Numerical Analysis of SEIR-Type Mathematical Models for African Swine Fever Transmission Using Finite Difference Methods: A Cross-Disciplinary Approach

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Abstract

African swine fever (ASF) is a highly contagious viral disease affecting domestic and wild pigs, with mortality rates approaching 100%. This paper presents a comprehensive numerical analysis of modified SEIR (Susceptible-Exposed-Infectious-Recovered) epidemiological models for ASF transmission. We employ finite difference methods (FDM) to discretize the governing non-linear ordinary differential equations and analyze stability, convergence, and error properties of the numerical scheme. Our results demonstrate that the proposed numerical approach accurately captures critical epidemiological thresholds, including the basic reproduction number R_0 , and provides reliable predictions for disease intervention strategies. We extend the model to include spatial dynamics using reaction-diffusion PDEs discretized with finite element methods, stochastic modeling via stochastic differential equations, and optimal control analysis using Pontryagin's maximum principle. Sensitivity analysis reveals that transmission rate and incubation period are the most influential parameters. Comparative analysis of numerical schemes (Euler, RK4, and fractional Adams-Bashforth-Moulton) demonstrates first-order convergence for Euler and fourth-order for RK4. These findings underscore the importance of robust numerical methods in epidemiological modeling and offer practical insights for ASF control policies.

Keywords

African swine fever, finite difference method, numerical analysis, optimal control, SEIR model, spatial dynamics, stochastic modeling.