

Research Proposal: Mathematical Modeling of Local Tumor Morphology with Chemotherapy and Immune Treatments

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1 Introduction

Exploring and understanding the interaction of tumor cells with chemotherapy and the immune system is fundamental to the effective treatment of cancer. Mathematical modeling can aid this understanding by allowing researchers to test hypothesis without resorting to lengthy and potentially deadly biological experiments.

Current cancer treatments rely heavily on chemotherapy but the effects of the immune system and subsequent immunotherapy show a promising new treatment avenue to explore. This proposed thesis will look at not only the effects of chemotherapy and the immune system on early stage tumor growth but also investigate their potential combined treatment value.

2 Proposed Research

This proposed model is based on the a model described by S. C. Ferreira, Jr. ([1], [2]). In this model tumor morphology is modeled on a cellular level in a cellular automata and is driven by a chemical which diffuses through the automata modeled by a PDE. This model has the interesting characteristic that it is essentially both a deterministic (the chemical PDE) and probabilistic (the cellular automata) incorporating both modeling techniques where they are the most applicable.

Currently we have reproduced Ferreira's work (discussed in Section 3) and are working on improving a currently crude immune system component of the model. We propose to run further simulation in the Fall of 2004 and tie the parameters of the model to clinical data and actual physical parameters, something that is notably lacking in Ferreira's current papers.

3 Prior Research

Summer of 2003 I began to investigate Ferreira's model with Prof de Pillis during summer research at HMC. This investigation has continued through the 2003-2004

academic year and is currently scheduled to continue into the Summer 2004 as well with additional summer research.

During the summer of 2003 a working version of Ferreir's nutrient based tumor model was developed with chemo and immuno elements incorporated. However the runtime for a single simulation was prohibitive (between 1-9 days depending on the parameters). As a result the model was not as thoroughly explored as was hoped for. Ferriera's results were reproduced and expected effects of chemotherapy were observed.

Over the academic year 2003-2004 several algorithm developments cut the runtime down to 9-24 hours. Additional simulations were also explored including pulsed versus continuous chemotreatments but the bulk of the year was given over to code optimization.

For the summer of 2004 we hope to focus on running simulations and tying in biological parameters into the model parameters. This work will continue into the fall of 2004 and I believe would benefit greatly from the structure of the Thesis program at HMC.

References

- [1] S. C. Ferreira, M. L. Martins, and M. J. Vilela. Reaction-diffusion model for the growth of avascular tumor. *Phys. Rev. E (3)*, 65(2):021907, 8, 2002.
- [2] S. C. Ferreira, M. L. Martins, and M. J. Vilela. Morphology transitions induced by chemotherapy in carcinomas *in situ*. *Phys. Rev. E (3)*, 67, 2003.