IITB-Monash Research Academy

An Indian-Australian research partnership

Indian Institute of Technology Bombay | MONASH University

Project Title:	Co-simulation framework for Bikes using traffic and driver simulators	
Project Number	**IMURA1026**	
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IITB Department:	Civil Engineering	

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***	***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

The proposed research aims at developing a unified framework for co-simulation of both lane-based traffic and non-lane based mixed traffic. By co-simulation, it is meant that a large-scale (even a city-wide) traffic scenario can be emulated by a simulation package suited to the task (e.g., SUMO - https://www.eclipse.org/sumo/); while the dynamics of a single, individual vehicle can be emulated by something else more appropriate (e.g., a driving simulator). In this research, the term 'mixed traffic' means that many different types of vehicles may occupy the same road; e.g., bicycles, cars, trucks, etc. The smaller mobility devices, such as conventional motor bikes, e-Bikes, e-Scooters and pedal bicycles, that meet the mobility needs of one or two persons, are of particular interest. This is due to the fact that the proportion of two-wheelers in many cities around the world, including India, are very high. In Australia, e-Bikes and e-Scooters are witnessing a rise in popularity, and thus are mixing more frequently with cars and/or pedestrians.

Project aims

1. Data collection and analysis (in India and Australia)
2. Developing an extended sumo model for non-lane based mixed traffic (in India),
3. Developing co-simulation scenarios with driver simulator (in India)
4. Validation on a real road using extended SUMO model and real e-Bikes (in Australia)
5. Development of applications, including the incorporation of V2V communication; e.g., two connected e-Bikes (in Australia)

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?

Prof. Tom Mathew*:* Expertise in microscopic traffic flow modelling and simulation. Background in transportation systems engineering. https://www.civil.iitb.ac.in/tvm/SiMTraM_Web/html/index.html

Dr. Wynita Griggs: Experience with vehicle-in-the-loop simulation, including the incorporation of real-time information (e.g., GPS, OBD-II) into SUMO; Background in mathematics, especially dynamical control theory; Interest in intelligent transportation systems.

Relevant publications:

1. W. M. Griggs, R. H. Ordóñez-Hurtado, E. Crisostomi, F. Häusler, K. Massow and R. N. Shorten, A large-scale SUMO-based emulation platform, IEEE Transactions on Intelligent Transportation Systems, vol. 16, no. 6, pp. 3050-3059, 2015. [eprint: https://wynitagriggs.com/wordpress/wp-content/uploads/j2015transits.pdf]
2. W. Griggs, R. Ordóñez-Hurtado, G. Russo and R. Shorten, A vehicle-in-the-loop emulation platform for demonstrating intelligent transportation systems, in H. Waschl, I. Kolmanovsky and F. Willems (Eds.), Lecture Notes in Control and

Information Sciences: Control Strategies for Advanced Driver Assistance Systems and Autonomous Driving Functions, vol. 476, pp. 133-154, 2019, Springer. [eprint: https://wynitagriggs.com/wordpress/wp-content/uploads/b2019springer.pdf]

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

IITB: IITB do have high-end driver simulator (car/truk/bike) and expertise in driver simulation and performance evaluation.

Monash: Validation experiments with SUMO and real e-Bikes; and (time-permitting), the incorporation of vehicle-to-vehicle communication.

As such, the project will merge the skillsets available through Prof. Tom Mathew at IITB, and Dr. Wynita Griggs at Monash, to enable a comprehensive program of research on non-lane based mixed traffic.

Expected outcomes

Highlight the expected outcomes of the project

It is expected that the project will deliver an extended sumo model for non-lane based mixed traffic, which will have been evaluated through co-simulation and real hardware experiments.
Tangible outputs may include:

1. open-source SUMO code modified for non-lane based mixed traffic.
2. publications; e.g., IEEE journals and conferences such as IEEE ITSC

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 is expected to make a contribution to the area of study of mixed traffic, which is an important area of study in transport engineering (i.e., civil engineering). It is an important area of study, since the proportion of two-wheelers in many cities around the world, including India, are very high (~40%), for instance. In Australia, e-Bikes and e-Scooters are witnessing a rise in popularity, and thus are mixing more frequently with cars and/or pedestrians. With populations around the world also looking for alternative greener sources of transport, and with the incorporation of connected autonomous vehicles also on the horizon, being able to accurately model mixed traffic reflective of contemporary traffic scenarios will be a necessity.

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. Nagendra Velaga – expertise on driver behavioural studies

Prof. Avijith Majhi – expertise on optimization and signal control

Prof. Hai Vu from Monash – expertise in intelligent transport systems, modelling and design of complex networks, deep learning, IoT and big data

Prof. Nan Zheng from Monash – expertise in modelling and optimisation of transport systems, traffic operation and control, and connected and automated mobility

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.

Students from Computer Science, Electrical/Electronics, Civil Engineering, Maths (with masters), with good background on computer programming, and statistics.

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, Computer programming, Advanced Probability and Statistics

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.

Not planned in this project

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
Modelling and Computer Simulation of vehicular traffic