IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Advancing microbial detection through Integrated Spectroscopic and Machine Learning Approaches**	
Project Number	**IMURA1176**	
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Research Clusters:

Highlight which of the Academy's CLUSTERS this project will address?
*(Please nominate JUST **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*

Research 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	*Artificial Intelligence and Advanced Computational Modelling*
2	*Circular Economy*
3	*Clean Energy*
4	*Health Sciences*
5	*Smart Materials*
6	*Sustainable Societies*
7	*Infrastructure*

The research problem

Define the problem

Pathogenic infections, exemplified by waterborne diseases, persist as critical challenges to global public health. Accurate and timely detection of pathogens across diverse mediums such as water, air, and pharmaceuticals are indispensable for effective mitigation strategies. However, current detection methodologies, including culturing and PCR assays, suffer from limitations in terms of time, cost, and sensitivity. In response to these challenges, our interdisciplinary team has engineered portable spectroscopic devices with the capability to detect pathogens. Our current objective is to enhance the analysis process through the application of machine learning and multivariate statistical analysis, thereby improving accuracy and sensitivity. Building upon our existing portable spectroscopic platforms, our focus is on optimizing the data analysis pipeline and developing methods to detect specific toxins associated with the pathogens. Functionalized plasmonic surfaces will amplify signal sensitivity, while filtration strategies will facilitate toxin concentration from complex samples. The acquired spectra, encompassing molecular phenotypes of pathogenic toxins, will undergo deconvolution utilizing advanced digital filtration methods developed by our team. Furthermore, machine learning algorithms will be trained on spectral data to precisely identify and categorize pathogens based We will subject spectral data obtained from samples to advanced machine learning algorithms and multivariate statistical analysis techniques. These methodologies will enable the identification of distinctive spectral signatures linked with various pathogens, even at low concentrations. **Our approach integrates expertise in analytical biospectroscopy, microfluidics, environmental engineering, device development, and machine learning. We will design and fabricate portable spectroscopic devices proficient in capturing spectral signatures of pathogens across diverse mediums.**

Project aims

Define the aims of the project

The central aims are:-

1. Enhance sensitivity and specificity in detecting various pathogens, including bacteria and protozoans using plasmonic surfaces and lithography.
2. Investigate novel spectroscopic markers for water and air contamination assessment.
3. Refine the analysis process for pathogen detection using machine learning and multivariate statistical analysis.
4. Develop algorithms to interpret spectral data and identify pathogens accurately.

What is expected of the student when at IITB and when at Monash?

Highlight how the project will gain from the students stay at IITB and at Monash

Some knowledge of machine learning will be helpful.

Expected outcomes

Highlight the expected outcomes of the project

By this project, we expect to come up with a portable device with a proper application to distinguish microbes based on their specific toxins . Students will publish high quality research outputs in journal and academic conferences.

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 fulfils the critical goal of healthcare by introducing a portable and cost-effective device tailored for the detection of microbes present in water, which are often the root cause of diseases. By leveraging multimodal technology and sophisticated computational methods such as machine learning and advanced modelling, we aim to develop a solution that can accurately identify and quantify these harmful microorganisms in water sources via the detection of their specific toxins. The incorporation of modelling and machine learning techniques for the deconvolution of bacterial Raman spectra represents a significant advancement in the field. This aspect of the project not only addresses the immediate need for reliable microbial detection but also provides a platform for the integration of artificial intelligence and advanced computational modelling into healthcare solutions.

Furthermore, by focusing on waterborne pathogens, our project aligns with broader environmental and public health initiatives aimed at ensuring clean and safe water supplies. By delivering a portable device capable of rapid microbial detection, we empower communities to monitor and safeguard their water sources, ultimately reducing the incidence of waterborne diseases. Overall, the integration of cutting-edge technologies, interdisciplinary collaboration, and a focus on addressing pressing healthcare challenges underscores the significance and potential impact of our project. It represents a tangible step towards leveraging artificial intelligence and advanced computational modelling to improve healthcare outcomes and promote public well-being.

Potential RPCs from IITB and Monash

Provide names of the potential research progress committee members (RPCs) and describe why they are most suited for the proposed project

Prof. Alison Funston, Prof. Prasanna Mural

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.

Bachelor and Master's degree in field of science or engineering

Necessary Courses

Name three tentative courses relevant to the project that the student should complete during his/her coursework at IITB (the student will require to secure 8 point in these courses)

BB653 Experimental Techniques in Biomedical Engineering
ES 639 Physico-Chemical Treatment Technologies
MM718 Laser processing & nanostructures
MM734 Electrical Properties of Materials
MM750 Vibrational spectroscopy

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.

Thermax, Reliance

K**eywords** relating to this project to make it easier for the students to apply.

Machine learning, nanoscience, sensor network, smart manufacturing