CHALLENGES IN MATHEMATICAL MODELING OF NOVEL CANCER TREATMENTS: AN OPTIMAL CONTROL APPROACH

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Abstract: Mathematical models for cancer treatments have a long history, but with the discovery and development of novel therapies new challenges in the formulation of the models and their analysis arise. In this talk we shall focus on mathematical models for one of the promising novel therapies, tumor anti-angiogenesis, whose goal is to prevent the tumor from developing the vascular network, by controlling its supply with oxygen and nutrients to further its growth. We shall introduce one of the most recognized models for tumor anti-angiogenesis formulated by a group at Harvard Medical School and we analyze it mathematically with the tools of optimal control theory. The problem will be considered both as a stand-alone procedure for tumor anti-angiogenesis and in combination with classical cancer treatments like chemo- and radiotherapy. Our goal is to find optimal protocols for the administration of the therapeutic agents that minimize the tumor volume. For the monotherapy problem a complete solution for the problem will be given in terms of an optimal synthesis of controlled trajectories. For combination therapies the mathematical problem becomes quite difficult due to its multi-control aspect and so far a full theoretical solution remains elusive. However, several examples of optimal protocols that have been computed numerically suggest a particular structure for these protocols that will be described. Both a nontrivial mathematical analysis based on Lie bracket computations and high-order conditions for optimality and interesting biomedical conclusions result from this study.