Mathematical modeling and simulation with deep learning methods of cancer growth for patient-specific therapy

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Numerous methods of tumor therapy have gained attention in recent decades for cancer treatment. Three of these methods include anti-angiogenic therapy, virotherapy, and immunotherapy, each of which attempts to inhibit growth of cancer cells in a different way. While much research has focused on experimental techniques, there has been parallel developments to understand these methods through novel mathematical models. Often, these models are described by a system of coupled ordinary differential equations that include the interactions between constituent proteins, molecules, and drugs, among others, that impact the growth of the cancer cells. This study aimed to build upon existing mathematical models by including new details and missing interactions to enhance our understanding of the dynamics and evolution of the disease. For the anti-angiogenic therapy, Aspirin was used as the drug of choice due to its protein-regulatory properties and its ability to induce apoptosis in cancer cells. For virotherapy, the effect of the immune system was included to enhance the interaction between the oncolytic virus and the cancer cells. For immunotherapy, the introduction of liposomes carrying IL-2 cells enhanced the dynamics of the model. Additionally, mathematical models of these therapies involve a number of parameters corresponding to growth, death, diffusion, and inhibition rates, which are often hard to estimate experimentally. We employ sophisticated numerical and optimization techniques, including deep learning, to estimate these parameters. MATLAB was utilized for numerical solutions and displaying the model dynamics. Python and Tensorflow were used to implement deep learning with a neural network approach, applied to physics informed and uninformed methods. Our computational results indicate that the enhancements to the models in this research have a significant impact on the cancer dynamics. Potential future applications also include the implementation of deep learning for predictive analysis of tumor growth and therapy stemming from patient-specific data in real-time.