IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Protocol optimization in surgical planning of FUS	
Project Number	**IMURA0431**	
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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

Remote ablation of deep-seated abnormalities by various modalities such as radiosurgery, RF, LASERS, Cryoablation and more recently, the use of focused high intensity ultrasound (HIFU) can provide completely non-invasive procedures if the energy in the beam is carefully targeted. HIFU, alternatively known as Focal Ultrasound Surgery (FUS), have shown promising clinical evidence, particularly in the field of urology and oncology. The dimension of the focal region produced in a single exposure, called a *lesion*, by the surgery transducer(s) is generally much smaller in size compared with the size of the targeted abnormality; raster scanning of the delivery unit is conventionally performed throughout the entire target

for thermal ablation for precise and accurate trajectory deployment in a given spatial configuration. Thermal diffusion affects the temperature elevation and the consequent lesion formation. Control of multiple variables and exposure conditions, effected both due to the delivery mechanisms as well as the target tissue attributes such as physio-chemical characteristics, its location, shape, size etc. contribute to the thermal damage. As a result, the lesion will grow continuously over the course of HIFU therapy. Because of thermal diffusion from the nearby treated region, the lesion size of each treatment spot will gradually become larger as the HIFU therapy progresses which may cause insufficient treatment of the initial spots and over-treatment of those later ones.

Thermal diffusion, the scanning pathway and the biophysical aspects of the target all play important roles in HIFU lesion production. By selecting the appropriate scanning pathway and varying the parameters as ablation progresses, HIFU therapy can achieve uniform lesions while minimizing the total delivered energy and treatment time. Optimized scanning and exposure conditions are required to treat the tumour volume as fast as possible while keeping the temperature in the healthy tissue within a safe threshold based on the minimum time formulation from optimal control theory.

Project aims

Define the aims of the project

The purpose of this study is to investigate the multivariate influence of scanning pathways and exposure properties for effecting optimized clinical protocols for efficacious results of ablative procedures.

Expected outcomes

Highlight the expected outcomes of the project

Successful completion of the objectives defined in the project would include devising automated mechanisms for ablative surgery planning by;

1. Optimized '*lesion fitting'* algorithm for 3D target volumes;
2. Modelling all possible pathways and respective bio-effects under given exposure conditions;
3. Converging algorithms under surgeon controlled constraints for safety and efficiency on case-by-case basis – *surgical customization.*

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 proposed project is important in the context of bioengineering and biotechnology. Numerical investigation on key parameters and protocols involved in FUS would lead to classified models to aid efficacious pre-planning of ablative procedures required for inducing the optimum thermal damage in selective targets while maintaining no/minimum harm to the overlying tissues.

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.

The interested candidates should have knowledge/skills in two or more of the following domains:

1. Skills in numerical/theoretical modelling.
2. Knowledge of Operations research topics like Integer programming, metaheuristics, stochastic programming, etc
3. Bio-physical properties and thermal transfer/analysis
4. Code development and data analysis.
5. Desirable background: Mechanical, Chemical, Materials Engineering

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Potential collaborators have already been identified:
Prof. Sunita Chauhan, Monash University
Prof.Abhiram Ranade, IIT Bombay.

Please provide a few key words relating to this project to make it easier for the students to apply.

Healthcare management, Operations Research, Numerical Modelling, Error and Risk Analyses