

ΥΠΟΜΝΗΜΑ ΕΡΓΑΣΙΩΝ

Dr. Kouloumpou Dimitra

Publications in Refereed Peer-reviews Journals

- **MULTICRITERIA OPTIMIZATION, Best Simultaneous Approximation of Functions** Nausivios Chora (To Apear)
Author(s): Bacopoulos Alex; Kouloumpou Dimitra

Abstract

The problem we consider is to find (the) **best approximation(s)** to a given function **simultaneously** with respect to more than one criterion of proximity. Questions of existence, characterization, unicity and computation are examined. Examples are given.

- **Limit behavior of the q -Pólya urn** The Ramanujan Journal –
<https://doi.org/10.1007/s11139-021-00542-4>
Author(s): Cheliotis Dimitris; Kouloumpou Dimitra

Abstract

The q -Pólya urn is a q -analog of the Pólya urn and is a model of ball extraction from an urn with balls of two colors, A and B. Balls of color B have priority to be picked over those of color A. We prove that, in an infinite sequence of extractions, almost surely, the number of balls of color A that are picked has a finite limit and we identify its distribution. Then we prove functional limit theorems for the number of balls of color A extracted. The limit is either a pure birth process or a diffusion, depending on the initial composition of the urn. Finally, we discuss basic results for the q -Pólya urn with more than two colors.

- **Functional Limit Theorems for the Pólya Urn**, Journal of Theoretical Probability – <https://doi.org/10.1007/s10959-021-01123-3>
Author(s): Cheliotis Dimitris; Kouloumpou Dimitra

Abstract

For the plain Pólya urn with two colors, black and white, we prove a functional central limit theorem for the number of white balls, assuming that the initial number of black balls is large. Depending on the initial number of white balls, the limit is either a pure birth process or a diffusion.

- **SBDiEM: A new mathematical model of infectious disease dynamics**, [Chaos, Solitons and Fractals 136 \(2020\) 109828](#)

Author(s): Bekiros Stelios; Kouloumpou Dimitra

Abstract

A worldwide multi-scale interplay among a plethora of factors. More precisely ranging from micro-pathogens and individual or population interactions to macro-scale environmental, socio-economic and demographic conditions, entails the development of highly sophisticated mathematical models for robust representation of the contagious disease dynamics that would lead to the improvement of current outbreak control strategies and vaccination and prevention policies. Due to the complexity of the underlying interactions, both deterministic and stochastic epidemiological models are built upon incomplete information regarding the infectious network. Hence, rigorous mathematical epidemiology models can be utilized to combat epidemic outbreaks. By adapting and expanding some of the results in the article “D. Kouloumpou, VG Papanicolaou, Certain Calculation Regarding the Brownian Motion on the Sphere, *Journal of Concrete and Applicable Mathematics*. Vol. 11, p. 303-316”, we introduce a new spatiotemporal approach (SBDiEM) for modeling, forecasting and nowcasting infectious dynamics, particularly in light of recent efforts to establish a global surveillance network for combating pandemics with the use of artificial intelligence. This model can be adjusted to describe past outbreaks as well as COVID-19. Our novel methodology may have important implications for national health systems, international stakeholders and policy makers.

- **Functional limit theorems for the Polya and q-Polya urns**, *arXiv preprint arXiv: 1905. 13336*, 2019,
Author(s): Cheliotis Dimitris; Kouloumpou Dimitra

Abstract

For the plain Polya urn with two colours, black and white, we prove a functional central limit theorem for the number of white balls assuming that the initial number of black balls is large. Depending on the initial number of white balls, the limit is either a pure birth process or a diffusion. We also prove analogous results for the q-Polya urn, which is an urn where, when picking a ball, the balls of one color have priority over those of the other.

- **On the pricing of exotic options: A new closed-form valuation approach**, *Chaos, Solitons and Fractals Nonlinear Science, and Nonequilibrium and Complex Phenomena Vol 122 (2019) pp 153–162*
Author(s): Bekiros Stelios; Kouloumpou Dimitra

Abstract

We provide a novel method to estimate in a closed-form solution the option prices of various exotic options, using techniques based on Laplace–Beltrami operator for estimating diffusion boundary times. We estimate exit times and their expectations, the hitting probabilities, boundary local times until the first hitting and other probabilistic quantities and moment generating functions related to local hitting times. Our findings maybe of paramount importance for traders, investors, speculators and – more broadly speaking - for financial institutions.

- **The Random Motion on the Sphere Generated by the Laplace-Beltrami Operator**, *Journal of Applied Functional Analysis*. Jan 2012, Vol. 7 Issue 1/2, pp. 26-41.
Author(s): Kouloumpou Dimitra; Papanicolaou Vassilis G.

Abstract

Using the Laplace-Beltrami operator we construct the Brownian motion process on the n -dimensional sphere. Then we evaluate explicitly certain quantities for this process. We start with the transition density and continue with the calculation of some probabilistic quantities regarding specific domains possessing certain symmetries.

- **Certain Calculation Regarding the Brownian Motion on the Sphere**, Journal of Concrete & Applicable Mathematics, Jan 2013, Vol. 11 Issue 1, pp. 303-316.

Author(s): Kouloumpou Dimitra; Papanicolaou Vassilis G.

Abstract

We evaluate explicitly certain quantities regarding the Brownian motion process on the n -dimensional space of radius a . Firstly, we review the transition densities of the process. Then we calculate some moments and cumulants of the exit times.

- **Modelling Random Walks on Manifolds: Brownian motion on the n -Sphere**, PhD thesis, NTUA, Jan 2013, pp. 1-95

Author: Kouloumpou Dimitra

Abstract

We study the Brownian motion on n -dimensional spheres. Mainly we prove results in cases of $n=1,2,3$ due to the fact that these dimensions have practical results in many disciplines such as economics, finance, epidemiology, sociology, meteorology, geology etc. For example, in case of $n=2$ the S^2 - Brownian motion can be utilized for epidemiological models and environmental economics (pollution) models. We utilize the Laplace-Beltrami operator to construct the Brownian motion process on the n -dimensional sphere, using stereographic coordinates. Then, we evaluate the transition density in case of $n=1,2,3$. The stochastic differential equation of the Brownian motion in local

coordinates is represented. We continue with the calculation of expectations possessing certain symmetries and some probabilistic quantities regarding exit times. Next, we evaluate the moment generating function of exit time T . Furthermore, we discuss the reflection principle on S^2 and extend it easily to S^n . In the last chapter we evaluate the boundary local times.

Publications in Refereed Peer-reviews Proceedings

- **Random Motion on Symmetric Spaces**, *Proceedings of the 2010 JSM - The Joint Statistical Meetings, Vancouver Canada*.
Author(s): Kouloumpou Dimitra; Papanicolaou Vassilis G.

Abstract

We discuss certain issues regarding Brownian-type motions (transition densities, hitting time probabilities, occupation times, etc) on spheres and other spaces. In addition, we discuss the reflection principle on S^2 , which can help to calculate the distribution functions of certain exit times. Moreover, we evaluate boundary local times.

- **Brownian Motion on Spheres**. *Technical Reports – University of Ioannina, Dept. of Mathematics*
Author(s): Kouloumpou Dimitra; Papanicolaou Vassilis G.

Abstract

We evaluate explicitly certain quantities regarding the Brownian motion process on the n-dimensional sphere of radius a. We start with the transition densities of the process. Then we calculate some probabilistic quantities (e.g. moments) of the hitting times of specific symmetric domains.

- **Multicriteria Optimization: Best simultaneous approximation of functions**, *Proceedings of the 7th Hellenic-European Conference on Computer Mathematics and its Application 2005, Athens, Greece*.
Author(s): Kouloumpou Dimitra; Bacopoulos A.C.

Abstract

We deal with the problem of optimizing simultaneously with the absolute and relative errors arising in functional approximation with respect to the supremum norm. We work on two cases and we provide solutions of existence, uniqueness and characterization of best approximations.