Estimating Vehicle Trajectories on a Motorway
by Data Fusion of Probe and Detector Data

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Loop Detector
(Intercity Motorways)

e.g. One loop detector between interchanges
(approximately one in every 10 km)

Ultra-sonic Detector
(Urban Expressway, Local Streets)

e.g. Metropolitan expressway
Ultra-sonic detectors installed at every 300 m
Probe Data

GPS + Communication equipment

DMCA
-Mobile
-Infrared
-Microwave (DSRC)

Transport Centre

GPS

Data Fusion

Probe data: sampled data but spatially cover a wide area
Detector data: measure all cars but at limited locations

space
detector
probe
probe
detector
detector
time

traffic in the dashed area could be monitored by data fusion
Richness of Probe Data

Probe trajectory: has more to offer!
Traffic conditions & driving modes

What is used in practice:
travel time only!

Objective

Downstream
Departing vehicles

Red intervals

Probe trajectory

Upstream
Arriving vehicles
Kinematic Wave Theory and 3D Representation

Cumulative Curves and Time Space Diagram (vehicle trajectories)

Three Dimensional Representation

Lighthill
Whitham
Richards

Newell

Daganzo

space
time
Probe + Detector Pulse + Signal Timing

Estimate vehicle trajectories of all running vehicles

Travel time variability
Environmental evaluation
Signal control improvement

Detector
Signal
Flow
FD
Density
Probe

Vehicle trajectories of all running vehicles

Test bed
Komazawa Street
Probe + Detector Pulse + Signal Data Fusion

Probe data have very rich information, not just travel time. Fusing probe information with other data, a complete picture of traffic condition can be drawn.

Fundamental Diagram

Flow $q$

$u = \text{forward wave speed}$

$-u = \text{backward wave speed}$

Density $k$
Complete Trajectories based on Kinematic Wave Theory

without Probe data
(only vehicle passing times at detector locations and signal timings are used)

Complete Trajectories based on Kinematic Wave Theory

with 4th Probe data (1-second uplink frequency)
(together with vehicle passing times at detector locations and signal timings)
Consideration of Incoming & Outgoing Vehicles in the middle of the Study Section

Incoming/Outgoing Vehicles
Influential Area in Time-Space

Suppose a vehicle enters (or leaves) at A. Cumulative height at A influences only in Region I.
Incoming/Outgoing Vehicles
Simultaneous Calculation: Adjusting Link Costs

A modified trajectory by adding and removing incoming and outgoing vehicles
Measured and Estimated Probe Trajectories

Application to Intercity Motorway
Tohoku Exp Inbound: Shiroishi IC to Motomiya IC
August 14, 2012
Probe Trajectories and IC Locations

Estimated Trajectories using One Probe without Considering In/Out Vehicles
Estimated Trajectories using Five Probes without Considering In/Out Vehicles

Estimated Trajectories using Five Probes Considering In/Out Vehicles
Summary

- Estimating trajectories of all running vehicles on an aerial with intersections and on an intercity motorway
- Fusing probe data with detector and signal timing data
- Emphasizing the utilization of rich information of probe trajectories
- Variational Theory oriented from Kinematic Wave