IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project title Clever Nonuniform Sampling Methods to Speed-Up Light Pulses Propagation Through Nonlinear Dispersive Media

Project number: IMURA0129

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Research Academy theme/s

1. Advanced computational engineering, simulation and manufacture
2. Nanotechnology

The research problem

Wave propagation in complex structures forms one of the most interesting area of research. For example light propagation in an optical fiber, semiconductor crystals or biological tissue cannot be efficiently simulated using conventional solution techniques. Most of the difficulty in these systems derive from the dependence of material properties on the energy transported by the wave and hence both pulse and the medium change with time. Therefore, clever numerical techniques need to be developed to handle such complex, coupled wave propagation problems. To begin with, it is proposed to explore the applications of wavelets and wavelet based methods in the solution of hyperbolic partial differential equations governing wave propagation in complex media. From another perspective, the research question to be explored may be posed in the following manner - discretization of a system, with underlying continuous signals, could be done through uniform or nonuniform sampling. Non-uniform sampling could offer some advantages where the local behaviour of the system differs over space and time. Such nonuniform sampling needs to adapt to the wave and material properties as the wave propagate through the medium. Wavelet based methods are one approach to handling such a generalized adaptive sampling paradigm. In this project we explore adaptable algorithms based on wavelets for effectively tackling nonlinear wave propagation in various complex media.

Project aims

Currently optical pulse propagation in devices are studied by simulating the propagation of uniform discrete samples of the pulse using mostly serial-computing analysis. Nonuniform sampling and subsequent parallel processor simulations are yet to be exploited in the context of active and passive optical communication devices. We intend to pursue this open research area. It is important to note that using conventional uniform sampling based current computational paradigms do not allow solution of a full system of dozen or so coupled second order differential equations in practically acceptable time frame. It may take decades for computational resources to reach the level when such computations will become possible. We intend to develop novel exact and approximate techniques to solve such problems using parallel algorithms.

In summary, the main aims of the proposed research are,

- Devise sparse, nonuniform discretization schemes for nonlinear differential equations representing devices in optical communications systems.
- Invent novel serial and parallel solution techniques for solving such descritezed solutions significantly faster than what is possible with current sequential computing techniques/algorithms.
- Develop efficient serial and parallel computer code to implement the above algorithms that can be used for analysis and design of high speed optical fiber communications systems.