Research Statement

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1 Primer:

As I journey through academia, I explore and investigate correlation and impact mathematics has on the world. The question I asked myself, "How can I apply what I love doing to help those that I love?" This came abreast to me in the fall of 2012 at Mississippi Valley State University. One of the professors at Mississippi Valley State University gave me the opportunity to work with him on research titled, "Chaos Control of a Financial System with Delayed Control Feedback".

Utilizing ordinary differential equations, we were able to model and simulate a financial system. We worked to find stability and uniqueness of different models while only controlling certain parameters. It was surprising and breathe-taking. I really enjoyed this study. I was encouraged to go to graduate school if I wanted to learn more.

The next chapter in my life included Mississippi State University. The research experience I obtained involved ordinary differential equations as well. We formulated a master equation that models Amyloid Beta protein in the brain. During this research, I got the opportunity to learn about the inner-workings of the brain. I kept being fascinated by the fact that we can use mathematics to model so many real-world problems.

After spending the first two years engaging in sturctured and faciliated learning as a Doctor of Philosophy student at Mississippi State University, I was still trying to find out how can I find a way to make a difference in the world with what I love to do. Image processing. From the medical field to law enforcement, there are so many things that can be done and so many areas that can be touched with image processing.

Some of these "groundbreaking" findings have revolutionize everything we know about how we see the world around us. Continuing through this research statement yield contributions and continuing work in this area.

This document's flow. In section II, contemporary endeavor may be found. Following, in section III, disseminated editorials are addressed. Later in section IV, future editorial(s) are exhibited. The next, section V, ferry onward. VI, belvedere, references.

2 Contemporary Endeavor:

In this work, via chaos control, a virtual laboratory is utilized to understand the dynamical behavior and inner connectedness of solid and liquid tumors in the process of eradication. From clinical data and research, mathematical models and algorithms are developed and formulated to uncover the precise consequence of these phenomena. With these virtual laboratories, we preserve all possible outcomes.

Chimeric Antigen Receptor T (CAR-T)–cell immunotherapy for immunodeficient mice therapy of hematological cancers response depends on the following factors:

1. Capacity of CAR-T cells to kill tumor cells.
2. The formulation of long-term immunological memory cells.
3. Immunosuppressive effects of the tumor microenvironment.

After the approval of CAR T cell therapies in 2017 by the Federal Drug Administration, immunotherapy attracted more recognition. This procedure can be initiated when an individual's/patient's T lymphocytes are genetically altered to identify tumor-specific antigens. This process helps with minimizing tumor growth and tumor remission. However, there is still a challenge in CAR-T cell immunotherapy and all cellular therapies, which is the exhaustion of implanted cells.

To investigate this occurrence, we look to a mathematical model of CAR-T immunotherapy in pre-clinical studies of Hematological cancers. Luciana R. C. Barros et. at. [11], constructed a mathematical model that explored the back-and-forth amongst tumor cells, effector CAR-T cells, and memory CAR-T cells. In their work, the authors built a three-population mathematical model to describe tumor response to CAR-T cell immunotherapy in immunodeficient mouse. Encompassing interactions between a non-solid tumor and CAR-T cells, their model is composed of ordinary differential equations (ODEs). We present their model,

$$\begin{cases} \frac{dC_T}{dt} &= \phi C_T - \rho C_T + \theta T C_M - \alpha T C_T \\ \frac{dC_M}{dt} &= \epsilon C_T - \theta T C_M - \mu C_M \\ \frac{dT}{dt} &= rT(1-bT) - \gamma C_T T. \end{cases} \tag{1}$$

In the above model, T represents tumor cells, C_T represents effector CAR-T cells, and C_M represents memory CAR-T cells

For example, we will investigate the dynamic behavior of Hopf bifurcation stability. We study this behavior because oscillatory contours are frequently observed throughout nature. Many have argued and shown the importance and strength of this line of research. To tackle the shortcomings, we are interested in the special case when the CART-cells have become ineffective in their ability to arouse or repress the tumor cells.

We now propose the new dimensionless system of ordinary differential equations for CAR-T cell therapy with numerical simulations to demonstrate the steadiness of the anew purported structure,

$$\begin{cases} X' &= -pX + qZY \\ Y' &= uX - qZY - wY \\ Z' &= Z(1-Z) - XZ. \end{cases} \tag{2}$$

Continuing the journey to acquire more about the mathematical world, we investigate undiscovered channels and pathways that reveal direct revelations of the world's connections. This has become further evident with some contemporary opuses. These compositions involve solid and liquid tumors elimination.

3 Disseminated Editorial(s)

- Edge Enhancing Accelerated Diffusion Model for Speckle Denoising in Medical Imagery
  https://doi.org/10.1051/itmconf/20192901009
- An efficient numerical method for one-dimensional hyperbolic interface problems
  https://doi.org/10.1051/itmconf/20192901002
- Quarter match non-local means algorithm for noise removal
  https://www.sciencedirect.com/science/article/pii/S2772415823000123
- Mathematical Modeling Insights into Improving CAR T cell Therapy for Solid Tumors: Antigen Heterogeneity, Bystander Effects, and Dosing Schedules
  reference number: NPJSBA-01302

4 Technique(s) Generated: Editorial Formulating

- Modeling and quantifying the effect of blood pressure, intraocular pressure, and blood viscosity on the central retinal artery hemodynamics in people of European and African descent [12, 13]
- Chambolle accelerated diffusion (CAD) model
- Cell immunotherapy of hematological Cancers Response: A mathematical model that uncovers the stability analysis and eradication

5 Ferry Onward:

We are currently working on combining Chamoblle's model with efficiency and Non-local means model with accuracy. Our new research requires new definitions as classical derivates are local operators.

Minimization functional:

$$\inf_u F(u) = \int_\Omega |\nabla_{NL} u| + \frac{\lambda}{2}(u - u_0)^2 dx. \tag{3}$$

Minimizing, Euler Lagrange gives the model as:

$$u_t = \int_\Omega w(x,y)(u(y)-u(x))\Big(|\nabla_{NL}u|^{-1}(x) + |\nabla_{NL}u|^{-1}(y)\Big) - \lambda(u(y)-u(x))dy. \tag{4}$$

$\Omega \subset \mathbb{R}^n, x \in \Omega, u : \Omega \to \mathbb{R}, w(x,y) =$ weights between points x and y. Consider $w(x,y) = w(y,x)$.

- Non-local vectors: Mappings $p : \Omega \; x \; \Omega \to \mathbb{R}$.

- Non-local gradient: $\nabla_{NL}u(x,y) = (u(y)-u(x))\sqrt{w(x,y)}$.

- Non-local norm: $|p|(x) = \sqrt{\int_\Omega p(x,y)^2 dy}$.

- Non-local divergence: $div_{NLl}p(x) = \int_\Omega (p(x,y) - p(y,x))\sqrt{w(x,y)}dy$.

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