IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Convergence Analysis of adaptive numerical methods for diffusion models
Project Number	**IMURA0438**
Monash Main Supervisor (Name, Email Id, Phone)	Dr. Jerome Droniou, jerome.droniou@monash.edu, +61 3 9905 4489 *Full name, Email*
Monash Department:	School of Mathematical Sciences, Faculty of Sciences
IITB Main Supervisor (Name, Email Id, Phone)	Dr. Neela Nataraj, neela@math.iitb.ac.in +919820420708 *Full name, Email*
IITB Department:	Mathematics

Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?
(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture

2. Infrastructure Engineering
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research

The research problem

We consider the diffusion models with Dirichlet/Neumann boundary conditions in this project. The plan is to study convergence analysis of adaptive methods based on different numerical methods like finite elements, mixed finite elements, or hybrid-mimetic-mixed methods (among which the mimetic finite difference method). Though there is a lot of literature on convergence analysis of adaptive finite element methods for elliptic problems, there is not much literature available on the above stated other numerical methods, which are useful in applications like oil recovery and carbon storage, electromagnetics, gas dynamics and diffusion. It is well known that hybrid-mimetic-mixed methods have advantages in comparison to finite element methods with respect to the generality of meshes. For instance, the method allows general polyhedral meshes with degenerate and non-convex elements, or non-conforming meshes (in which the interface between two cells may not correspond to physical faces of the cells). This is extremely attractive in a scenario when adaptive strategies need to be developed for error control.

We propose to derive a posterioiri error estimates for the hybrid-mimetic-mixed method applied to diffusion-convection equations. These estimates will be reliable and efficient, and will allow us to analyse the convergence of the adaptively process. This last step will require use to establish quasi-orthogonality results for these methods.

Project aims

Define the aims of the project

We aim to

(a) Implement the diffusion model using hybrid-mimetic-mixed methods
(b) develop reliable and efficient a posteriori estimates that guide adaptive refinements for the hybrid-mimetic-mixed methods;
(c) define a marking procedure and perform the adaptive refinement;
(d) Derive volume and edge estimator reduction results and the quasi-orthogonality result which helps to establish the convergence.

Expected outcomes

(a) Convergence results for adaptive numerical methods which are important for applications;
(b) Quality international research publications;
(c) Joint supervision of a Ph.D. student from India which will help to boost the research in Numerical Analysis in the country;
(d) Initiating collaborative research work between Monash University and IIT Bombay in the broad area of numerical analysis and scientific computing.

How will the project address the Goals of the above Themes?

Advanced computational engineering, simulation and manufacture

We would be addressing the first and second components in the above mentioned theme. Computational PDEs is an extremely active topic internationally. The proposed project aims at providing tangible progress in the direction of the growth of the topic.

Capabilities and Degrees Required

Candidates should

1. have a strong mathematical background in post graduation;
2. have done courses in Partial differential Equations & Functional Analysis in Masters level,
3. Knowledge and aptitude in computer languages – like Matlab, Fortran90, C or C++ – is essential.