UNIVERSIDADE DE ÉVORA
ESCOLA DE CIÊNCIAS E TECNOLOGIA
DEPARTAMENTO DE MATEMÁTICA

Centro de Investigação em Matemática e Aplicações
Departamento de Matemática
Programa de Doutoramento em Matemática

Seminário online

18 de novembro de 2020

Mathematical modeling, optimal control and complex network of epidemic models: case study of COVID-19 in Portugal

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Abstract In this talk, we propose a SAIRP mathematical model, for the transmission dynamics of SARS-CoV-2, given by a system of ordinary differential equations, which is fitted to the number of active infected individuals with COVID-19 in Portugal. We apply optimal control theory to the SAIRP model, to maximize the number of people returning to "normal life" and minimizing the number of active infected individuals with minimal economical costs while warranting a low level of hospitalizations.

After we generalize the SAIRP model, considering piecewise constant parameters, and construct a complex network of dynamical systems, in order to take into account the mobilities of individuals, which are known to play a decisive role in the dynamics of the epidemic. We prove the existence of pseudo-periodic solutions of the epidemic model and analyze its relation with multiple epidemic waves in COVID-19 pandemic. The model with piecewise constant parameters is calibrated in order to fit with the real data of the COVID-19 active infected individuals in six regions of Portugal mainland, namely Norte, Centro, Lisboa e Vale do Tejo, Alentejo, Algarve and Pinhal Litoral. Through numerical simulations, we explore the effect

of the topology of the network on the dynamics of the epidemics (disposal of connections and coupling strength) and identify which type of topology minimizes the level of infection of the epidemic.

This seminar is based on the work developed under the project Project Nr.147 "Controlo Ótimo e Modelação Matemática da Pandemia COVID-19:contributos para uma estratégia sistémica de intervenção em saúde na comunidade", in the scope of the "RESEARCH 4 COVID-19" call, financed by the Portuguese Foundation for Science and Technology (FCT).

Keywords: COVID-19, SAIRP model, optimal control, epidemic waves, piecewise constant parameters, pseudo-periodic solutions, complex network, Portugal case study

Acknowledgements

This talk has been partially supported by Centro de Investigação em Matemática e Aplicações (CIMA), through the Project UID/04674/2020 of FCT-Fundação para a Ciência e a Tecnologia, Portugal.