National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Numerical and Semi Analytical Solutions of Applied Fractional Differential Equations
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Venue	: Seminar Room, Department of Mathematics
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Abstract

: Real-world phenomena are typically modeled by various differential equations with integer orders, and differential equations frequently explain their behavior. It might sometimes be valuable to use non-integer order derivatives to understand the behavior of the physical problems. In this context, fractional calculus (FC) has provided a unique opportunity to serve the cause. Fractional-order models are more realistic and adapted to real situations than integer-order models because of their hereditary nature and ability to describe memory specifications. Fractional calculus has grown significantly in prominence and popularity over the last three decades, primarily due to its recognized applicability in various disciplines, including science and engineering. The unique non-local characteristics of fractional derivatives are among their most remarkable aspects. This nonlocal feature offers a potent tool for simulating complex systems with long-range interactions, anomalous behavior, and memory effects. As such, some standard fractional operators have been defined to handle the fractional differential equation, viz., Grünwald-Letnikov, Riemann-Liouville, and Caputo fractional operators. This dissertation addresses solving and analyzing different types of physical and real-world problems, in particular, wave equations, heat equations, telegraph equations, financial models, and biological models. These problems are usually governed by fractional-order ordinary and partial differential equations. It may not always be possible to get analytical solutions to these fractional differential equations. Accordingly, various semi-analytical and numerical methods, including the modified extended tanh method, homotopy perturbation method, Taylor series expansion method, block pulse function method, and triangular basis function method, are applied here to handle governing fractional differential equations corresponding to the problems undertaken. Some hybrid methods, such as the Elzaki-homotopy perturbation method, the Sumudu-homotopy perturbation method, and the Aboodh-homotopy perturbation method, have been applied, where Elzaki, Sumudu, and Aboodh transforms help in dealing with nonlinearity in the fractional differential equations. The convergence of each method is discussed numerically, and validation of the findings has been shown. The effect of the involved parameters has been illustrated graphically for all considered models. Generally, the physical parameters used in different physical problems and dynamical models are assigned crisp values. However, in practical scenarios, these parameters may be uncertain in nature due to errors in the measurements, observations, or experiments. The involvement of uncertain parameters mimics the actual practical problems and leads to uncertain differential equations. The uncertain parameter(s) may be considered in terms of an interval or fuzzy number. Further, the homotopy perturbation method has been extended with the aid of the double parametric concept of fuzzy numbers to handle uncertain differential equations.