Smart Mobility: Optimization and Behavioral Modeling

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Smart Mobility in Singapore

Source: SMART Mobility 2030: ITS Strategic Plan for Singapore, Land Transport Authority, Singapore, 2014
Smart Mobility in the US

“Hang on—I’ll Uber us a school bus.”

Source: The New Yorker, MAY 16, 2016
Outline

• Smart Mobility Research Agenda
• Laboratory Platforms: FMS and SimMobility
• Solutions: Using Optimization and Behavioral Modeling
• Future Urban Mobility
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Smart Mobility

• Mobile / communication technology
• Real-time / on-demand
• Personalized
• Shared
Research Agenda

Behavioral Data

Behavioral Models/Optimization

Solutions

Sponsors include Singapore NRF, US Department of Energy, US Department of Transportation, Ferrovial, Ford and Fujitsu
Designing Effective Smart Mobility Solutions

- Efficiency ➔ Real-time optimization
- Personalization ➔ Behavioral modeling
- Real Data ➔ App-based behavioral laboratory [http://its.mit.edu/future-mobility-sensing](http://its.mit.edu/future-mobility-sensing)
- Testing ➔ Computer simulation laboratory [http://its.mit.edu/research/simmobility](http://its.mit.edu/research/simmobility)
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App-Based Behavior Laboratory: FMS

A platform that leverages:

- pervasive smartphone ownership
- sensing technologies
- machine learning

to deliver high-resolution observations of travel and activity behavior
FMS: Architecture

**Sensing Technologies**
- GPS
- WiFi
- Bluetooth
- Accelerometer

**Context Info**
- Transit Network
- Points of Interest
- Land Use
- Events
- User Info
- ...

**Time Line**
- Stops
- Modes
- Activities
- Other info

**SMARTPHONE APP/TRACKING DEVICES**

**MACHINE LEARNING BACKEND**

**MOBILE/WEB INTERFACE**
**FMS: Commercialization**

- **Mobile Market Monitor** (established 2014, US & Singapore)

<table>
<thead>
<tr>
<th>Awarded Projects</th>
<th>Description</th>
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<tr>
<td>Maricopa Association of Governments</td>
<td>• First 100% GPS-based travel survey in the U.S.</td>
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<tr>
<td>(Phoenix, Arizona metropolitan area)</td>
<td>• Smartphones and loggers</td>
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<tr>
<td>Israel Ministry of Transport</td>
<td>• Tel Aviv and Haifa</td>
</tr>
<tr>
<td></td>
<td>• Smartphones and loggers</td>
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<td>World Bank demonstration project</td>
<td>• Dar es Salaam, Tanzania</td>
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<td></td>
<td>• Android phones given to participants</td>
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<td>Singapore Land Transport Authority</td>
<td>• 30,000 surveys in first year</td>
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<td>• 5,000 surveys in each of 3 subsequent years</td>
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Computer Simulation Laboratory: SimMobility

Development and evaluation of smart mobility solutions

Demographic & Behavioral Shifts + Services and Operational Models + Infrastructure Investments + Land Use Plan
SimMobility Overview

- A **laboratory** for analyzing future urban scenarios

- **Integrated/modular** agent-based platform

- Mobility-sensitive **behavioral** dynamic plan/action models

- Local and city-wide multimodal networks

- Multiple spatial-temporal scales
Outline

• Smart Mobility Research Agenda
• Laboratory Platforms: FMS and SimMobility
• Solutions: Using Optimization and Behavioral Modeling
  1. Real-time Toll Optimization
  2. Autonomous Mobility On-Demand (AMOD)
  3. Flexible Mobility On-Demand (FMOD)
  4. Tripod: Sustainable Travel Incentives with Prediction, Optimization and Personalization
• Future Urban Mobility
1. Real-time Toll Optimization

Behavioral models (e.g., route choice, departure time choice)

Prediction

Optimization

Data

DynaMIT

Information

Tolls

Users
Simulation Case Studies

- Area-wide tolling in Singapore (with NUS)
- Managed lanes in Texas (with Cintra / Ferrovial)

Reduced travel time and increased revenues
2. Autonomous Mobility On-Demand (AMOD)

- Taxi service with optimized fleet size and rebalancing in a defined area
- Used for last-mile/first-mile and other local trips
Simulation Case Studies

- Less than 5 minutes waiting time with optimal fleet size and predictive rebalancing
3. Flexible Mobility On-Demand (FMOD)

Provides a personalized menu of paratransit options

- **TAXI**
  - **DEPARTURE TIME**: 09:30 AM - 09:40 AM
  - **ARRIVAL TIME**: 10:00 AM - 10:17 AM
  - **TIME**: 30-37 min
  - **Cost**: 16 SGD

- **SHARED-TAXI**
  - **DEPARTURE TIME**: 09:30 AM - 09:35 AM
  - **ARRIVAL TIME**: 10:05 AM - 10:19 AM
  - **TIME**: 35-41 min
  - **Cost**: 8 SGD

- **MINI BUS**
  - **DEPARTURE TIME**: 09:40 AM - 09:45 AM
  - **ARRIVAL TIME**: 10:25 AM - 10:38 AM
  - **TIME**: 45-63 min
  - **Cost**: 5 SGD
Simulation Case Studies

- Tokyo (with Fujitsu Research)
- Singapore

- Menu optimization increases user benefit and vehicle fleet utilization
- Learning about travelers’ preferences from repeat choices
4. Tripod: Sustainable Travel Incentives with Prediction, Optimization and Personalization

Menu-based trip planner with optimized incentives
Tripod: Framework

- **System Optimization**
- **User Optimization**

**Token Value & Trip Attributes**

**Users**

**Travel Choices**

**Personalized Menu**

**TripOD**

**System Optimization**

**Experienced Network Conditions**

**Real-time Data**

**Transportation Network**
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Future Urban Mobility

• How would…
  o Smart mobility
  o Vehicle and fuel technologies
  o Energy and environmental policies
  …affect future mobility?

• Apply SimMobility to prototypical cities representing worldwide clusters of major metropolitan areas
Future Mobility Consortium of the MIT Energy Initiative

- Alfa
- Aramco
- BP
- Chevron
- ExxonMobil
- Ferrovial
- GM
- Toyota
Smart Mobility: Optimization and Behavioral Modeling

Behavioral Data

Behavioral Models/Optimization

Solutions
References (2/2)

Thank you

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