Optimal cancer treatment strategies in a cell population model with healthy–cancer cell competition

Pauline MAZEL, Université Côte d'Azur, Inria, INRAE, CNRS, MACBES Project-Team, Valbonne - France

Walid DJEMA, Université Côte d'Azur, Inria, INRAe, LOV (CNRS—Sorbonne University) GREENOWL Project-Team, Valbonne - France

Frédéric GROGNARD, Université Côte d'Azur, Inria, INRAE, CNRS, MACBES Project-Team, Valbonne - France

Among the numerous disorders affecting living organisms, cancer stands out as one of the leading causes of mortality worldwide. The complexity of cancer progression, driven by the uncontrolled growth and spread of cancerous cells, motivates the use of mathematical and computational approaches to gain deeper insights into its dynamics and potential treatment strategies. In this study, we analyze an ordinary differential equation model that describes the dynamic interactions between healthy and cancerous cell populations, with the goal of studying acute myeloid leukemia. Following the approach in [1], we define an optimal control problem (OCP) to determine the most effective treatment strategies for reducing the cancer cell population while preserving healthy cells. A theoretical analysis of the OCP is conducted using Pontryagin's Maximum Principle, which provides the necessary conditions for optimal solutions. We then examine the static version of the OCP to gain insights into its structure and the behavior of optimal treatments over time. Finally, using direct optimization methods, we illustrate through simulations the theoretical results and reveal the emergence of a turnpike phenomenon, where the optimal treatment strategy stabilizes around a specific point over time.

[1] P. Mazel, W. Djema, F. Grognard. *Optimal control for a combination of cancer therapies in a model of cell competition.* In *2024 IEEE 63rd Conference on Decision and Control (CDC)*, pp. 1351–1357, 2024. doi :10.1109/CDC56724.2024.10886792.

Contact : `pauline.mazel@inria.fr`