Traffic Monitoring and Control Systems and Tools

Roberto Horowitz
Professor
Mechanical Engineering
PATH Director

Pravin Varaiya
Professor in the Graduate School
EECS
University of California, Berkeley

Carlos Canudas de Wit
Director of Research at the CNRS
NeCS Team director

Grenoble France
Traffic Monitoring and Control Systems and Tools

- Information flow in ITS
- TOPL at UC Berkeley
- Grenoble Traffic Lab
Real-time Information flow in ITS

Collecting → Communicating → Processing → Serving

Real-time Information (ICT) flow
Large offer in new sensor technologies:

- Wireless,
- Heterogeneous,
- Richness,
- Mobile
Communicate Information; build up a information flow from sensors to system

New communication Technologies will open opportunities:

- Vehicle-to-Vehicle communications,
- Vehicle-to-Infrastructure,
- Infrastructure-to-Vehicles,
- Information to users
Processing (controlling) Information: brings add value at the brut information

Ramp meeting control (EURAMP source)

Variable speed control (Mail online source)

Ramp metering control:
- Products already in use are not optimal,
- Decentralized,
- Room for a lot of improvements

Variable velocity control:
- Under investigation,
- Relay on “Soft” actuators (drivers),
- High potentially
The results of the processed information is transformed into user services:

- Desktop applications,
- Mobile phones,
- On-board navigation devices,
- Traffic control centers
Expected impact & Benefits of using feedback control

Table ES.1  Annual Benefits of the Ramp Metering System (Year 2000 Dollars)

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>Annual Benefit</th>
<th>Annual $ Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Travel time</td>
<td>25,121 hours of travel time saved</td>
<td>$247,000</td>
</tr>
<tr>
<td>Travel time reliability</td>
<td>2,583,620 hours of unexpected delay</td>
<td>$25,449,000</td>
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<tr>
<td>Crashes</td>
<td>1,041 crashes avoided</td>
<td>$18,198,000</td>
</tr>
<tr>
<td>Emissions</td>
<td>1,161 tons of pollutants saved</td>
<td>$4,101,000</td>
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<tr>
<td>Fuel consumption</td>
<td>5.5 million gallons of fuel depleted</td>
<td>($7,967,000)</td>
</tr>
<tr>
<td>Total annual benefit</td>
<td></td>
<td>$40,028,000</td>
</tr>
</tbody>
</table>

Figure ES.6  Crash Occurrence in the “With Meters” and “Without Meters” Study Periods (for Metered Freeways in the Morning and Afternoon Peak Periods)

Expected Benefits

- Decrease traveling time
- Regularity
- Reduce accidents
- Decreases stop-go behavior
- Reduce emission of pollutants
- Minimize fuel consumptions

From Cambridge Systematics for the Minnesota Department of Transportation  2001
Traffic Monitoring and Control Systems and Tools

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# TOPL (Tools for Operations Planning)

**TOPL TEAM**

<table>
<thead>
<tr>
<th>Name</th>
<th><strong>TOPL PI’s</strong></th>
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</thead>
<tbody>
<tr>
<td>Gunes Dervisoglu</td>
<td>Roberto Horowitz</td>
</tr>
<tr>
<td>Gabriel Gomes</td>
<td>Professor</td>
</tr>
<tr>
<td>Roberto Horowitz</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Alex A Kurzhanskiy</td>
<td><a href="mailto:horowitz@berkeley.edu">horowitz@berkeley.edu</a></td>
</tr>
<tr>
<td>Xiao-Yun Lu</td>
<td></td>
</tr>
<tr>
<td>Ajith Muralidharan</td>
<td></td>
</tr>
<tr>
<td>Rene O. Sanchez</td>
<td>Pravin Varaiya</td>
</tr>
<tr>
<td>Dongyan Su</td>
<td>Professor</td>
</tr>
<tr>
<td>Pravin Varaiya</td>
<td>EECS</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:varaiya@eecs.berkeley.edu">varaiya@eecs.berkeley.edu</a></td>
</tr>
</tbody>
</table>

Supported by grants from Caltrans and National Science Foundations
Motivation

2007 USA Traffic Congestion Caused:

• 4.2 billion hours of additional travel time
• 11 billion litters of additional fuel

Congestion delay in California:

• 500,000 veh-hrs/day
• will double in 2025
What is **TOPL?** (Tools for Operational Planning)

TOPL provide tools to

- specify actions for traffic corridor operational improvements:
  - ramp metering, incident management, traveler information, and demand management;

- quickly estimate the benefits of such actions

TOPL is

- based on macro-simulation models that are
- automatically calibrated using traffic data
- can be extended for real time traffic monitoring, prediction and control
Perform traffic operation control simulation studies and test enhancements:
- ramp metering, variable speed limits
- incident management,
- traveler information,
- demand management, etc.

Help Caltrans achieve a 55% reduction in traffic congestion by 2025

Select & “prune” corridor from Google maps

Import corridor freeway and arterial topology into the AURORA simulator

Use PeMS traffic data for automatic
- model calibration
- imputation of missing detector data

I880 corridor
Examples: I210-W (Pasadena, CA) and 880-N (Bay Area)

I210-W (Pasadena)

Flow contours (PeMS vs simulation) <5% error

Performance Measurements (PeMS vs simulation)

I880-N Accident simulation

Simulation vs PeMS

Traffic-responsive Ramp metering
Some details of TOPL Self-Callibration Procedure

- Specify Freeway Network
  - Eg: I-210 EW, I-880S, I-80E

- Data
  - PeMS (Performance Measurement Systems) - Data archive
  - Aggregate flow, density and Speed data from loop detectors

- Perform TOPL procedures for operations planning/benefit assessment
A decision support structure for ATM

- Traffic measurements
- Model calibration
- Network model
- Estimation of missing flows and split ratios
- Current and historical flows and densities
- Model parameters
- Prediction of baseline and hypothetical outcomes
- Warnings and recommendations
- Deployment of operational measures
- Scenarios and tactics
- Traffic data
- Networks
Towards a Smart Corridor TMC

Supervisory Control And Data Acquisition

Road network

Control center

SCADA

Alarm

Recurrence congestion

Non-recurrence congestion

Productivity loss

Security assessment

Scenario database

Trusted, fast corridor simulator

Traffic state estimation and prediction
ATM Workflow

- Operations planning
- Simulator (fast and trusted)
- Repository of road networks
- GIS data
- Scenario database
- Calibration, missing data imputation
- Historical measurement data
- Short term prediction, strategy selection
- Dynamical filter
- Real-time measurements

Road network
Example I-80 W, 01/14/09

Calibration

Speed contours

Measured (PeMS)

Simulated

Performance measures

Measured (PeMS)

Simulated

VMT

VHT

Measured (PeMS)

Simulated

0:00  6:0  12:00  18:00  24:00

0:00  6:0  12:00  18:00  24:00

0:00  6:0  12:00  18:00  24:00

0:00  6:0  12:00  18:00  24:00

0:00  6:0  12:00  18:00  24:00
Example: HOT lane management

- Changes in % traffic in HOT lane produce changes in total delay.
Example I-80 W, 01/14/09  Best/worst case prediction

- Current time  6:00 am
- Prediction horizon: 2 hours
- Uncertainty: 1% in capacity, 2% in demands
Example I-80 W, 01/14/09  Best/worst case prediction

Past ← Future

VMT

VHT

Delay

worst case

best case

Time (AM)
Example I-80 W, 01/14/09  Best/worst case prediction

Density at Past Future

Speed at Past Future

worst case
best case

05:00 05:28 05:57 06:26 06:55 07:24 07:52
Time (AM)
Example I-80 W, 01/14/09  Best/worst case prediction

Ramp metering at ★
Example I-80 W, 01/14/09

Accident hot spot
I-80 West accident strategy 4: ALINEA and VMS detour

- ALINEA + queue control: upstream of accident
- VMS Detour: 10% use Carlson and Central junctions to 580 EB
Traffic Monitoring and Control Systems and Tools

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GTL is a WSN data collection platform for real-time traffic modeling, prediction and control.

- Model-based control
- M2M network
- Micro-Simulator
- Show room
- NeCS Research in model estimation & Control
- Public-Private Partnership
- Data Base

- A national center of traffic data collection
- Multi-purposes data exploitation (model, prediction, control, statistics, etc.)
- Public Partnership: INRETS, DIR-CE, CG38, Metro,
- Research transfer to KARRUS-ITS (Grenoble start-up)

- Wireless magnetic sensor
- Speed and density
- 4 sensors per line each 400 m
Fig. 3 This figure shows the role and position of the GTL in connection with the NeCS team activities, and its interrelation with the academia, the governmental traffic authorities, and industry.
WP5 – Benchmark: Traffic Modeling, Estimation and Control

C. Canudas de Wit

Context: Grenoble south ring, wireless sensor networks