AN INTELLIGENT TRANSPORT MANAGEMENT SYSTEM FOCUSED ON MICROSCOPIC TRAFFIC SIGNAL CONTROL

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ABSTRACT

An intelligent road transport management system focused on microscopic, real-time traffic signal control is proposed. Referring to the development of those systems in Japan, extensive use of image traffic detectors observing the movement of vehicles inside intersections, and direct data exchange between the signal controllers of neighboring intersections are newly assumed. On site investigation of five intersections in Japan or in Malaysia shows the possibility of effective information provision and simple algorithm for solving heavy congestion, as well as easy installation.

1. INTRODUCTION

An intelligent road transport management system focused on microscopic, real-time traffic signal control is proposed and investigated. Main features of the system are as the followings.

1) Distributed configuration of the system is proposed to achieve microscopic, real-time traffic signal control and to realize easy installation and operation in rural areas or in developing regions by reducing central control facilities.

2) Extensive use of image vehicle detectors monitoring the vehicles inside intersections is assumed. Effective control algorithms to relieve heavy congestion are investigated.

Investigations of the congested intersections are done by on-site, manual observation or through video-recorded materials at three intersections in Tokyo Metropolitan and two intersections in Malaysia.

Effective as well as simple control algorithms are found based on these investigations. Evaluation of the algorithms, and also planning for the detailed system configuration are going on.

2. OUTLINE OF THE SYSTEM

2.1 Traditional configuration of traffic signal control systems

Majority of traffic signal control systems around the world adopts traditional way of centralized control configuration, which is composed of roadside-installed signal controllers and central facility at a control center Monitoring traffic situation and deciding control strategy are done at the control center. Gathering data from vehicle detectors as well as operating traffic lights are carried out at the signal controllers.

Especially in the Japanese systems developed in 1970's, extensive centralization of control functions was done. [1] Primary data on presence of vehicles at the detectors were shown as bit sequence of several tenth bps. The commands for proceeding signal steps were sent as a bit signal at the time of their occasion. Sophistication of functions at the signal controllers was done in the recent years. [2] [3] Handling data for increased number of vehicle detectors, those for variable message signs with increased transmission rate in the telephone line was performed. Even so, each leased telephone lines for dedicated use basically connect each signal controllers to the center due to the star-like connection of commercial telephone lines between the switching station and each subscriber terminals.

2.2 Proposed configuration of the systems

Revised configuration of the systems is investigated to realize the following new functions.

1) Enhanced abilities are given to the signal controllers for them to enable real-time, microscopic control.
2) Exchanging data between neighboring intersections is intended.
3) Functions of the control center are decreased and some of them are reallocated to signal controllers.
4) Signal controllers are enabled to analyze data from vehicle detectors.

Fig. 1 shows general configuration of the systems realizing these four proposed functions. In this new configuration, only the data communication between the signal controllers is added to the conventional configuration. It can be realized either by optical or wireless short-range communications, or by wireless / fiber networks which may appear in the near future.

Fig. 2 shows the data flow in the proposed system. Signal controllers receive data from vehicle detectors. After they process these data, and combining data from the neighboring signal controllers and those from traffic control center, they can control traffic signals.

In the future, well co-operated signal controllers may work without data from traffic control center. Applications of these systems to the developing regions where there is no traffic control centers can offer traffic management services in the short period of time.

3. COLLECTION OF TRAFFIC INFORMATION INSIDE INTERSECTIONS

Collection of detailed and accurate traffic information is essential for sophisticated traffic signal control. In the Japanese traffic control systems, ultrasonic vehicle detectors have been widely used for long years. As they detect presence of vehicles at the small area of only a few square meters, they are difficult to satisfy the requirement mentioned above.

Installing TV cameras at the intersection and obtaining detailed data of vehicles by analyzing these images has been developed since 1970's [4], and are recently being widely used [5]. This type of image traffic detectors is to be installed at the intersection. Two categories of them are considered. As the first category, they are installed to observe vehicles at the flow-in zone of the intersection. Vehicles flowing into the intersection from an incoming direction and to different outgoing directions are measured as shown in Fig. 3. As the second category, they are installed to observe vehicles at the flow-out zone of the intersection. Vehicles coming from different directions and flowing out to the same direction are measured as shown in Fig. 4.

From these measurements, number of vehicles which turning left, turning right or going straight through can be counted. With their summation, total number of vehicles, that is, total traffic volume on each incoming and outgoing links can be calculated. Vehicles stopping at the intersections due to blocking of outgoing links are also measured.

4. INVESTIGATION ON TRAFFIC FLOW AT THE INTERECTIONS

4.1 Categories and the site of investigated intersections

Field investigations on traffic flow at the intersections were performed to know relations among configuration, condition and situation of traffic congestion.

As the configurations of intersections, they are classified to X, T and Y type. As the traffic relations, isolated intersections and neighboring pairs of intersections (which are called twin intersections hereafter) are considered. In this investigation, twin intersections as X-X or X-Y were selected.

The following five intersections were investigated. Three of them, which were investigated by one of the authors, are in Tokyo Metropolitan area. The other two

are in Malaysia, which were investigated by public authorities in the country to inform one of the authors of traffic problems to solve at the site.

I Nakano-sakaue Intersection (Tokyo)	Isolated,	X
II Kayaba-cho Intersection (Tokyo)	Twin,	X-X
III Akebono, Kashiwa city (Chiba)	Twin,	X-Y
IV Malaysia	Twin,	X-X
V Malaysia	Twin,	X-X

4.2 Investigation I

An isolated intersection of X type was investigated to measure traffic volume and speed of incoming vehicles as well as stopping vehicles inside the intersection in each signal cycles.

Fig.5 shows outline of investigation at the site: Nakano-sakaue intersection (Tokyo). Two people engaged in the observation. Handy TV camera was used for recording video images during each hour starting 9AM, 1:30PM and 5:30PM of the day.

Fig. 6 shows the results of the investigation. Traffic volumes of straight-through, left-turn and right-turn vehicles and their sum in each signal cycles are shown. The result shows close relation of total traffic volume in each signal cycles and stopping vehicles. In case that more than sixty vehicles flow in the intersection, there are stopping vehicles inside the intersection.

4.3 Investigation II

Twin intersections were investigated with almost the similar method as shown above.

Fig. 7 shows outline of investigation at the site: Kayaba-cho intersection (Tokyo). Distance between twin intersections is 260m.

Two people engaged in the observation. Handy TV camera was used for recording video images during each hour staring 10:30AM, 2PM and 6PM of the day.

Flow-out traffic volume at the upstream intersection as well as flow-in traffic volume at the downstream intersection was measured. Straight through, left-turn and right-turn traffic inside intersections are classified in the measurement. Fig. 8 shows examples of the results of the investigation; comparison of straight-through traffic during each signal cycles at two intersections.

4.4 Investigation III

Other twin intersections were investigated to analyze occurrence of stopping vehicles inside upstream intersection at amber signal. Fig. 9 shows outline of investigation at the site: Akebono intersection (Kashiwa city, Chiba). Distance between twin intersections is 120m.

With the similar method as the former cases, traffic volumes for each direction at twin intersections were measured. Relation of traffic volumes in each signal cycles and occurrence of stopping vehicles was analyzed. Fig. 10 shows examples of data obtained. Close relation of them was also found though signals of twin intersections are not coordinated.

5. Discussion

Analysis of data obtained from these investigations gives useful information. Simple relation between flow-in traffic volume and occurrence of stopping vehicles inside the intersection gives useful suggestions on signal control to prevent traffic jam.

The relation may not always the same as the site and situation change. Even in that case, accurate measurement and appropriate finding of the rule will be effective. Processing the system following the model described by the rule as well as predicting its behavior utilizing the data transmitted from the neighboring intersections will be the more useful.

Preventing expansion of traffic jam as well as accelerating its dissolution is achieved by control keeping traffic demand below capacity. Dispersion and restriction of traffic flow are essential in some cases.

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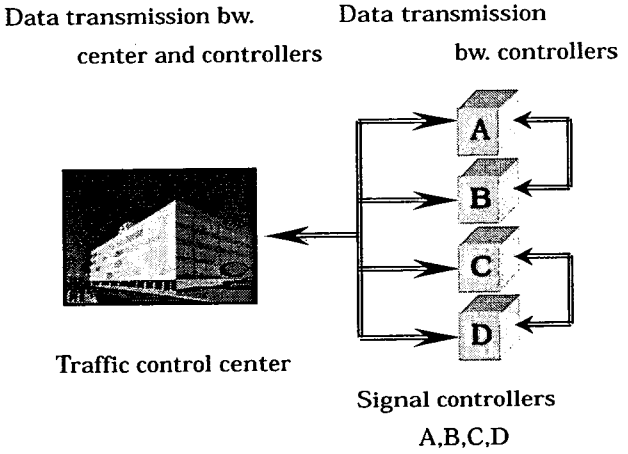

Fig. 1 Configuration of the proposed traffic signal control system

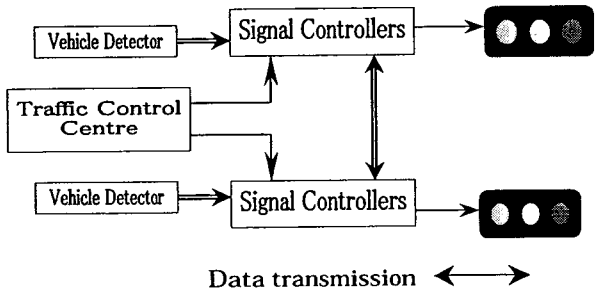

Fig. 2 Data flow in the proposed system

AUTHOR BIOGRAPHIES

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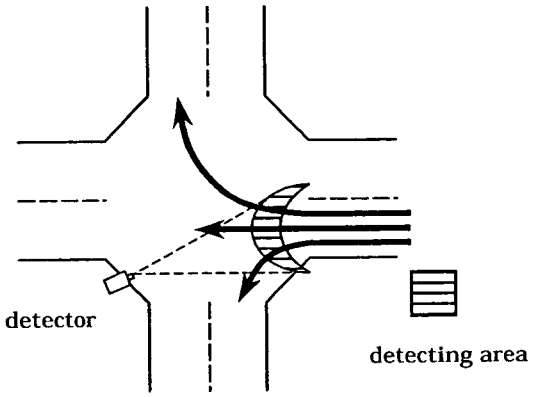


Fig. 3 Measurement at the flow-in area

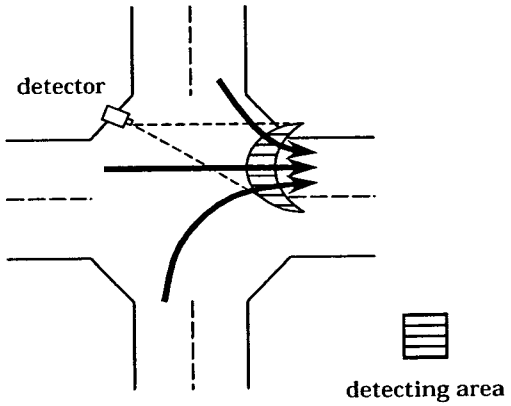


Fig. 4 Measurement at the flow-out area

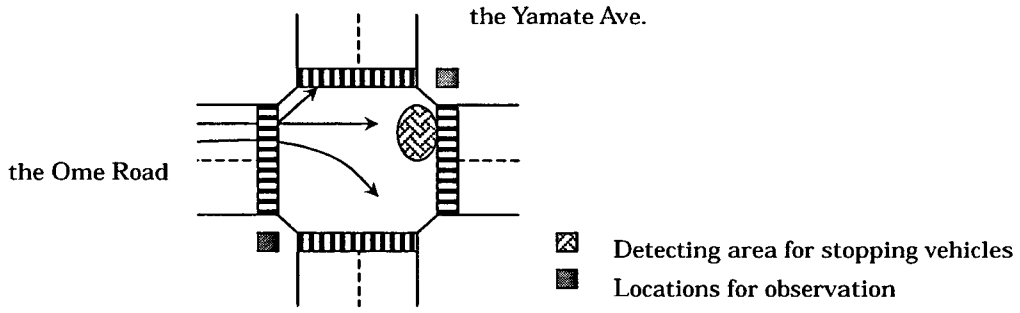


Fig. 5 Outline of the investigation at the site I: Nakano-sakaue intersection

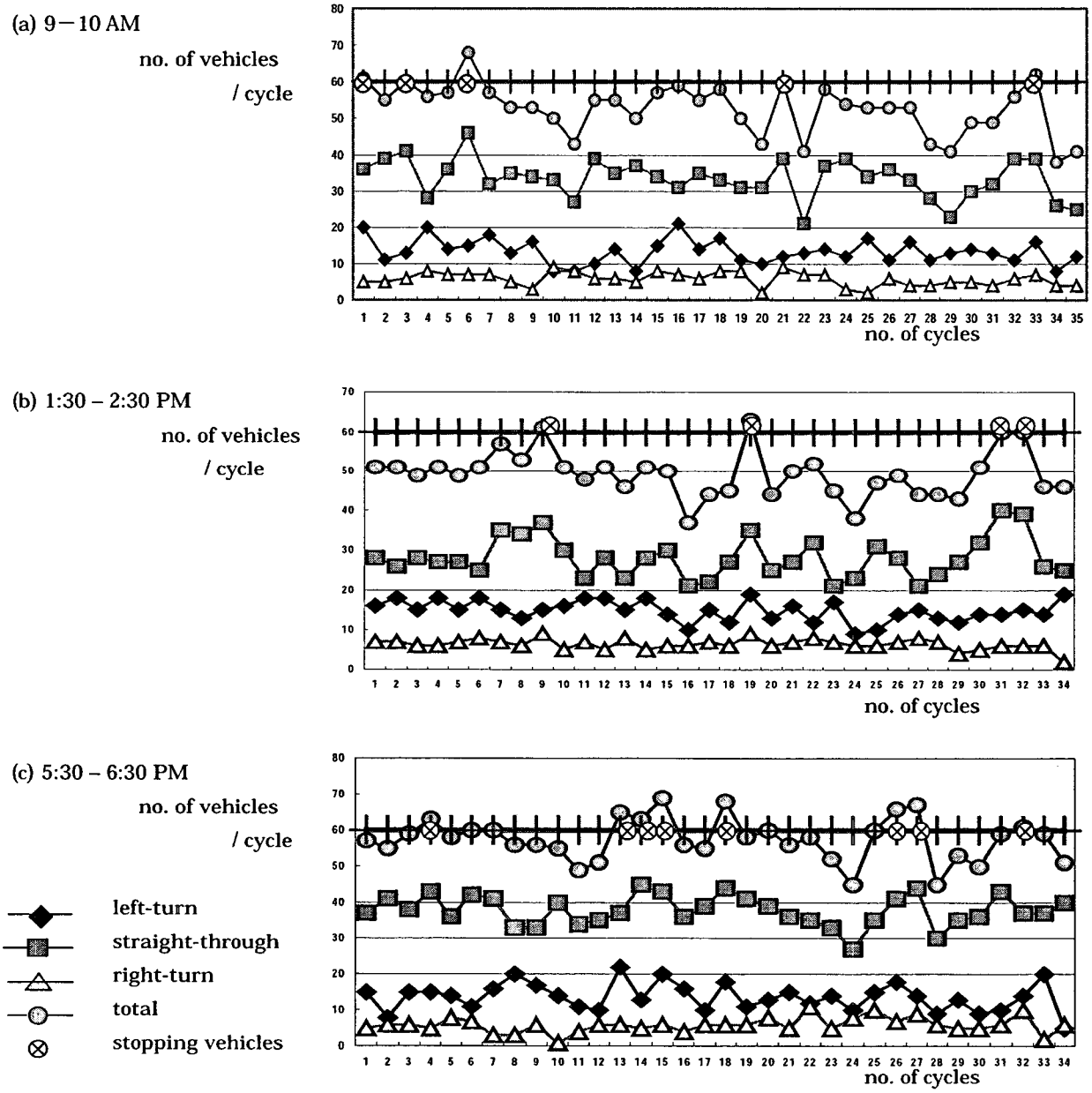


Fig.6 Traffic volume in every signal cycles

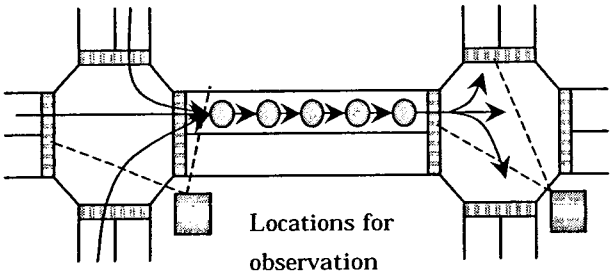


Fig. 7 Outline of the investigation at the site II:
Kayabacho intersection

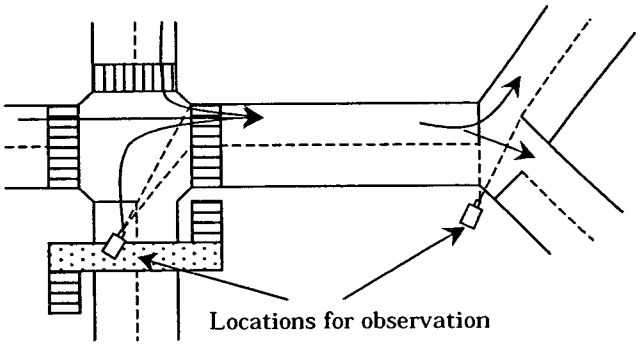
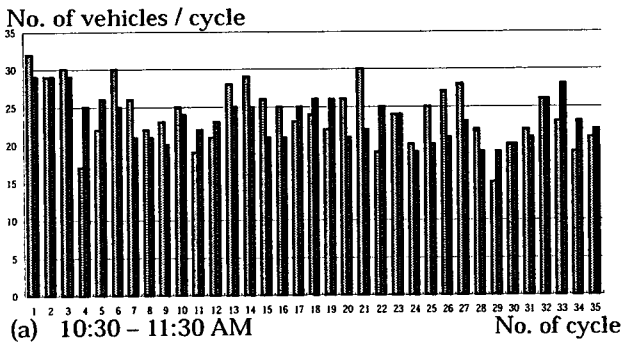
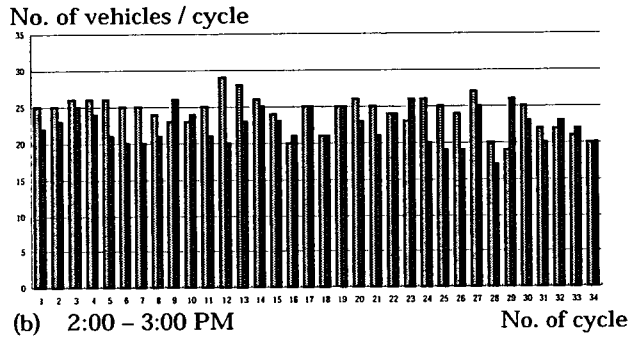


Fig. 9 Outline of the investigation at the site III:
Akebono intersection in Kashiwa city





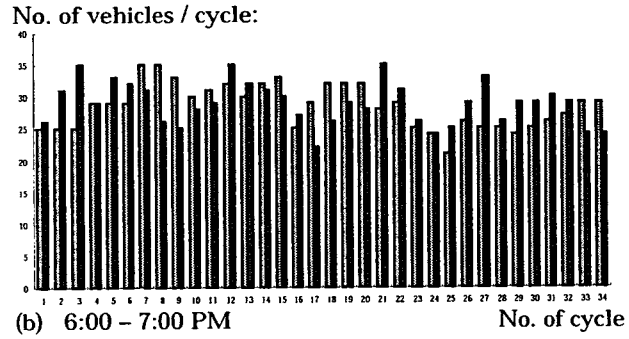
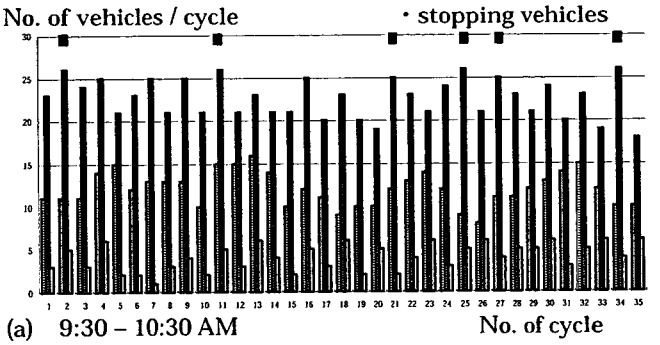
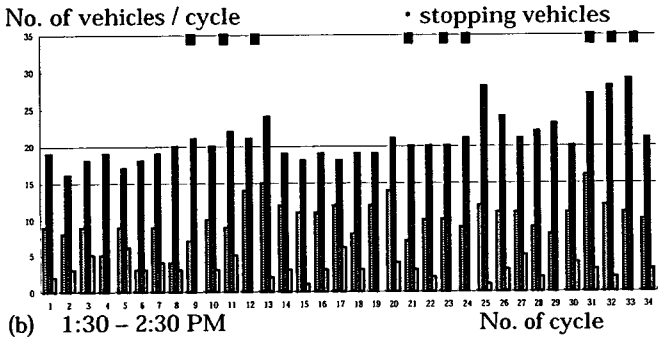


Fig. 8 Straight-through traffic at twin intersections
of the site II
white bars : at the upstream intersection
black bar: at the downstream intersection





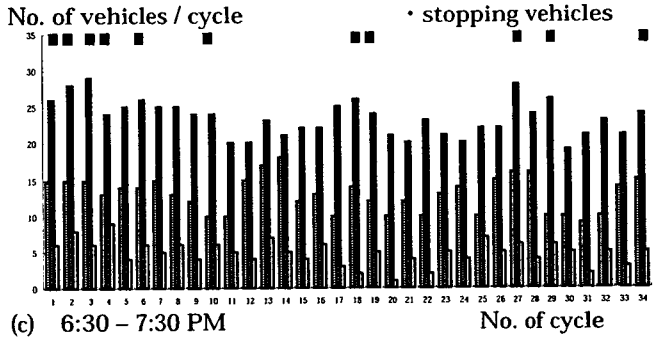


Fig. 10 Flow-in traffic of the upstream intersection
and stopping vehicles at the site III
bars from the left to the right:
left-turn, straight-through, right-turn,