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A vehicle re-identification algorithm based on multi-sensor correlation

Key words: Vehicle re-identification, Magnetic sensor network, Correlation, Cross matching

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Motivation

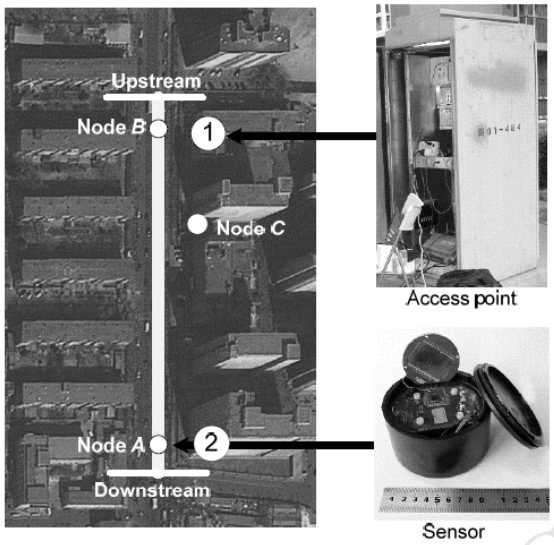
➢ Disadvantages of existing methods:

- When the traffic flow is unblocked, systems may misidentify a bus as several passenger cars.
- When the traffic flow is congested, in addition to the former error, two passenger cars that are close to each other may most likely be identified as a bus.

➢ Our method:

We propose a multi-sensor spatio-temporal correlation algorithm for vehicle re-identification. This algorithm can provide input parameters that are more effective for vehicle recognition, which improves the recognition accuracy. This algorithm relies on a magnetic wireless sensor network that contains several independent magnetic sensor nodes connected by wireless communication.

Framework of our method



Signature waveform model for an arbitrary vehicle:

$$E_v^n = \{\tilde{\delta}(t_{\mathrm{p},l}^n(k)) : t_{\mathrm{v,in}}^n \le t_{\mathrm{p},l}^n(k) \le t_{\mathrm{v,out}}^n\}$$

$$\text{s.t.} \quad t_{v,\mathrm{in}}^n = t_{\mathrm{p},l}^n(k),$$

$$t_{v,\mathrm{out}}^n = t_{\mathrm{p},l}^n(k+\Delta),$$

$$E_v^n \in E^n,$$

$$k \ge 0,$$

$$\Delta \ge 0,$$

The Pearson correlation coefficient ρ_{ij} between the vehicle j detected by node B and the vehicle i detected by node A:

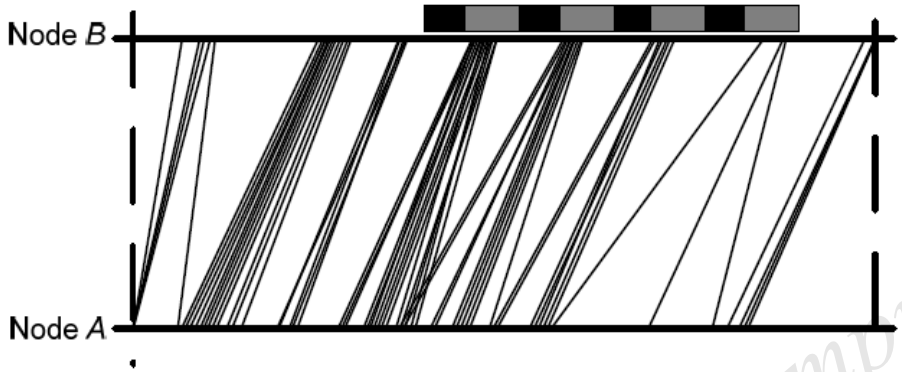
$$\rho_{ij} = \frac{\sum E_i^A E_j^B - \frac{\sum E_i^A \sum E_j^B}{\|\boldsymbol{E}_v\|}}{\sqrt{\sum (E_i^A)^2 - \frac{\left(\sum E_i^A\right)^2}{\|\boldsymbol{E}_v\|}} \sqrt{\sum (E_j^B)^2 - \frac{\left(\sum E_j^B\right)^2}{\|\boldsymbol{E}_v\|}}}.$$

The maximum likelihood estimation of vehicle signature:

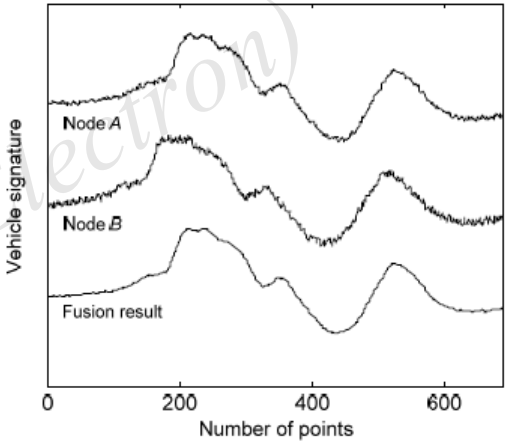
$$\tilde{E}_v^N = \frac{1}{2} \sum_{n=A,B} \tilde{\delta}(t_{\mathrm{p},l}^n(k) + \tau_n).$$

Experiment results

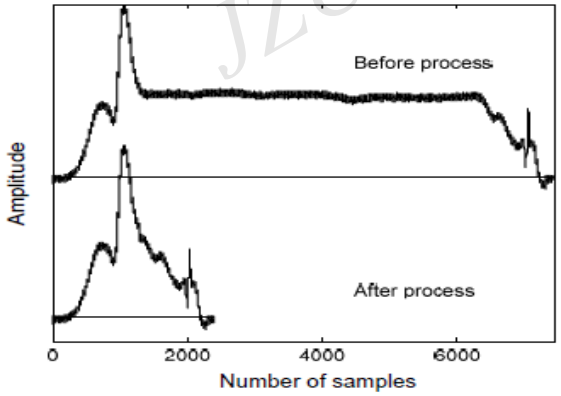
The matching results of vehicles detected in one cycle:



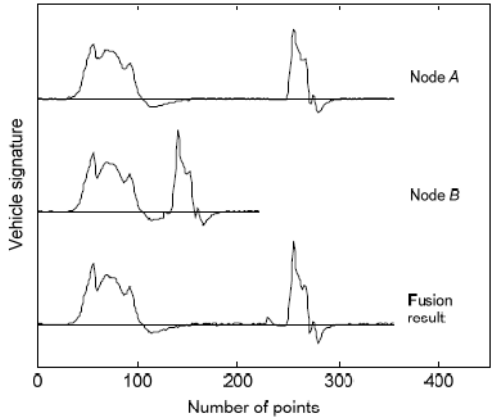
Two signature waveforms of a same vehicle and the fusion result:



The processing results of bad values caused by stop:



A kind of recognition error caused by a single node and the result of multi-sensor node fusion:



Summary

- A method to re-identify vehicles by using the correlation of signatures from multiple sensor nodes has been proposed.
- The proposed algorithm has high practical value. It applies wireless sensor network consisting of magnetic sensor nodes, so it is cost saving and easy to lay out.
- The vehicle re-identification algorithm can effectively improve the accuracy of vehicle identification.