NITheCS Webinar

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Modelling the glucose-insulin system for diabetes: problems and perspectives

Prof Andrea De Gaetano
(Institute for Systems Analysis and Informatics "A. Ruberti", National Research Council of Italy, Rome, Italy)

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Venues: NITheCS Boardroom, Stellenbosch University, and Online

ABSTRACT

We exemplify the application of mathematical and statistical techniques to the analysis of biomedical data by addressing a problem of practical importance in diabetology clinics, that of assessing the severity of Type 2 Diabetes Mellitus by estimating the degree of insulin sensitivity of resistance of a given patient.

We showcase early attempts at modelling the glucose-insulin system and discuss the criteria by which a mathematical model of some physiologically relevant dynamical system is judged to be good or bad. We point to potential pitfalls in parameter estimation, with examples from widely diffuse medical literature. We try to understand what are the difficulties that arise when moving from the experimental diabetology lab to the analysis of data streams from common clinical practice.

We progressively move from simpler Ordinary Differential Equations models to more mathematically advanced formulations: Fractional Differential Equations may be used to summarise, with an order that can in principle be estimated from data, different (presumably integer-order) interacting controls or influences upon the observed variable of interest, especially if the information content of the observations is relatively small compared to the complexity of the system of interacting variables. This is the case, for example, of trans-cutaneously measured glycemia, where besides glycemia itself (possibly decaying by first-order elimination) also unobserved factors (insulinemia, other hormones) may exert higher order effects.

The problem is complicated by the fact that random events (food intake, exercise, emotions) may affect glycemia as well, leading to the formalisation of the problem with Fractional Stochastic Differential Equations (FSDEs). We exemplify the use of simple FSDE models of glycemic control and undertake model parameter estimation in this framework. The difficulties in dealing with a numerically daunting task, while attempting to adhere to a physiological interpretation of the available data, are described.

BIOGRAPHY

Prof Andrea De Gaetano is a distinguished biomathematician whose research focuses on the mathematical modelling of physiological systems, particularly through ordinary, stochastic and fractional differential equations. He has authored more than 300 peer-reviewed publications and has made significant contributions to the modelling of energy metabolism and the application of mathematics in biomedical research.

Formerly Director of the Institute for Biomedical Research and Innovation at the National Research Council of Italy (CNR), he is currently Distinguished Professor at Óbuda University, Budapest, and Adjunct Professor at Mahidol University, Bangkok. He is also a Past President of the European Society for Mathematical and Theoretical Biology.

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