IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Simulations of fracture in neurological tissues**	
Project Number	**IMURA0333**	
Monash Supervisor(s)	Dr. Nikhil Medhekar, Senior Lecturer	*Full names and titles*
Monash Primary Contact:	Nikhil.Medhekar@monash.edu, +61 3 990 51421	*Email, phone*
Monash Head of Department:	George Simon, Professor, George.Simon@monash.edu	*Full name, email*
Monash Department:	Department of Materials Engineering	*Full name*
Monash ADRT:		*Full name, email*
IITB Supervisor(s)	Tanmay K. Bhandakkar, Assistant Professor	*Full names and titles*
IITB Primary Contact:	tbhanda2@iitb.ac.in, +91 22 2576 7537	*Email, phone*
IITB Head of Department:	R. P. Vedula, Professor	*Full names and titles*
IITB Department:	Department of Mechanical Engineering, head.me@iitb.ac.in, +(91)(22)2576-7503	*Email, phone*

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

Define the problem

Neurological injuries (for example, brain and spinal cord injuries) caused primarily due to falls-collisions during vehicle accidents, sports, occupational mishaps and assaults are a major cause of permanent disability, mental impairment and death. Many times the impact is so severe that it leads to permanent damage to nerve connections within the nervous system. Phase-field method originally conceived for simulating phase transformations in materials is now widely applied to study fracture by treating crack propagation as a first order transformation between solid phase and a 'broken' state inside the crack. In this project, using phase field methodology, we will develop a bio-

mechanical model to understand the conditions for initiation and propagation of fracture in tissues and nerves when subjected to very heavy impact to head.

Project aims

Define the aims of the project

1. Identify appropriate constitutive laws to model neurological tissues
2. Develop phase-field code to simulate fracture in material based on the constitutive laws from (1)
3. Utilize code to understand the effect of impact to head by varying loading rates and loading conditions
4. Utilize step (3) and propose a failure map linking impact conditions to tissue damage

Expected outcomes

Highlight the expected outcomes of the project

A robust phase-field code will emerge from the project. It will be used to delineate the mechanism of force transmission during impact and subsequent damage through a bio-mechanical model. The impact conditions will be based on the loading scenarios and rates commonly encountered by human head subjected to injury. The knowledge gained during the project will be beneficial to medical fraternity and can be potentially used to suggest improvements in design of protective head-gears and helmets.

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

Describe how the project will address the goals of one or more of the 6 Themes listed above.

The project involves numerical solution of two-dimensional (possibly three-dimensional) solution of coupled non-linear partial differential equations and hence requires high-end computation. Simulations are targeted towards improved understanding of fracture and damage in neurological tissues owing to impact. Hence, our project will address the goals of both the themes highlighted above.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

Persons with the following qualification should be considered eligible:

B.Tech/M.Tech degree in Mechanical, Civil, Aerospace, Bio-engineering.
Capabilities: An ideal candidate will have a strong interest in computational studies of fracture of biological materials. The candidate with some experience and interest in basic programming languages (Fortran/C/C++/MATLAB) will be preferred.