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THE OPTIMAL ARRANGEMENT OF INFRARED BEACONS ON A ROAD NETWORK TO COLLECT VEHICLE TRAJECTORIES - PATTERN ANALYSIS USING SCHEMA THEORY

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Abstract

An infrared beacon used in VICS (Vehicle Information Control System) in Japan has the role as a media both to provide the traffic information and to collect the identical communication with equipped vehicles (up-link). It is now strongly expected to derive the valuable information like travelling vehicle trajectories from the collected up-links, and to utilize it for transportation planning and management.

This research purposes to estimate the optimal arrangement of infrared beacons on road networks to collect the travelling vehicle trajectories. The paper, at first, describes the methodology to evaluate the quality of the estimation using “schema”, which is the pattern to be extracted from available paths with certain beacon arrangement. The “schema” can be extended to “advanced” up-link format, which contains the recent history of travelling links. Subsequently the estimation is described as a combination optimization problem using “schema”. This optimization problem is NP-complete, but may be solved using some efficient searching methods. To demonstrate the estimation of the optimal arrangement, a case study in Tokyo area will be included in this paper.

By simply chaining up-links of each identified vehicle, we may estimate the trajectories of the vehicles. If beacons are very sparsely installed, the estimated trajectory has some uncertainty because there might be alternative paths connecting two adjacent up-links’ beacons. If beacons are fully installed onto each link, all of the trajectories of the equipped vehicle will completely determined, but this leads overinvestment off course. There must be an optimal arrangement of the beacons which ensures some certainty of estimated trajectories and satisfies the limit of the number of beacons. When the network becomes complicated and containing various directions of travelling vehicles, however, it is getting harder to estimate the optimal arrangement of beacons only with “chaining” up-links.

The analysis using “schema” among paths does not chain the up-links, but extracts common patterns contained in the paths. As the “schema” eliminates the “order” of up-links, it becomes possible to estimate various directions of trajectories simultaneously. In the full paper, the concept of “schema” proposed here will be detailed as well as its application to find the optimal

arrangement of beacons.