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Francesc Font
Tim Myers *Eds.*

Multidisciplinary Mathematical Modelling

Applications of Mathematics to the Real World

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Preface

Since 2014, the Centre de Recerca Matemática (CRM) received PhD and post-doctoral funding from the La Caixa Foundation and the CERCA Programme of the Generalitat de Catalunya to carry out "interdisciplinary and collaborative research". These projects have been supervised by members of the CRM and also university researchers from biology, physics, nanoscience as well as local research centres. This has led to a broad range of research lines where, due to the influence of the non-mathematical partners, the focus has been firmly on practical problems.

In this book, we present work from a selection of talks resulting from this research and presented at the "International Congress on Industrial and Applied Mathematics", held in Valencia, 2019. The various chapters describe a wide variety of topics: cancer modelling, carbon capture by adsorption, nanoscale diffusion and complex systems to predict earthquakes. These mathematical studies were specifically aided via collaborations with biomedical engineers, physicists and chemists.

The wide range of topics described in this book reflects not only the multidisciplinary nature of the La Caixa programme but also the true versatility of mathematics.

Barcelona, Spain
August 2020

Francesc Font
Tim G. Myers

Contents

Editors and Contributors

About the Editors

Francesc Font received his PhD in Applied Mathematics from the Universitat Politècnica de Catalunya in 2014, and he is currently a Juan de la Cierva research fellow at the Centre de Recerca Matemàtica. He specialises in the mathematical modelling of transport phenomena and has worked on topics such as nanoscale heat transfer, Li-ion batteries or cell motility. Part of his research is in collaboration with industry, and he has been involved in industrial mathematics workshops throughout Europe.

Tim G. Myers is a Senior Researcher at the Centre de Recerca Matemàtica, Adjunct Professor at the Universitat Politecnica de Catalunya and Adjunct Professor of Industrial Mathematics at the University of Limerick. He has been involved in a wide variety of Industrial Mathematics initiatives and is currently the co-ordinator for all European Study Groups with Industry. He is a co-author of "Optics Near Surfaces and at the Nanometer Scale" and has written over 90 journal publications on a range of applied mathematics topics.

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Spatiotemporal Dynamics of Cancer Phenotypic Quasispecies Under Targeted Therapy

Celia Penella, Tomás Alarcón, and Josep Sardanyés

Abstract Cancer cells have an enormous genetic and phenotypic heterogeneity. Despite modelling this heterogeneity is not trivial, several mathematical and computational models have used the so-called quasispecies theory. This theory, originally conceived to describe the evolution of information in prebiotic systems, has also been applied to investigate fast evolving replicons with large mutation rates, such as RNA viruses and cancer cells. Here, we investigate a quasispecies system composed of healthy and cancer cells with different phenotypic traits. The phenotypes of tumour cells are coded by binary strings including three different compartments with genes involved in cells' proliferation, in genomic stability, and the so-called housekeeping genes. Previous works have studied this system in well-mixed settings with autonomous ordinary differential equations and stochastic bit-string models. Here, we extend the stochastic bit-strings approach to a spatially explicit system using a cellular automaton (CA). In agreement with the prediction of the well-mixed systems, the spatial one also shows a transition towards tumour extinction at increasing tumour cells' mutation rates, displaying however different stationary distributions of cancer phenotypes. We also use the CA to simulate targeted cancer therapies against different tumour phenotypes. Our results indicate that a combination therapy targetting the fastest proliferative cancer cells with and without

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