UNIVERSIDAD DE GRANADA

Departamento de
Estadística e
Investigación Operativa

# Seminario 5 (SPA Series): Diffusion models related to growth curves. Inference on some epidemiological statistical models

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Seminario de la profesora **Giuseppina Albano** (Studi Politici e Sociali/DISPS. University of Salerno) (https://docenti.unisa.it/021908/en/curriculum) en la **sala de conferencias del IMAG**. Dos sesiones, el **26 de marzo** de 2025, **de 9:30-11:00 y de 11:30 a 13:00.**

Part I. **Diffusion models related to growth curves**

The seminar focuses on a general growth curve able to unify the classical cases of Malthusian, Richards, Gompertz, Logistic and several of their generalizations. Here two stochastic generalizations of the deterministic growth are obtained by introducing a multiplicative and an additive noise, respectively, to the deterministic equation. We show that the resulting processes are lognormal and gaussian respectively, and their mean is the deterministic trend of the curve. Since the distributions of the two processes are known, the problem of estimating the parameters of the model is analyzed by means of the maximum likelihood method. Further, due to the parametric structure of the processes, the resulting systems of equations are quite complex, and numerical solutions must be searched. Estimating procedures for the involved parameters make use of specific metaheuristic algorithms. They try to find the solution of an optimization problem by iterative procedures in which the current solution must be better than the previous one. Most of such algorithms are based on the behavior of search agents moving randomly across the parametric space.

Following certain rules of movement, life or death, the algorithm evolves until reach a stable state. The values of the parameters at that time become the final solution. An extensive simulation study is then made to evaluate the goodness of the proposed procedure, i.e. the convergence of the algorithms and the properties of the estimates. Another interesting focus of the talk is the first passage of passage of processes across suitable boundaries. In particular, by suitable choice of parameters, we show that the threshold can be a percentage of the average size of the population, and this is often of interest in applications in population growth. For such cases we provide explicit solutions for the probability density function of the random variable First Passage Time.

Part II: **Inference  on some epidemiological statistical  models**

In this seminar the focus is on epidemiological stochastic models. We firstly consider a time-inhomogeneous diffusion process able to describe the dynamics of infected people in a susceptible-infectious epidemic model. Such a model describes epidemics evolution in micro-parasites or the evolution of the size of individuals who have contracted a disease that has made them immune. Here we focus on the inference for such a process, by providing an estimation procedure for the involved parameters. Such procedure is based on the transformation of the original process to a non-homogeneous Wiener process and on the subsequent Generalized Method of Moments to find suitable estimate for the infinitesimal drift and variance of the transformed process.

In the second part, a Susceptible-Infected- Removed stochastic model is discussed, emphasizing the role of the contribution of each subpopulation. Such a model is able to include the natural growth of the Susceptible population, and it is shown that it captures multi-peaks dynamics in the epidemic spreads. The inference is addressed by means of a quasi-maximum likelihood method. Numerical procedures for determining the local maxima of the likelihood function are discussed. Emphasis is placed on the problems associated with the use of such techniques and some insights are provided.