IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Machine Learning for Improved Value of Information of Structural Health Monitoring	
Project Number	**IMURA0926**	
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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)*	***1***	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering* ✓
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)* ✓	5	*Nanotechnology*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Around the world, ageing infrastructure is a significant problem. Just as these structures corrode and degrade, the demands placed upon them are increasing, such as heavier vehicles and longer trains. Structural health monitoring (SHM) is a technology that allows for the remote monitoring of the physical response of infrastructure to its environment and the loads placed upon it. Newer major pieces of infrastructure sometime have many hundreds of sensors placed throughout the structure, such as the Stonecutters Bridge in Hong Kong. This is because it is well-recognised that quick notice of potential catastrophic failures is essential for structures. Unfortunately though, such instrumentation is rare, especially for existing structures. There are two main challenges limiting the widespread adoption of SHM techniques for the management of existing infrastructure.

First, asset owners have strict budgetary processes for making investment decisions. A key example is the widespread use of cost-benefit ratios, which aims to balance the cost of an investment with the financial benefit that can result. At the present time, there is very little knowledge on the financial value of the data from SHM systems. While asset owners often realise the benefit of such data intuitively, they are often constrained by the inability to express the benefit of SHM in monetary terms, for inclusion in the cost-benefit analysis. As a result, many asset owners, who recognise the potential for SHM data, are prohibited from acquiring such systems for the management of their inventory.

Second, SHM systems typically comprise 10s or 100s of sensors, many of which must record at high sampling rates to acquire meaningful data. This enormous stream of data presents serious challenges to asset owners in storage, processing, and interpretation of the data streams. These challenges are compounded by the need for real-time indicators of structural health for critical infrastructure. As a result, until there are suitable approaches for managing and interpreting massive incoming data streams, asset owners often prefer traditional visual inspection approaches to asset management.

The dramatic advances in computer-based data science in recent years present an enormous opportunity to remove both obstacles to the widespread adoption of SHM. Machine Learning offers a means to handle and gain meaningful information from large data streams coming from structural sensors. This learning can then be applied to better identify the value of the information that SHM offers. Even more challenging is that to properly capture the monetary value a proposed SHM system will bring, it is necessary to predict what these data streams may reveal, and what decisions may result. However, by combining the value of information approaches with machine learning, it will be possible to adequately capture the potential monary benefit of SHM systems, facilitating their widespread adoption which will lead to safer aged infrastructure globally.

Project aims

This project aims to remove some of the key barriers to the adoption of SHM through improvements in knowledge of the use of machine learning and value of information analysis. Specifically, this project will:

- determine suitable algorithms for processing large incoming streams of data from disparate sensor types, to infer on the structural behaviour through updating of a structural model;
- provide (a set of) suitable machine learning algorithms, making the arduous computation of value of information more implementable in real decision making scenarios
- use the methodologies from this analysis, the predictions of likely behaviour and decision making in various possible measurement scenarios

Expected outcomes

- A novel algorithmic framework for processing large data streams from SHM, focussing specifically on bridges
- A simplified and practicable approach to VOI computation using machine learning algorithms
- Demonstration of the developed frameworks in the decision making for infrastructure asset management

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

Presently, across the globe, a significant percentage of bridges are undergoing deterioration due to aging and showing visible signs of distress under regular service loads. News of recent bridge collapses from within India and across other nations are a tragic testimony to the degrading infrastructure quality. This project addresses a critical problem in infrastructure engineering with respect to the use of structural health monitoring techniques to manage the safety of older structures. The outcomes of this project will aid decision makers decide on periodic maintenance policies and employ cost-effective SHM strategies for up-to-date tracking of bridge performance.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. 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.

Degree required: B.Tech / M.Tech in Civil Engineering

Capabilities required:

- Sound knowledge of structural engineering
- A formal course in probability and statistics
- A solid background in mathematics
- Sound knowledge of and experience with scientific computing using Matlab/Python/R

Capabilities desired:

- Knowledge on structural reliability and risk assessment
- Knowledge on structural health monitoring techniques

- Experience of working using a computational cluster

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.

Next Generation Infrastructure
Modelling and Simulation
Data Science, Optimisation, Algorithms
Computer Simulation