

An Indian-Australian research partnership

**Project Title:** **Coordinated inspection of railway tracks using multiple robots**

**Project Number** **IMURA0638**

**Monash Main Supervisor**  
(Name, Email Id, Phone)

Professor Sunita Chauhan  
[Sunita.chauhan@monash.edu](mailto:Sunita.chauhan@monash.edu);

*Full name, Email*

**Monash Co-supervisor(s)**  
(Name, Email Id, Phone)

Mr. Ravi Ravitharan  
[Ravi.ravitharan@monash.edu](mailto:Ravi.ravitharan@monash.edu)

**Monash Department:**

Mechanical & Aerospace Engineering

**IITB Main Supervisor**  
(Name, Email Id, Phone)

Dr. Leena Vachhani  
Email: [leena.vachhani@iitb.ac.in](mailto:leena.vachhani@iitb.ac.in)

*Full name, Email*

**IITB Co-supervisor(s)**  
(Name, Email Id, Phone)

Dr. Arpita Sinha  
Email: [asinha@iitb.ac.in](mailto:asinha@iitb.ac.in)

**IITB Department:**

Systems and Control Engineering Group

## 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](http://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
7. Humanities and Social Sciences

## The research problem

The rapid growth for freight, passenger and heavy haul railway across the world introduces the challenges of increased costs of upgrading railway infrastructure and increased demand for enhanced efficiency and performance. Integration of robotics and smart communication technologies presents opportunities to develop rail into a more commercially sustainable industry. One of the important rail infrastructure management activities involves regular inspection of track conditions, which is labour intensive and could be potentially augmented with robotics.

The proposed project aims to address the above problem by introducing autonomous inspection of railway tracks using multiple agents. A good communication link between the agents for coordination and localization is required to achieve the objective of this project. Therefore, a dedicated methodology needs to be developed that uses a network of fixed and

mobile agents. Since the railway track network is known, and so comes under structured environment category, we address the problem of known graph exploration using multiple agents. A challenging problem to address is robustness of technique under faults in the operation of agents: Design an energy efficient and fault tolerant technique for repeated autonomous exploration using multiple fixed and mobile agents.

This project aims to develop a novel technique to coordinate multiple autonomous robots for efficient and robust inspection. A network of fixed and mobile robots/agents is needed to accomplish this goal. The fixed sensor agents are particularly used for providing location information or charging points for the mobile agents. An online technique to build a fixed information network by multiple agents is proposed along with the deployment of robots for establishing a wireless backbone network to establish connectivity. An optimal position of fixed agents resulting in stronger backbone for communication and localization is required to be addressed.

### **Project aims**

The project aims to repeatedly explore a known graph using both fixed sensing nodes for referencing and localization (s.a. pre-installed signals at stations and pre-appointed locations along the tracks) as well as mobile sensors (s.a. those mounted on the dedicated edges of a sub-graph) for exploring and wireless communication to control rooms. We aim to address following problems through this project:

1. Given the fixed and mobile agents, what is the optimal size of team for exploration of a known graph?
2. What is the best time/ energy solution?
3. What is the best initial placement of agents to provide an optimal solution?
4. Solutions to above problems under decentralized/centralized framework and failure cases.

### **Expected outcomes**

The efficient distribution of resources to the mobile agents under the novel scenario of autonomous inspection and coordination is addressed in this project. It aims to provide solution of placing fixed and mobile sensor agents on a known graph. Moreover, the placement of fixed agent is constraint to be a point on the graph is identified as a research problem.

- A dynamic graph distribution and localization algorithm for optimum deployment of autonomous agents
- Efficient and fault tolerant exploration and coordination strategies for autonomous task allocation among the robots and area mapping.
- Hardware-software integration and validation.
- Publications in peer-reviewed journals and conferences.

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

The project is related to designing, modelling and optimizing algorithmic strategies for efficient and fault tolerant exploration using sensor networks embedded in autonomous mobile robots for inspection of rail infrastructure.

Capabilities of the system would be investigated by extensive simulations considering various graph structures, offline/online and decentralized/centralized techniques. The computations required to achieve the goal of efficient and fault tolerant exploration would be addressed in this project.

The above mentioned research activities thus fall under the two main themes of the research academy, viz. Advanced computational engineering, simulation and manufacture and Infrastructure Engineering

## Capabilities and Degrees Required

B.E. or M.Tech in relevant branch of engineering with strong knowledge and aptitude in mathematical and computational methods; object oriented programming, coding and interface with hardware; robotics and motion/path planning.

## Potential Collaborators

Potential collaborators have already been identified:  
Professor Sunita Chauhan and Mr. Ravi Ravitharan, Monash University and  
Profs. Leena Vachhani and Arpita Sinha IITB

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

Sensor network, graph theory, multi-agent graph exploration