IITB-Monash Research Academy

An Indian-Australian research partnership

Project Title:	**Incremental Infrastructure Planning, Optimization, and Incentivization for Autonomous Vehicles**
Project Number	**IMURA0600(Xerox)**
Monash Main Supervisor (Name, Email Id, Phone)	Mohan Krishnamoorthy mohan.krishnamoorthy@monash.edu
Monash Co-supervisor(s) (Name, Email Id, Phone)	Andreas Ernst andreas.ernst@monash.edu
Monash Department:	Mech and Aerospace
IITB Main Supervisor (Name, Email Id, Phone)	Abhiram Ranade ranade@cse.iitb.ac.in
IITB Co-supervisor(s) (Name, Email Id, Phone)	
IITB Department:	Computer Science and Engineering

Full name, Email

Full name, Email

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)*

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

External Mentor from Xerox: Ragavendran Gopalakrishnan

Fully autonomous vehicles, once the subject of science fiction, are fast approaching reality in their implementation [Litman2015]. Many major automobile manufacturers have announced plans to roll out such vehicles in the coming years, and legal operation of such vehicles on public roads is now permitted in some areas. The benefits of a road transportation network with predominantly autonomous vehicles are many - reduction in traffic and parking congestion, accidents, pollution, to name a few. However, we are currently far from approaching such a reality, and must work to facilitate and encourage the transformation. This proposal identifies a framework for a city to incrementally prepare its streets to allow for autonomous vehicles to operate with minimal disruption to regular traffic, while at the same time, incentivizing regular traffic to switch over to autonomous vehicles. The two major parts of this framework are:

1. *Infrastructure Planning:* Along major roads, dedicated lanes can be set aside for autonomous vehicle operation (just like carpool lanes or BRT lanes). These lanes would have higher speed limits or no speed limits and signal priority. The idea is to mimic the idea of a "freeway" for autonomous vehicles, but at the city level. The primary optimization problem here is to identify a subset of major roads that minimizes the impact on regular traffic, such that autonomous vehicles perform better than regular vehicles according to some desirable metric, e.g., the average vehicle speed.

2. *Route Planning:* Given the departure/arrival time, source, destination, and optional waypoints, the routes of travel for autonomous vehicles must be centrally coordinated/controlled in real-time to provide the best possible outcome (according to some desirable metric, e.g., travel time). The optimization problem here would assume knowledge of the roads where dedicated lanes for autonomous vehicles exist, so that, in general, the route may try to maximize the distance travelled along these roads to get to the destination faster.

The solutions at each of the above stages would dynamically adapt to changes in the number of autonomous vehicles, e.g., an increase in the number of autonomous vehicles would lead to more roads with dedicated lanes for them, while maintaining or improving their routes. Both stages involve important research challenges:

(a) Modelling - city transportation network, traffic pattern.

(b) Identifying/Defining - desirable metrics of performance that are simple to work with.

(c) Problem formulation at various stages.

(d) Solutions/Algorithms.

(e) Simulation/Implementation.

This project should explore *systemic* (as opposed to *monetary*) incentives for regular vehicle owners to switch over to autonomous vehicles, and provides an expandable framework that can adapt to increasing presence of autonomous vehicles. Simultaneously, one can also explore the design of both systemic and monetary incentives for regular vehicle owners (who may be unwilling to make the switch for various reasons) to allow their travel routes to be centrally controlled.

References:

[Litman2015] "*Autonomous Vehicle Implementation Predictions: Implications for Transport Planning*," Todd Litman, Victoria Transport Policy Institute. August 24, 2015. http://www.vtpi.org/avip.pdf

Project aims

The overall goal is to improve the overall feasibility of autonomous vehicle use (and to incentivize its users) through effective infrastructure planning and design and through optimal route planning.

Expected outcomes

Outputs:

- Prototype Software for network design, planning and scheduling for use by autonomous vehicles
- Development of state-of-the-art models and algorithms for route planning for autonomous vehicles.
- 2-3 good quality publications in this area.

Outcomes:

- Better use of autonomous vehicles, leading to reduction in traffic congestion,
- Better fleet management and incentive mechanisms for use of autonomous vehicles.

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 will involve the development of models and algorithms for route planning and network design for the deployment (and scheduling) of autonomous vehicles. This will lead to more people using this form of transport and this will, in turn, reduce the burden on urban infrastructure, reduce emissions, and improve infrastructure utilisation.

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.

Essential:

- Operations research, optimisation
- Graph theory and graph algorithms
- Optimal network flows and network design
- Algorithm development
- Masters in Computer Science or Operations Research
- Programming in C/C++

Desirable:

- Knowledge of CPLEX, Matlab, R and other software packages
- 2-4 good publications
- Knowledge of the key issues in autonomous vehicles
- Knowledge of simulation modelling

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.

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

Algorithms, operations research, graph theory, transportation