IITB-Monash Research Academy

An Indian-Australian research partnership

Indian Institute of Technology Bombay | MONASH University

Project Title:	**Optimal damage detection in structures through uncertainty quantification**

Project Number	**IMURA0813**	

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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? (Please nominate JUST ***one***. For more information, see www.iitbmonash.org)	**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. *Material Science/Engineering (including Nano, Metallurgy)* 2. *Energy, Green Chem, Chemistry, Catalysis, Reaction Eng* 3. *Math, CFD, Modelling, Manufacturing* 4. *CSE, IT, **Optimisation, Data, Sensors, Systems, Signal Processing**, Control* 5. *Earth Sciences and Civil Engineering (Geo, Water, Climate)* 6. *Bio, Stem Cells, Bio Chem, Pharma, Food* 7. *Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng* 8. *HSS, Design, Management*	1. *Advanced computational engineering, simulation and manufacture* 2. ***Infrastructure Engineering*** 3. *Clean Energy* 4. *Water* 5. *Nanotechnology* 6. *Biotechnology and Stem Cell Research Humanities and social sciences*

The research problem

Define the problem

Structures (civil, mechanical or aerospace) form a significant part of various engineering infrastructure systems, such as transportation, electrical power supply and telecommunication. These engineered components, after their installation, undergo ageing or deterioration over time. Ageing may result in damages in the structural component rendering it incapable of its functionality. Degrading structures are a major concern across the world (for example, ASCE has graded the bridges of USA with 'C+' and aviation infrastructure with 'D', as of 2017). Keeping the infrastructure systems in a functional state requires huge investments – both public and private – failing to allocate which may involve risk of an equal or larger magnitude (ASCE has estimated an investment of up to 3.5% of US GDP for the same).

Structural health monitoring (SHM) techniques help us in detecting these damages and to plan risk mitigating actions. However, these techniques (including SHM instruments and SHM algorithms) are subject to random errors and biases, giving us a (randomly) erroneous picture of the actual damage. An uncertainty quantification (UQ) framework can help us in scientifically quantifying these errors (and biases), giving a better clarity in the estimation of damage.

Project aims

Define the aims of the project

This project aims to quantify the uncertainties (errors and biases) in a structural health monitoring (SHM) technique, such that it helps us in

1. Having a probabilistic characterisation (such as, location and dimension/intensity) of the damage
2. Increasing the confidence in estimating the damage location and intensity
3. Adopting an optimal SHM technique in localising the damage
4. Quantifying the risk associated with the damage

The scope of this project will be limited to one SHM technique (*eg*, using guided Lamb waves) and one kind of damaged structural component (*eg*, metallic structures with fatigue crack).

Expected outcomes

Highlight the expected outcomes of the project

This project will result in one or two Ph.D. graduates with industry-relevant skills in numerical/computational modelling and experimentation. The graduate(s) will have knowledge of three domains: structural health monitoring, uncertainty quantification, and optimisation.

The key technical outcomes of the project will include:

1. An improved (probabilistic) assessment of the actual damage in the structure, both in terms of its location and size
2. A cost effective optimal damage detection strategy
3. A method to assess the risk brought by the damage

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.

This project directly identifies a real problem area and will examine improved measures for damage detection in structural components, ageing of which may result in infrastructure risk of great proportions.

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.

Essential:

- A Bachelors Degree in Civil/Aerospace/Mechanical Engineering with a High Distinction (or equivalent) from a reputable institute in India like the IITs; **or** a Masters Degree in Civil/Aerospace/Mechanical Engineering, specialising in Structural Engineering, from an IIT or an institute of similar repute from outside India
- Relevant courses in Structural Engineering with evidence of performance at the highest level
- A clear understanding of the basic concepts in Statistics and Probability
- Demonstrable excellent oral/written communication skills in English

Desirable:

- Ability to fluently program in Python or Matlab with good debugging skills
- TOEFL or IELTS scores to demonstrate English language proficiency
- Previous experience with experimental setup/methods in structural/solid mechanics
- Publications in reputed journals/conferences

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.

Select up to **(4) keywords** from the Academy's approved keyword list (available at **http://www.iitbmonash.org/becoming-a-research-supervisor/**) relating to this project to make it easier for the students to apply.

1. **Optimisation**
2. **Algorithms**
3. **Sensor networks**
4. **Next generation infrastructure**