeled using appropriate linear systems of differential equations. Considering adaptive therapy as one of the effective methods of treating this disease, prolonging the therapeutic advantage in the sensitivity of the disease to pharmacological intervention and thereby improving the quality of life of the patient, such linear systems of equations are combined into a bilinear controlled system by introducing a control function. This control function takes on two different values: one value defines the interaction between the cancer cell populations in question during hormone therapy, and the other describes the state of these populations in the absence of hormone therapy. The target function that should be minimized is the prostate specific antigen (PSA) level at the end point of a given overall prostate cancer treatment period. The solution to the stated minimization problem is carried out by enumerating the points of the attainable set corresponding to the bilinear control system in accordance with the values accepted by the objective function. To do this, we first need to find a uniform estimate for the number of switchings of piecewise constant controls corresponding to the points of such a set. After this, a general form of controls is formed with a given number of switchings corresponding to the boundary and the interior of the attainable set. This allows us to replace the original optimal control problem with a finite-dimensional nonlinear optimization problem. This problem is solved numerically in the MAPLE environment. The report presents and discusses the results of corresponding numerical calculations for various parameter values and initial conditions of the bilinear controlled system.

References

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