As computing power, mathematical modeling and computational algorithms continue to enjoy phenomenal advance, numerical simulations are playing an ever increasing role in many branches of sciences and engineering. My research interest generally spans several areas of numerical analysis and scientific computing, but is centered around the design, analysis and applications of high-order methods for emerging applications and image processing using PDEs and variational techniques. Below is a slice of my recent research.

**SPECTRAL AND HIGH-ORDER METHODS**

The recent Springer (co-authored) book provides a systematic exposition of my research on high-order methods and their applications over the last ten years. In particular, it includes fundamental spectral approximation theory, efficient methods for high-order PDEs and unbounded domains. This 480-page monograph is largely intended for active practitioners and experts in spectral and high-order methods.

**SIMULATION OF ACOUSTIC/ELECTROMAGNETIC WAVES**

Accurate simulation of acoustic/electromagnetic wave scattering constitutes a centrally important part of many industrial and engineering applications. I am interested in developing fast high-order methods for time-domain scattering problems involving high-frequency content. The design of high-order schemes requires accurate means for domain truncations, and fast, stable solvers for temporal and spatial discretization. We have constructed methods integrating exact nonreflecting boundary conditions, domain perturbation, direct spectral-Galerkin solvers and unconditionally stable time marching schemes. They have been proven to be very attractive for high-frequency wave simulations.

**NEW TRIANGULAR SPECTRAL ELEMENTS**

Triangular elements are known to be more flexible for complex geometries and for adaptivity than the quadrilateral meshes. We have recently found a new triangle-to-rectangle mapping which is virtually free of singularity. Armed with such triangular elements, we are able to generate high quality meshes for high-order simulations without extra overheads.

**SPARSE METHODS FOR HIGH DIMENSIONS**

High-dimensional PDEs naturally arise from diverse areas such as finance. Conventional methods suffer from the “curse of dimensionality”. We are interesting finding efficient means to surmount the obstacles. The approach we explored includes efficient sparse spectral-methods based on hyperbolic cross and sparse grids. This initiates a long-term goal to develop reliable methods that meet the challenges of high dimensions.