National Institute of Technology Rourkela

Synopsis Seminar

Seminar Title	: Numerical Solution of Stochastic Models Based on Polynomial and Wavelet Approximations
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Venue	: Seminar Room, Department of Mathematics
Date and Time	: 08 Oct 2025 (11:00 AM)

Abstract

: In many complex real-life models, the parameters governing the system are not precisely known instead, they may be incomplete, random, or time-varying due to unpredictable influences often following probability distributions. Such uncertainties may arise from external disturbances like environmental noise or internal variability within the system, making stochastic models essential. However, obtaining analytical solutions for these models is challenging, especially for nonlinear, high-dimensional problems or those driven by complex noise such as fractional Brownian motion (fBm). This motivates the development of efficient numerical methods for solving a wide range of stochastic models. This study makes significant contributions by implementing three efficient numerical schemes, namely, the operational matrix method, spectral Galerkin method, and spectral collocation method, constructed using various orthogonal polynomials (Chelyshkov, Chebyshev, Vieta-Fibonacci, Bernoulli, Legendre, Jacobi) and wavelet bases (Chelyshkov, Jacobi, Euler). These approaches are applied to solve diverse stochastic problems, such as stochastic Itô-Volterra-Fredholm integral equation, stochastic Itô-Volterra integral equation, one- and two-dimensional stochastic Itô-Volterra equation with weakly singular kernel, stochastic fractional integro-differential equation, stochastic differential equation driven by fBm, and multidimensional stochastic integral equation with fBm. In each method, the unknown solution is approximated as a finite linear combination of basis functions, and the coefficients are determined to yield the approximate solution. Theoretical results on existence, uniqueness, stability, convergence, and error bounds establish the reliability of the proposed methods. Their effectiveness is further validated through extensive numerical experiments and real-world applications, including financial models for stochastic volatility, stock price dynamics, and power pricing the Lotka-Volterra predator-prey system population growth and models in climate science, network traffic, and biophysics. The numerical results obtained have been compared with analytical solutions, where available, or with results from other existing methods. In this case, the proposed methods demonstrate high accuracy and robustness while substantially reducing computational cost, making them well-suited for large-scale and high-dimensional stochastic problems.