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English summaries

Joaquim Bruna

Non-linear approximation and compressive sampling

In this paper we give an introduction to relatively new field in mathematics, the so called compressed sensing or compressive sampling. It can be presented as a branch of signal analysis, whose appearance is related to another important field, big data analyis. Compressed sensing does not deal with processing big data sets, but rather with sampling methods that do not lead to unnnecessary data. For the sake of the exposition we briefly refer as well to non linear approximation theory.

Keywords: discretisation, linear approximation, non-linear approximation, Hilbert basis, compressive sampling, sparse vectors, decodificator, random matrices, non-coherent bases.

MSC2010 Subject Classification: 94A12, 68P30, 41A46.

Pilar Guerrero and Tomás Alarcón

Stochastic multiscale models of cell population dynamics: asymptotic and numerical methods

In this paper we present a new methodology that allows us to formulate and analyse stochastic multiscale models of the dynamics of cell populations. In the spirit of existing hybrid multiscale models, we set up our model in a hierarchical way according to the characteristic time scales involved, where the stochastic population dynamics is governed by the birth and death rates as prescribed

by the corresponding intracellular pathways (e.g. stochastic cell-cycle model). The feed-back loop is closed by the coupling between the dynamics of the population and the intracellular dynamics via the concentration of oxygen: Cells consume oxygen which, in turn, regulate the rate at which cells proceed through their cell-cycle. The coupling between intracellular and population dynamics is carried out through a novel method to obtain the birth rate from the stochastic cell-cycle model, based on a mean-first passage time approach. Cell proliferation is assumed to be activated when one or more of the proteins involved in the cellcycle regulatory pathway hit a threshold. This view allows us to calculate the birth rate as a function of the age of the cell and the extracellular oxygen in terms of the corresponding meanfirst passage time. We then proceed to formulate the stochastic dynamics of the population of cells in terms of an age-structured Master Equation. Further, we have developed generalisations of asymptotic (WKB) methods for our age-structured Master Equation as well as a τ-leap method to simulate the evolution of our age-structured population. Finally, we illustrate this general methodology with a particular example of a cell population where progression through the cell-cycle is regulated by the availability of oxygen.

Keywords: multiscale modelling, stochastic modelling, cancer, cell-cycle.

MSC2010 Subject Classification: 92B05.

Timothy G. Myers and Sarah L. Mitchell

A mathematical analysis of the motion of an in-flight soccer ball

In this paper an analytical and numerical study of the three-dimensional equations describing the motion through the air of a spinning ball is presented. The initial analysis involves constant drag coefficients but is later extended to involve drag varying with the spin ratio. Excellent agreement is demonstrated between numerical and analytical results. The analytical solution shows explicitly how the balls motion depends on parameters such as ball roughness, velocity and atmospheric conditions. The importance of applying three-dimensional models, rather than two-dimensional approximations, is demonstrated.

Keywords: aerodynamics, soccer ball flight, spinning soccer ball, Magnus force, perturbation solution.

MSC2010 Subject Classification: 34L30, 76G25.

Joaquim Ortega-Cerdà

(Random) power series

The construction of random functions with interesting properties is a classical subject in Mathematics. Lately, there has been a renewed interest in the random zeros of polynomials and of entire functions spurred in part by the growing literature on the spectrum of random matrices.

Keywords: Random polynomials, Gaussian analytic functions.

MSC2010 Subject Classification: 30B20, 26C10, 30C15, 15B52.