Pengembangan Sistem Routing Dinamis untuk Kendaraan

(Studi Kasus di Kota Surabaya)

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Tujuan

1. Mempelajari dan mengembangkan algoritma optimisasi rute transportasi yang dinamis terhadap lamanya perjalanan.
2. Mempelajari dan mengembangkan metode estimasi dan prediksi lama perjalanan sehingga rute optimum dapat dicari.
3. Membangun sistem tracking kendaraan real-time berbasis GIS.
4. Merancang dan membangun sistem pelayanan tracking kendaraan.

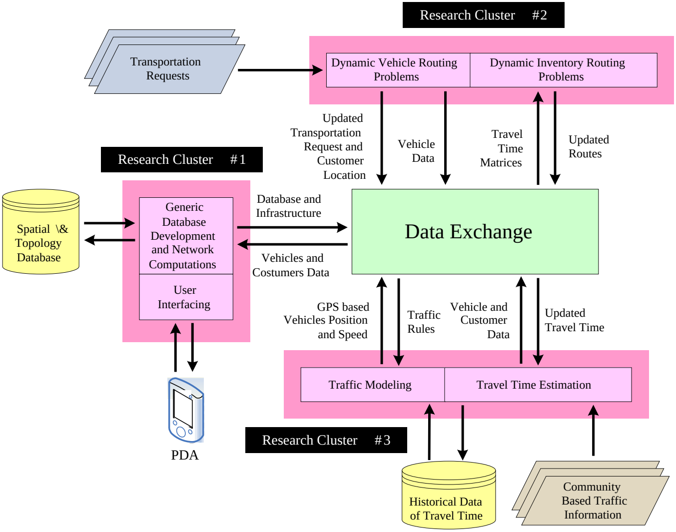
Kelompok Riset

Kelompok #1: Pengembangan sistem (perangkat lunak) tracking kendaraan berbasis GIS.

Kelompok #2: Pengembangan metode-metode optimisasi rute kendaraan dan aplikasinya untuk routing dinamis.

Kelompok #3: Estimasi lama perjalanan dan permodelan lalu lintas.

Skema Riset



Research Cluster #2
Transportation Requests
Dynamic Vehicle Routing Problems
Dynamic Inventory Routing Problems
Updated Transportation Request and Customer Location
Vehicle Data
Travel Time Matrices
Updated Routes
Research Cluster #1
Spatial \& Topology Database
Generic Database Development and Network Computations
User Interfacing
Database and Infrastructure
Vehicles and Costumers Data
Data Exchange
GPS based Vehicles Position and Speed
Traffic Rules
Vehicle and Customer Data
Updated Travel Time
PDA
Traffic Modeling
Travel Time Estimation
Research Cluster #3
Historical Data of Travel Time
Community Based Traffic Information

Kalman Filter Based Freeway Travel Time Estimation

Laboratorium Teknik Sistem
Teknik Elektro FTI

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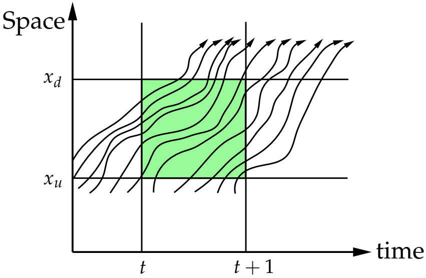
Definition of Travel Time Estimation (1)

- Definition: mean travel time within the closed area defined by the time (t and $t+1$) and space (x_u and x_d).
- True space-mean speed for vehicles inside the close area equal to total travel distance divided by total travel time of vehicle of vehicles inside closed area.



Gambar: 1

Definition of Travel Time Estimation (2)

Unbiased estimate of space-mean speed

$$\overline{v} = \frac{\sum_{n=1}^{N} \left\{ \min(x_{t+1}^n, x_d) - \max(x_t^n, x_u) \right\}}{\sum_{n=1}^{N} \left\{ \min(t+1, t_d^n) - \max(t, t_u^n) \right\}}$$

N = number of vehicles traversing the section during the time interval
x_t^n = position of vehicle n at time t
x_u = position of upstream boundary
x_d = position of downstream boundary
t_d^n = time when vehicle n passes the downstream boundary

Definition of Travel Time Estimation (3)

- Average section travel time (tt_s) can be estimated from the unbiased estimate of the space-mean speed

$$tt_s = \frac{x_d - x_u}{\overline{v}} = \frac{\Delta x}{\overline{v}}$$

- Equation above can be considered as a "true" mean travel time of the temporal and spatial section.

Travel Time Estimation Based on Section Density (1)

- Section density model used is based on conservation or continuity equation and it shows the same form as in fluid flow.

$$\frac{\partial q}{\partial x} + \frac{\partial k}{\partial t} = 0$$

  q is flow (vehicles/hour), k is density (vehicles/mile), x is location, and t is time.

- If the speed of the traffic fluids is v basic identity is obtained

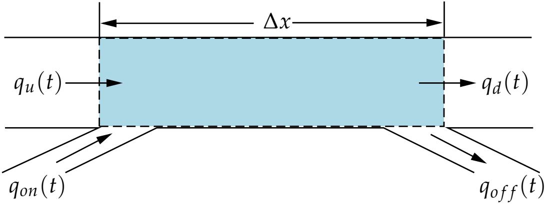
$$q = kv$$

Travel Time Estimation Based on Section Density (2)

- In urban freeway, freeway section includes one on-ramp and one off-ramp. Traffic flow passing the section during time period $(t-1, t)$ can be estimated as

$$q(t) = \alpha[q_u(t) + q_{on}(t)] + (1-\alpha)[q_d(t) + q_{off}(t)]$$

α is smoothing parameter, $q_u(t)$ and $q_d(t)$ are traffic flows of the upstream and downstream boundaries within $(t-1, t)$, $q_{on}(t)$ and $q_{off}(t)$ are total on-ramp and off-ramp traffic flows within $(t-1, t)$.



Travel Time Estimation Based on Section Density (3)

- Using homogeneity of traffic inside section, an intuitive estimation of the section travel time is

$$tt(t) = \frac{\Delta x}{v(t)} = \frac{\Delta x}{q(t)} k(t) \tag{1}$$

Δx is the length of the section between upstream and downstream detectors.

- Based on traffic flow conservation equation, estimation of travel time depends on a non-observable state variable, i.e. section density $k(t)$, which can be represented as a time series

$$k(t) = k(t-1) + \frac{1}{L\Delta x}\{[q_u(t) + q_{on}(t)] - [q_d(t) + q_{off}(t)]\} \tag{2}$$

L is the number of lanes on the mainline freeway.

Kalman Filter Traffic Flow Estimation (1)

- Equation (1) and (2) are rewritten as

$$\text{State equation: } k(t) = k(t-1) + u(t) + w(t-1)$$
$$\text{Measurement equation: } tt(t) = H(t)k(t) + v(t)$$

- $u(t)$ and $H(t)$ can be estimated by

$$u(t) = \frac{1}{L\Delta x}\{[q_u(t) + q_{on}(t)] - [q_d(t) + q_{off}(t)]\}$$
$$H(t) = \frac{\Delta x}{\alpha[q_u(t) + q_{on}(t)] + (1-\alpha)[q_d(t) + q_{off}(t)]}$$

Kalman Filter Traffic Flow Estimation (2)

- Section density is treated as a state variable and section travel time as a measurement variable.
- Systematic errors, system and measurement error, are also introduced. State noise $w(t)$ with mean $q(t)$ and variance $Q(t)$ and measurement noise $v(t)$ with mean $r(t)$ and variance $R(t)$.

Solution to Kalman Filter Problem

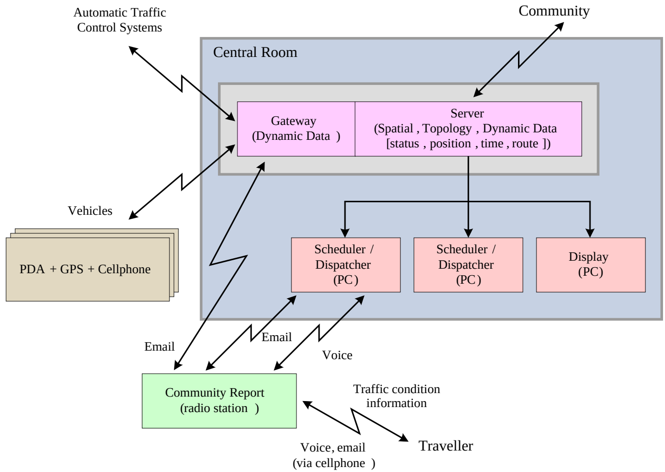
Solution to Kalman filter problem is

$$\begin{aligned}
\bar{k}(t) &= \hat{k}(t-1) + u(t) + q(t-1) \\
\overline{P}(t) &= \hat{P}(t-1) + Q(t-1) \\
G(t) &= \overline{P}(t)H(t)^T\left[H(t)\overline{P}H(t)^T + R(t)\right]^{-1} \\
\hat{k}(t) &= \bar{k}(t) + G(t)[tt(t) - H(t)\bar{k} - r(t)] \\
\hat{P}(t) &= \overline{P}(t) - G(t)H(t)\overline{P}(t)
\end{aligned}$$

Current Work

- Including community information to adjust traffic flow estimation.
- Software development for GIS based vehicle tracking system
- Dynamic routing optimization using Ant Colony

Current Work



Reference

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