FUTURE URBAN MOBILITY

Research Projects in the SMART FM IRG
(September 1, 2015)

1. **Application-Guided Network Design**
   Mobile devices are now ubiquitous. Equipped with sophisticated sensors such as GPS, camera, accelerometer and more, they already sense and generate large amounts of data. With quad-core phones now on the market, smartphones will increasingly be able to compute on the sensed data in-situ as well. Yet, mobile phone applications still use the conventional client-server model, with a thin client front-end on the phone, delegating compute-intensive tasks to servers in the cloud. Here, we investigate new programming models and middleware, along with novel applications, that can harness many phones as a collaborative computing platform for directly hosting transportation services.

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2. **Communications for Internet of Vehicle**
   In Internet of Vehicles (IoV) paradigm, each vehicle is considered as a smart object equipped with a powerful multi-sensor platform, advanced communications technologies. Each vehicle maintains connectivity to the Internet and to other vehicles either directly or through multi-hop networking, thus enabling the interactions between vehicles and vehicles, vehicles and road side infrastructure, and vehicles and people. IoV enables the acquisition and processing of large amount of data from versatile geographical areas via intelligent vehicles computing platforms to offer various categories of services for road safety and other services to drivers and passengers. In this project, we are going to design next generation wireless communications technique to support the IoV connectivity, in particular IEEE 802.11p standards. We seek students who are keen to span from MAC and physical layer protocol design and simulation, to actual prototyping of the protocol on FPGA emulators interfacing with smart phone applications for IoV.

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3. **Next Generation ITS Design with Commuter Behavioral Impact**
   Intelligent transportation systems (ITS) are increasingly a part of our daily commute. Many ITS systems now rely heavily on mobile phones which have a myriad of sensors available to sense the environment as well as commuters. Commuters' behavior interact strongly with their mobile devices and other commuters, influencing the outcomes of the ITS systems. In this project, we seek to investigate and design next-generation ITS apps that take into account behavioral impact. The student is expected to have a broad multi-disciplinary interest from transportation science to computer science, and have prior experience in Android or iOS phone app development.

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4. **Autonomy in Mobility-on-Demand Systems**
   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.

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5. **Real-Time Control and Learning for Urban Transportation Systems**
   The focus of this project is the development of new tools, combining real-time, distributed control techniques, systems and control theory, and machine learning to develop new approaches to the design of urban transportation systems. Examples include traffic signal control and scheduling, road pricing, and resilience analysis under disruption.

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6. **LIVE Singapore!**
   A platform for the collection, fusion, distribution and visualization of real-time 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.

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7. **Exploring Interactions Between Personal and Organisational Urban Data**
   Analytical work on big data has the potential to provide deep insights on the changing urban environment and suggest new architectural forms, public policies and products technologies that are able to improve the quality of urban life. Up until recently, the main sources of big data were governments, service providers and companies in general. However, with advances in Web and mobile technologies, individuals are starting to produce their own, very personal big data. Similar to big data from organisations, personal big data (pBd) is starting to change and shape many areas of our daily lives. The aim of this project is to study interactions of personal with more global, i.e. city-wide data. The project will investigate how the use of data is influencing our understanding of cities and our personal behavior and lastly how personal big data can be used effectively in the urban design process.

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8. **Congestion-Aware Routing for Urban Mobility**
   Develop, implement, and evaluate novel decentralised control algorithms for individual participants in urban traffic; algorithms should provide stability and global behaviour guarantees under different types of traffic scenarios, by combining machine learning and control techniques.

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9. Behavioral Models for Land Use, Mobility and Energy and Resource Use

To plan sustainable future urban mobility systems, we need a set of forecasting tools to help make well-informed, consistent assessments of future conditions under various scenarios. Behavioral models are at the heart of the approach. The objective is to develop state-of-the-art models to understand and forecast different behavioral rationales of households and firms.

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10. Place-Centric Sensing for a Smart City

In order to better understanding on space utilization, and human traffic across pedestrian network in a smart city, it is important to employ an un-instrumented (i.e. without having a personnel to equip with any device) space-centric human sensing in order to understand how a space is being occupied across time. The objective of this project is to design the sensor network, perform system modelling and data analytic, so as to extract useful information at the areas of interest in a smart city environment.

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11. People-Centric Sensing for Elderly in an Aging Society

Singapore, just like many other countries, will experience an unprecedented age shift. It is of critical for urban designer to better understand the needs of elderly, so as to better design the public facility to cater for the needs. In this project, student is going to design people-centric based crowd sensing using smart-phone or other smart devices. The system consists of big data analysis based on multiple sensory data fusion; also mobility study based on analytic models and collected data.

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12. Improving Urban Mobility's Environmental Performance and Sensing

We are interested in exploring ways to improve the efficiency of both passenger and freight transportation in dense, urban environments. Projects include road traffic emissions sensing, modeling, transport policy analysis, travel surveys, and commuter/driver feedback experiments.

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13. Real-Time Model System for Network Management and Emergency Response

Develop an Integrated suite of models to estimate the impact of alternative interventions and support the real-time deployment of such interventions to mitigate urban mobility problems as they occur on a daily basis.

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14. Real-Time Transport Prediction with Advanced Behavior Models and Big Data

DynaMIT2.0 is an integrated suite of models that allows for both estimating the current state of the network and for predicting how it will change in different time horizons. This allows for estimating the impact of alternative interventions and supports the real-time deployment of such interventions to mitigate urban mobility problems as they occur on a daily basis. DynaMIT2.0 considers new data types, such as big data (e.g. from telecoms, GPS probes) and internet data.

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15. Visual Data Analytics and Learning for Road Traffic Monitoring

We research robust and scalable visual analytics and learning algorithms / tools with applications to transportation systems monitoring and analysis. Topics include visual feature design, classifier fusion, deep learning and unsupervised feature learning and their optimization for visual traffic data and systems.

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16. Context Sensing for Mobility Prediction

Besides existing road sensors (loop counters, cameras, GPS probes), there exist a wide range of data that can directly or indirectly explain or help predict mobility phenomena. A simple example is special events announcements websites (e.g. sports games, concerts) and the corresponding demand oscillations for transportation. Other cases exist such as weather or news feeds, social networks and so on. These contextual data sources are rich but challenging to capture and process. Our research aims to solve such challenges in order to solve mobility analysis and prediction problems.

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17. Integrated Simulation Platform: SimMobility

Integrate and link together various mobility-sensitive behavioral models with state-of-the-art simulators to predict impacts of mobility demands on transportation networks, services and vehicular emissions. The platform will integrate different types of modelling into a coherent agent-based micro-simulation. The decision process of the agents will be modelled by an activity-based approach. This simulation will be linked with a range of networked computing and control technology-enabled mobility innovations. This integrated simulator will simulate urban behavior in multiple time frame from year to year, day to day and even in second to second time dimension.

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18. Urban Freight

The urban freight project aims at developing 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 behavioral models, estimated based on innovative data collection methods.

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19. Real-time Path Tracking/Predictions and On-Demand Route Guidance under Uncertainty

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 behavioral techniques.

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20. 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 modeling techniques are used to leverage different sources of information in order to make the most sensible decisions.

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