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Optimal coefficient restoration for COVID-19 epidemic modelling

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A mathematical deterministic compartment SIR-type model is utilized to investigate the impact of COVID-19. This model is deemed appropriate since it accounts for the non-permanent immunity of the virus after infection. It is also realistic because it considers the nonlinear incidence rate and the delayed transmission dynamics [1]. The model poses a coefficient identification inverse problem, which involves reconstructing the transmission and recovery rates. These rates are crucial for medical professionals and policymakers to make informed decisions regarding the management and mitigation of the virus.

To further elaborate, the basic models assume that individuals move from the susceptible to the infected compartment and then to the recovered compartment, and once recovered, they have permanent immunity. However, the SIR-type model accounts for the fact that COVID-19 may not confer permanent immunity after recovery, making it a more appropriate model for this virus.

The identification of the transmission and recovery rates is a challenging problem that requires the use of mathematical tools such as inverse problems [2]. This process involves estimating the unknown parameters of a model from observed data, in this case, the number of confirmed cases and recoveries. Accurately identifying these rates is essential for policymakers to make informed decisions on implementing measures to slow the spread of the virus and to allocate resources such as hospital beds and medical supplies. It also aids in the development and evaluation of effective treatments and vaccines.

The task of solving the inverse problem in this study is transformed into a minimization problem, which is tackled by finding the solution that yields the

smallest squared error [3]. Once the values of the parameters are obtained, it is conducted an identifiability analysis to ensure that the estimated values are reasonable and reliable [4]. To validate the findings of the study, the results are compared with those of previous studies, using real data collected from Bulgaria. The comparison involves evaluating the consistency and accuracy of the estimated parameter values, as well as assessing the model's ability to predict the behavior of the COVID-19 epidemics.

Keywords: COVID-19, epidemic model, nonlinear incidence rate, delayed dynamics, least-squares fitting

MSC2020: 34A55, 65L09, 92D25, 92D30

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