FUTURE URBAN MOBILITY

Research Projects in the SMART FM IRG
(September 1, 2016)

1. **SimMobility Pax**
   Develop and integrate state-of-the-art behavioural models with simulation tools to predict the impact of different mobility portfolios, including flexible mobility on demand services and autonomous mobility, on travel demand and activities, both for passengers and freight, and on transportation networks and land-use. The research includes:

   - *Short-Term*: Calibration of the entire Singapore network and development of flexible traffic, fleet and information control modules that will enable the design and testing of innovative ITS solutions.
   - *Mid-Term*: Implement a rescheduling plan model (i.e. in terms of en-route choice, changes in modes, departure times and trip making) and representation of individual day-pattern choices.
   - *Long-Term*: Development and testing of the components that relate to land use, residential and commercial real estate, and their sensitivity to transportation infrastructure and various accessibility and mobility measures.

   MIT Principal Investigator(s):
   Moshe BEN-AKIVA (Civil and Environmental Engineering)
   Joseph FERREIRA (Urban Studies and Planning)
   Chris ZEGRAS (Urban Studies and Planning)

   Singapore Co-Investigator(s):
   Gary TAN (NUS, School of Computing)
   Mi DIAO (NUS, Real Estate)

2. **SimMobility Freight**
   Develop agent-based models for the movement of goods and materials in the urban environment. Commodities will be traced through their entire life cycle; from its production, its distribution through various channels and its consumption by an end-consumer, to its final disposal or recycling. All relevant transport and logistics choices will be simulated using behavioural models, estimated based on innovative data collection methods.

   MIT Principal Investigator(s):
   Moshe BEN-AKIVA (Civil and Environmental Engineering)
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   Lynette CHEAH (SUTD, Engineering Systems and Design)

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3. DynaMIT 2.0

Develop a multi-modal network state estimation and prediction system that utilizes heterogeneous real-time data from a variety of sources to assess the impact of congestion-causing planned and unplanned events and optimize interventions/network management strategies to facilitate the real-time deployment of measures to mitigate congestion. The research includes:

- *Multi-Modal Traffic State Estimation and Prediction System*
- *Online Calibration Methodologies*

MIT Principal Investigator(s):
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Gary TAN (NUS, School of Computing)

4. Data-Driven Traffic Modelling and Route Guidance

Algorithms that use real-time data from many heterogeneous sources in order to (i) track and predict paths in dynamic transportation networks, and (ii) provide on-demand route guidance under uncertainty, based on a combination of optimization, data-fusion, machine learning, and novel behavioural techniques. The research includes:

- *Data-Driven Traffic Modeling for Passengers and Freight*
- *Large-Scale Modeling and Prediction of Spatiotemporal Traffic Phenomena*
- *Selfish and Competitive Routing in a Network under Uncertainty*

MIT Principal Investigator(s):
Patrick JAILLET (Electrical Engineering and Computer Science)

Singapore Co-Investigator(s):
Justin DAUWELS (NTU, Electrical and Electronic Engineering)
Pradeep VARAKANTHAM (SMU, School of Information Systems)
Bryan LOW (NUS, Computer Science)
Melvyn SIM (NUS, Department of Decision Sciences, Business School)
Hai WANG (SMU, School of Information Systems)

5. Next-Generation Traffic Control

Develop an optimal vehicle traffic management system and the corresponding control mechanism so that the transportation infrastructure can support the maximum amount of traffic with minimal traffic congestion throughout the system. Such a system is likely to include mechanisms for traffic scheduling, routing, and flow control.

MIT Principal Investigator(s):
Daniela RUS (Electrical Engineering and Computer Science)
Sertac KARAMAN (Aeronautics and Astronautics)

Singapore Co-Investigator(s):
Dan Wei WANG (NTU, Division of Control and Instrumentation)
Lihua XIE (NTU, Division of Control and Instrumentation)

6. Mobility on Demand

Develop models and algorithms to configure dynamically portions of the urban transportation service network to meet mobility demands in real- time; the objective is to provide passenger-centric, timely service while minimizing costs and maximizing system efficiency. The research includes:

- *Anytime Planning with Optimal Schedules*
- *Activity Recognition Planning with Ride Sharing*
- *Routing Algorithms for Mobility-on-Demand*

MIT Principal Investigator(s):
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Singapore Co-Investigator(s):
Bryan LOW (NUS, Computer Science)
Der-Horng LEE (NUS, Civil Engineering)
Shih-Fen CHENG (SMU, Information Systems)

7. Technologies of Autonomy

Assess and demonstrate the role of autonomy in mobility-on-demand and its impact in terms of feasibility, safety, and efficiency through modelling and simulation, algorithm development and experimental demonstration ("*Autonomy for Mobility-on-Demand*").

MIT Principal Investigator(s):
Daniela RUS (Electrical Engineering and Computer Science)
Sertac KARAMAN (Aeronautics and Astronautics)

Singapore Co-Investigator(s):
Marcelo ANG (NUS, Mechanical Engineering)
David HSU (NUS, Computer Science)
Gim Hee LEE (NUS, Mechanical Engineering)

8. Mobility Management

Envision a future scenario for Singapore in which the urban mobility service provided as a public utility that combines public transit, walking and bicycling, and autonomous vehicles. The project aims to design and test the new mobility scenarios in which autonomous vehicles are embedded in the public transit system.

MIT Principal Investigator(s):
Jinhua ZHAO (Urban Studies and Planning)

Singapore Co-Investigator(s):
Hai WANG (SMU, School of Information Systems)
Justin DAUWELS (NTU, Electrical and Electronic Engineering)

9. LIVE Singapore! 2.0

A platform for the collection, analyzing, distribution and visualization of urban mobility data from different sources in Singapore that can serve as the active application of a semantic web platform to the management of the city, and form the basis for crowd sourced open application development. The research includes:

- *Social Implications of Universal Mobility*: Analyze large scale, fine grained global mobility data sets as the ones derived from cellular phone data and social networks to advance our knowledge and understanding of the fundamental laws governing human mobility at the urban and regional scale.
- *Indoor Tracing:* Analyze human occupancy and flows through public spaces as it is essential to improve already existing environments, and to better plan and design future spaces.
- *DataCollider:* Refine a tool that allows the user to turn real-time data streams into sophisticated, next- generation visualizations.

MIT Principal Investigator(s):
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Rex BRITTER (Urban Studies and Planning)

Singapore Co-Investigator(s):
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Mehul MOTANI (NUS, Electrical and Computer Engineering)
Wolfgang MUELLER-WITTIG (NTU, Centre for Advanced Media Technology)
Weng-Fai WONG (NUS, School of Computing)

10. Future Mobility Sensing (FMS)

Development of a next generation individualized mobility sensing system that leverages advanced mobile technologies and machine learning techniques to capture high resolution, multi-day human behaviour and vehicular and freight movements as well as related preferences and satisfaction information. The research includes:

- *FMS-Core:* Improve quality of the travel behavior data by reducing battery consumption and using additional sensor and context information to improve the stop/mode detection algorithm.
- *FMS-SP:* Develop a context specific stated preferences (SP) survey system to test new transportation solutions and policies.
- *FMS-Real time:* Develop real-time on-phone surveys based on specific events of interest being detected by the FMS app.
- *FMS-Feedback:* Provide information and recommendations to users based on their data.
- *FMS-DES:* Understand the capabilities of, behavioral understanding from, and data implications of implementing FMS in a city of the Global South, Dar es Salaam (Tanzania).

MIT Principal Investigator(s):
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Lynette CHEAH (SUTD, Engineering Systems and Design)

11. New Tools & Technologies

FlockTracker: Create a standalone platform, including surveyor and tracker capabilities, project builder, credential system, data visualization and survey monitoring capability; continue to promote deployment of the technology in a range of settings; finalize the analysis of its capability for walk auditing in Singapore; develop new collaborative uses in Singapore; seek spin-off opportunities.

MIT Principal Investigator(s):
Chris ZEGRAS (Urban Studies and Planning)

Singapore Co-Investigator(s):
Keng Hua CHONG (SUTD, Architecture and Sustainable Design)

12. Internet-informed Traffic Prediction and Route Planning

This project studies the use of information from the Internet on predicting traffic conditions and route planning. Such information is mostly in the text form, and can include news facts such as road works and sport events being held at specific time and locations, police records such as the influence of particular accidents at specific locations, and social media texts such as Tweets on road conditions. Natural language processing, information extraction and statistical modelling techniques are used to leverage different sources of information in order to make the most sensible decisions.

MIT Principal Investigator(s):
Patrick JAILLET (Electrical Engineering and Computer Science)

Singapore Co-Investigator(s):
Yue ZHANG (SUTD, Information Systems Technology and Design)
Bryan LOW (NUS, Computer Science)

13. Cyber-Physical Security and Resilient Control of Transportation Networks

This project is on developing tools to detect and proactively respond to incidents in networked transportation systems, both reliability failures (random faults) and security failures (malicious attacks). Our approach involves modelling strategic attacker-defender interactions using game-theoretic tools, and combining incentive mechanisms with network control strategies to improve the transportation network resilience, even in the presence of simultaneous cyber-physical failures.

MIT Principal Investigator(s):
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