

An Indian-Australian research partnership

Project Title:	Data driven model for real-time OD predictions	
Project Number	IMURA1015	
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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? <i>(Please nominate JUST one. For more information, see www.iitbmonash.org)</i>		Highlight which of the Academy's Theme(s) this project will address? <i>(Feel free to nominate more than one. For more information, see www.iitbmonash.org)</i>	
1	Material Science/Engineering (including Nano, Metallurgy)	1	Artificial Intelligence and Advanced Computational Modelling
2	Energy, Green Chem, Chemistry, Catalysis, Reaction Eng	2	Circular Economy
3	Math, CFD, Modelling, Manufacturing	3	Clean Energy
4	CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control	4	Health Sciences
5	Earth Sciences and Civil Engineering (Geo, Water, Climate)	5	Smart Materials
6	Bio, Stem Cells, Bio Chem, Pharma, Food	6	Sustainable Societies
7	Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng		
8	HSS, Design, Management		

The research problem

Define the problem

This task aims at developing a library of OD matrices, using conventional data such as historical data as well as real-time data. By utilizing knowledge from off-line estimation results on multiple days, historical data represents a *a priori estimate* of the regular OD demand pattern. In particular, in the context of OD demand prediction, reliable historical data can serve as an *informative source under normal conditions* (i.e. under static environment). On the other hand, it is necessary to recognize the possible structural deviations of real-time OD demand from the regular pattern which might be caused by changing environment due to disruptions and special events, as well as the responses of road users to control strategies (via changing route choices). The first two factors have been well documented as important elements in the effectiveness of travel demand management systems. In addition, random fluctuations would still account for the effect of other unobserved factors and the inherent stochastic nature of daily time-varying demand. In the early development of real-time OD estimation and prediction, a common issue is that only unreliable historical demand data with significant uncertainty is available, often consisting of out-of-date survey data and limited surveillance data. In this case, as the prior estimate cannot adequately describe the average conditions, the real-time estimate becomes more informative in the sense that it captures the prevailing demand pattern and encapsulates up-to-date demand information. Nevertheless, a challenging issue is the limited samples of real-time traffic data which causes the real-time learning process inefficient. To tackle this issue, the following primary functional requirements need to be satisfied: (1) incorporate regular demand information into the real-time demand prediction process; (2) recognize and capture possible structural changes in demand patterns under various conditions; and (3) optimally update the a priori estimate of the regular pattern using new real-time estimation results and traffic observations. The following equation summarises our proposed method: $D_{i,j,t} = \widehat{D}_{i,j,t} + S_{i,j,t} + \epsilon_{i,j,t}$, where i,j present the origin i and destination j , t is the time instant. $D_{i,j,t}$ denotes the estimated real-time demand, $\widehat{D}_{i,j,t}$ is the corresponding regular demand, estimated from the historical data up to the previous day (i.e. the prior estimate). In case of no disruptions, these two demands are approximately identical subject to the random disturbance term $\epsilon_{i,j,t}$. In case of disruptions, they are substantially different due to the structural demand deviation of from the priori estimate $S_{i,j,t}$. The estimation of this structural deviation will be investigated in this proposal using adaptive machine learning algorithms which explicitly consider a fast-changing transport environment due to disruptions in the network based on a large amount of historical data and limited real-time data.

Project aims

Define the aims of the project

The aims of this project are to

- 1) Investigate the possible structural changes in demand patterns under various disruptive conditions
- 2) Develop adaptive machine learning algorithms to estimate the structural deviation in the OD demand
- 2) Estimate real-time OD matrices in a fast-changing transportation environment by utilizing historical and real-time data

How skills/experience of the IITB and the Monash supervisor(s) support the proposed project

Highlight the purpose of the collaboration and/or the complementary skills/experience that you bring to the project. Do you have any joint or independent publications in the area of the proposed project?

In order to develop a robust system for estimating real-time OD estimation, there is a need to use the demand data from different cities. The plan is to use the data from Melbourne and Mumbai in developing the real-time OD demand estimation framework. The project needs data on traffic analysis zones and historical OD matrices. Prof. Dong Ngo Duy will help procure data for Melbourne city and Prof. Gopal Patil for Mumbai city or Navi Mumbai city.

Monash supervisor has expertise in traffic flow modelling, machine learning, and data fusion. The IIT Bombay supervisor has a background in data analytics, OD estimation and data analytics. IIT Bombay and Monash supervisors have the necessary skills and experience to support the proposed project.

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

During the stay at IIT Bombay, the student is expected to obtain necessary data for Mumbai or Navi Mumbai. The data from Melbourne will be transferred to IIT Bombay. The student will investigate changes in the OD demand patterns and develop algorithms to estimate structural deviations in OD demand. The student is expected to spend two semesters at Monash during which they will create a framework to estimate real-time OD demand. The framework will be validated using sampled OD data.

Expected outcomes

Highlight the expected outcomes of the project

The expected outcomes are

- 1) Expected variation in OD matrices due to change in transportation environment
- 2) New ways of estimating real-time OD matrices

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 develops mathematical models based on which new advanced computational methods and simulation will be developed to estimate Origin-Destination matrices and understand travel behaviors in different environments. The real-time OD estimation enables various traffic management strategies to minimize congestion and delay. These measures reduce travel times, emissions, and fuel consumption, thereby helping to create sustainable societies.

How well the IITB and the Monash supervisor(s) know each other

Provide details of previous collaborations (if any). For new collaborators, have you had a chance to meet each other in person or through VC or Skype?

The IIT Bombay supervisor has a collaboration with another Professor (Prof. Hai Vu) from Monash, and they have a student who is in the third year. Prof. Vu does not have the capacity to recruit more students at this stage. He introduced IITB and Monash supervisors to each other. This is a new collaboration. There has been communication with each other over emails and through Zoom.

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

1. Prof. Nagendra Velaga, Department of Civil Engineering, IIT Bombay
2. Prof. Mallikarjuna Rao, Industrial Engineering and Operations Research, IIT Bombay
3. Prof. Hai Vu, Monash University

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 candidate should have good analytical skills and should be comfortable in writing computer programs.

The background in one or more of the following areas is desired

- network optimization
- machine learning algorithms
- traffic simulation and
- traffic flow modelling

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)

- Traffic Engineering
- Probability and Statistics
- Engineering Optimization

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.

IIT Bombay and Monash supervisors are already decided.

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.

- Transportation and Traffic Engineering and Logistics
- Data Science, optimisation, algorithms