

BANGKOK TRAFFIC MONITORING SYSTEM

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Abstract: Traffic data is essential for determining better traffic management and providing valuable information to drivers. Especially to tackle traffic congestion, traffic data is needed to understand traffic patterns, and to come up with proper solutions for congestion alleviation. In Bangkok, many authorities are involved with the management of traffic, and in recent years, Royal Thai Police has installed a comprehensive image processing detector system throughout Bangkok, in order to monitor traffic. This paper describes Bangkok traffic monitoring system of Royal Thai Police. The system consists of 152 image processing cameras installed at 45 intersections and central unit at a traffic control center. The detectors are capable of providing traffic volume, speed, queue length, and traffic image. All the cameras are linked to the Central Traffic Control and Command center, where the data are stored and made available to operators and commanders. A set of traffic data from the system was analyzed to display the traffic patterns in Bangkok. The system could provide the knowledge of traffic both in details (lane-by-lane, by intersection) or by aggregate (general traffic patterns). The analyses demonstrate that the information from Bangkok traffic monitoring system is useful for both planning and operation. Some ideas on future work are also presented.

Key Words: *Traffic Monitoring, Data Collection, Bangkok*

1. INTRODUCTION

Nowadays, several organizations focus on the mitigation of traffic congestion especially in Bangkok. The knowledge of traffic is required first to understand, and to come up with appropriate and pertinent solutions for improving traffic congestion. Traffic data are obtained from various kinds of traffic sensors, traditionally installed on roads. In recent years, the technology of image processing have been adopted in the field of traffic data collection in which the video camera can be installed on the road section or intersection to collect traffic data such as traffic volume, speed, and occupancy. The collected traffic data are generally used to analyze traffic condition and further provide traffic information in order to manage traffic. Among many traffic data collection technologies, video image processing is one of the

promising and mature technologies that could be used for capturing traffic flow condition. The ability of video image processing in collecting traffic data has been demonstrated and accepted in practice worldwide.

Not only it is important to obtain many traffic data through traffic data collection, but also it is of importance to convert the received traffic data into useful traffic information comprehended and suitable for traffic condition interpretation. The basic traffic data can be analyzed to yield useful interpretation. Basic traffic characteristic can show the amount of traffic demand over time, and the level of demand on various locations. Traffic performance measures, such as queue length, can be a valuable indicator to show the traffic operational conditions. Moreover, the related information such as traffic signal status and operation is also a valuable parameter that could be linked to the performance of the traffic control, and illustrates the potential improvement to traffic control operations and traffic situation.

Royal Thai Police has installed the traffic detection system in Bangkok, and traffic data have been collected and processed at Traffic Command and Control center. Traffic data are collected and processed using image processing cameras at 152 locations throughout the road network in Bangkok, at 45 intersections. In the same project, 77 CCTVs have been installed for traffic surveillance purpose. The project can be seen as a large scale implementation of the advanced traffic data collection technology. In addition, the command and control center has been updated to integrate many parts of the center's functions together, such as the integration of Phase 1 and 2 CCTV to the new central surveillance system and traffic report from traffic data processing (image processing) at 152 detection locations in Bangkok.

This paper reports the development of traffic monitoring system in Bangkok and the analysis of collected data from the system. First, the brief description of traffic monitoring system is explained. Then the principle of traffic data collection is presented. Details on data collected from the system is displayed. Next, a sample of traffic data are analyzed to determine the patterns of traffic in Bangkok. The data are also analyzed to exhibit the performance of traffic flow and traffic control. The paper demonstrates the use of traffic monitoring system to monitor traffic conditions, and the capability to draw results on traffic flow and control conditions in Bangkok.

2. TRAFFIC MONITORING SYSTEM CONFIGURATION AND FUNCTIONS

2.1 System Configuration

As shown in Figure 1, the system is configured with the following six components:

1) Image Processing Type Detector

The camera is installed on roadside pole with the height of 8-10 m above road level, as an example shown in Figure 2. The locations of the camera are near stop line looking at the approach to the intersection. One camera covers a maximum of 4 lanes for traffic volume collection and a maximum of 2 lanes of queue length measurements. Traffic data that could be collected from the camera are traffic volume, vehicle type, speed, and image (still picture) data.

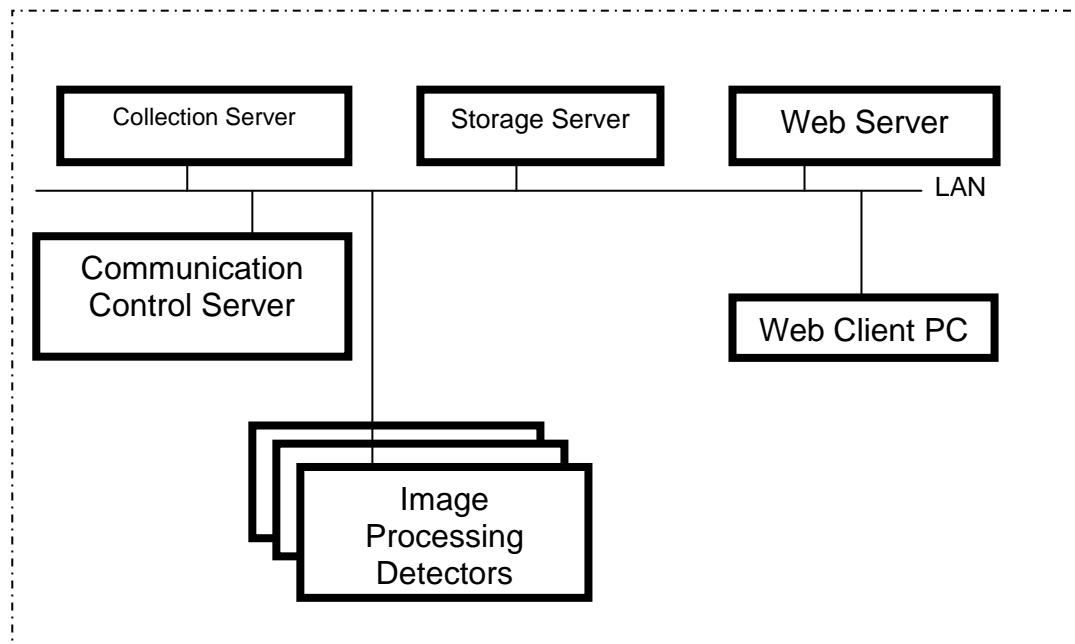


Figure 1. Traffic monitoring system configuration



(a) Location



(b) Detection area of a camera

Figure 2. Image Processing Type detector and its installation

Traffic data are sent back to the center via ADSL lease line. The system is designed to optimize the communication rate and thus the 256 kbps line is sufficient for the linkage between each roadside camera and the center. The traffic data (volume, speed, queue length) transmission is set to every 5 minutes, while the image data is sent every 1 minute and this transmission interval can be changed at the center.

2) Communication Control Server

This communicates with image processing detector terminals using TCP/IP to request, retrieve, edit and control a variety of data and send data to the Collection Server.

3) Collection Server

This holds and controls parameters (constants) required to operate the system and supervises the operation of the Communication Control Server and converts the format of data received from the Communication Control Server to transfer the data to the Storage Server.

4) Storage Server

This stores and controls data received from the Collection Server in a specified format and distributes stored data upon a request from the Web server.

5) Webserver

All the functions of the operation terminal are realized by application on the web server. Then, the operation is possible by access from the web browser on the operation terminal. The Web server gets data from the storage server by request of the operation terminal, and generates web page for web browser.

6) Web Client PC

The operation terminal is a Web based system designed to process traffic data in Bangkok by importing image data from image processing cameras. This data can be analyzed and displayed on the map and graphs shown in the Figure 3.



Figure 3. Example of display from the monitoring system (Web Client PC)

2.2 Functions

The Bangkok traffic monitoring system aims at enhancing the traffic management in Bangkok. It provides knowledge of traffic to the traffic operators and commanders. The traffic information can be used for planning and operational aspects. For planning analysis, the traffic data can be used for reviewing the historical traffic conditions. Traffic volumes are reviewed to get the actual traffic demand patterns which would lead to examination of the past traffic management strategies, finding traffic “hot spots” (critical junction/area), and the periods of traffic congestion. This could help the operator (police) to plan the workforce for their manual operation. At the same time, the traffic information can be used for detailed traffic analysis to determine the systematic traffic management solution, such as the optimization of traffic signal control, lane management, or the implementation of traffic management measures.

For operational analysis, the traffic monitoring system provides timely and continuous traffic surveillance. The monitoring of the changes in traffic conditions is crucial for real-time traffic management decision. At this time, city of Bangkok does not possess urban traffic signal control (UTC) which could automatically control traffic signals in the road network in real-time. Nonetheless, the traffic monitoring system gives valuable traffic conditions for operators and commanders at the center. The continuous surveillance enables the operators to explore the change in traffic conditions, the change in traffic “hot spots”, and the effect of congestion of one intersection to adjacent nodes. The operator can not only judge the right execution through numerical data, but also quickly scan the current and historical traffic conditions through a series of traffic images.

In the case of the enhancement of traffic signal control system from the traditional one into the adaptive traffic signal control system (i.e. UTC), the data from the traffic monitoring system is also readily used for such a system. Since the image processing detectors are situated at the stop lines, it is an ideal location for gathering traffic data input for the advanced traffic control system.

3. TRAFFIC DATA ANALYSIS

The traffic monitoring system enables grasping the 24 hours traffic conditions on in Bangkok city. The continuous surveillance makes available useful traffic information. In this section, the current traffic conditions analyzed using traffic data from the system are explained.

The traffic monitoring system collects important traffic data, namely traffic volume, vehicle types, speed, and queue length. With these data, analyses can be done to disclose useful historical and current traffic conditions (real-time).

3.1 Traffic Distribution

Traffic volume is collected on every traffic movement at an intersection continuously. Therefore, the trend in traffic volume can be summarized. The analysis can reveal temporal distribution of volume over time, by each intersection or for all intersections.

Figure 4 shows the aggregate traffic volume entering all intersections (in which the system is installed). The figure shows the peak traffic demand on the road network in Bangkok. Based on the data on Friday July 2, 2011, the total amount of entering volume at all installed

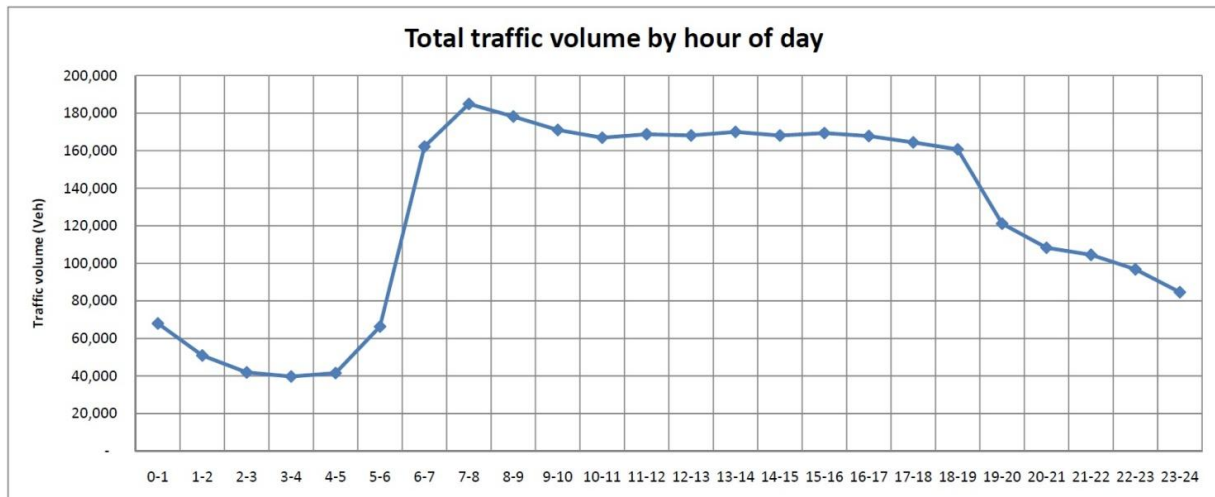


Figure 4. Hourly distribution of traffic in Bangkok (All intersections)

intersections is the highest at 7:00-8:00am. Bangkok roads keep busy throughout the day, mainly from 6:30-19:00.

The hourly distribution can be uncovered for each intersection as well, to show the difference in traffic patterns among spatial locations. Figure 5 shows a sample of hourly distribution at each intersection. The historical traffic demand is essential for estimating specific traffic pattern and for planning and preparation of the man-power for manual traffic management. It is also the valuable database for performing traffic prediction, when the real-time current traffic condition and historical traffic database are used as input for short-term traffic forecast.

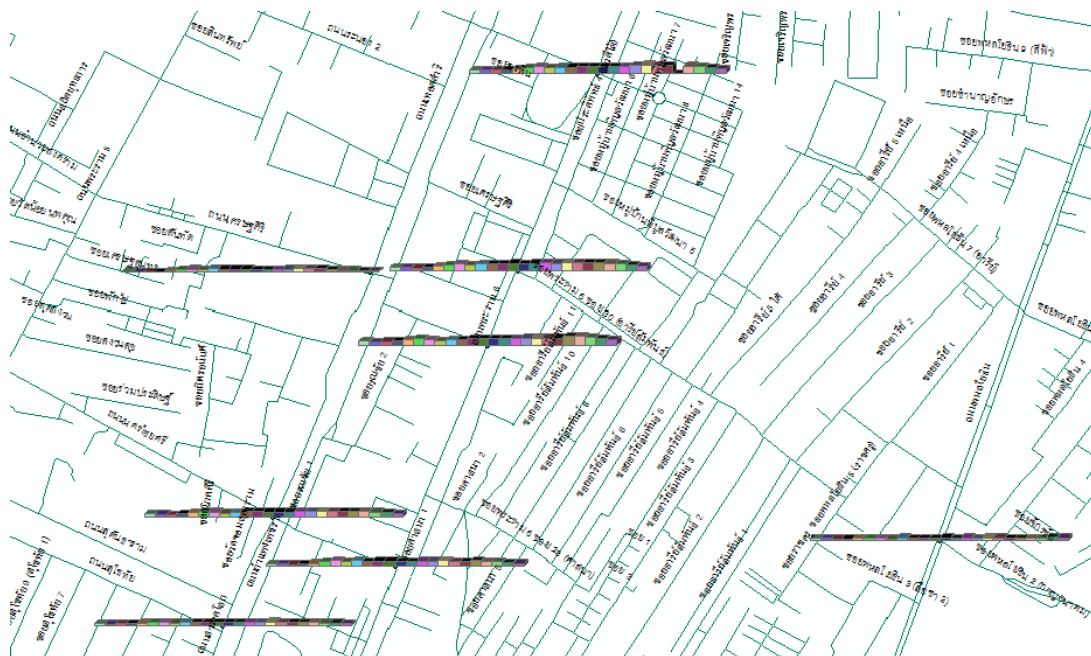


Figure 5. Hourly distribution at each intersection (aggregate entering volumes)

The traffic volume can be aggregated for weekly distribution as well. Figure 6 shows an example of weekly distribution of traffic. The figure is used for pinpoint the busy day(s) at the intersection and it discloses different traffic patterns by days of week.

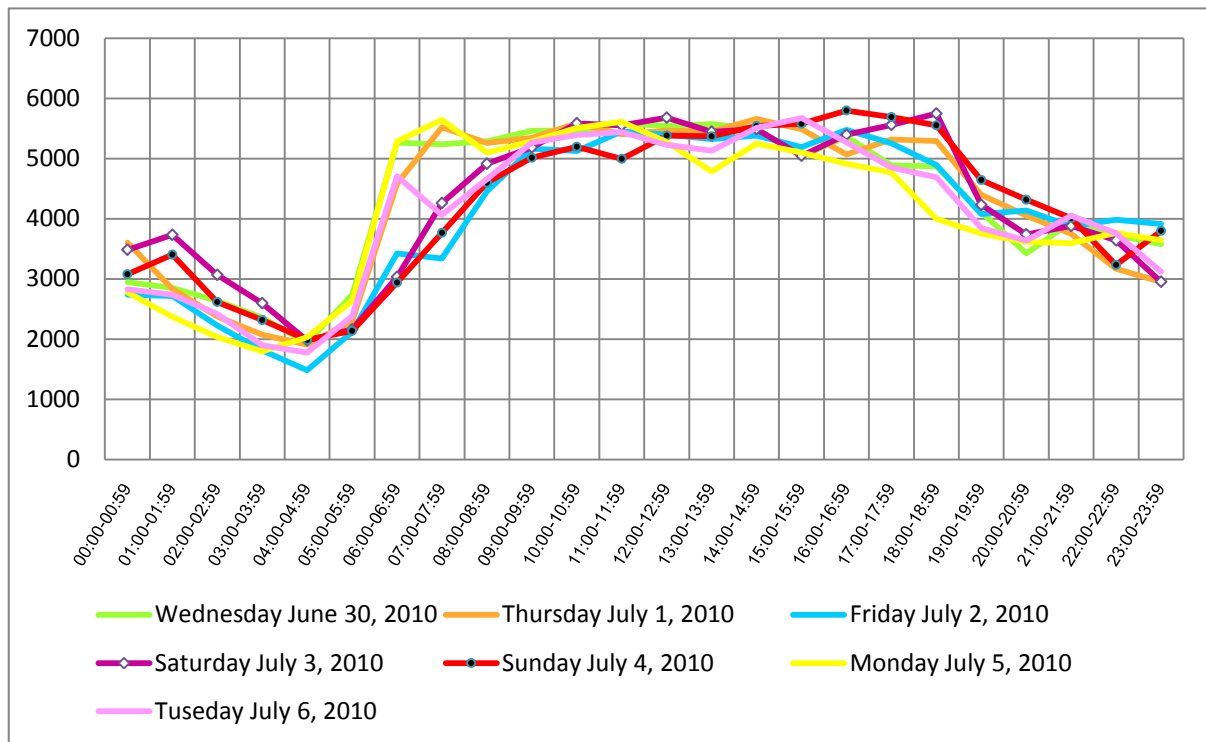


Figure 6. Hourly distribution by day of week (Example, Asoke intersection)

From Figure 6, at this intersection, it is observed that the morning peak periods on Monday, Tuesday, Wednesday, and Thursday starts at 6:00am and sharply rise. This implies a lot of traffic is on the roads during this peak period. The peak traffic on these days reach their peak before 7:00am as compared to other days (Friday, Saturday, Sunday) when the peak periods start at 10:00am. In the evening, the traffic drops during 18:00-19:00pm. There is not discernable difference between days of week. This is intuitive plausible as this intersection is at busy business and night life area. This analysis can be done for many weeks and the historical trend can show that each day of week has a specific hourly distribution.

Figure 7 exemplifies the display on traffic volume on each approach at one intersection. The picture (or the numeric data) showing the demand by approach is useful to learn the congestion pattern at the specific intersection. It can be used for priority treatment at each intersection. From the figure, at XX intersection traffic on approach I-DET 68 (in-bound) is heavy in the morning and traffic on approach I-DET 66 (out-bound) is heavy in the afternoon. The data analysis can disclose the critical movement of traffic at the intersection which varies by time of day.

3.2 Determination of peak periods

For grasping traffic flow pattern at peak periods, the time of highest traffic volume at intersection are pointed on the maps. The traffic flows into the city center in the morning and the peak of traffic volume are occurring earlier at entrance intersections than those in the city center. The traffic flows out from the city center in the evening and the peak of traffic volume are occurring earlier at exit intersections than those in the city center. (This tendency is more distinctive than the morning). This traffic flow pattern means that the managing of border intersections between city center and suburb is important. Figure 8 summarizes the peak patterns of traffic at all intersections. The picture gives a valuable view on the movement of traffic demand (and congestion) on the network.

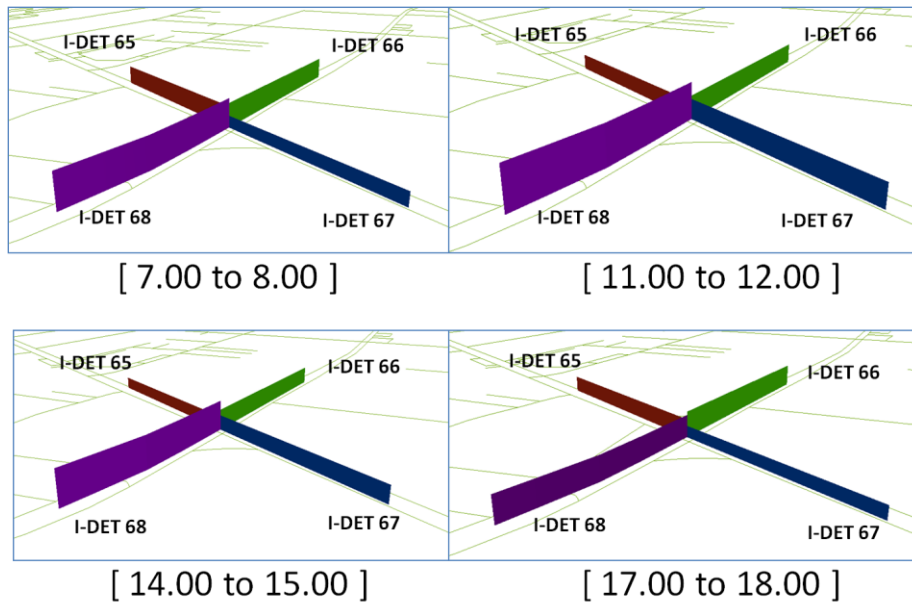


Figure 7. Example of traffic volume at an intersection

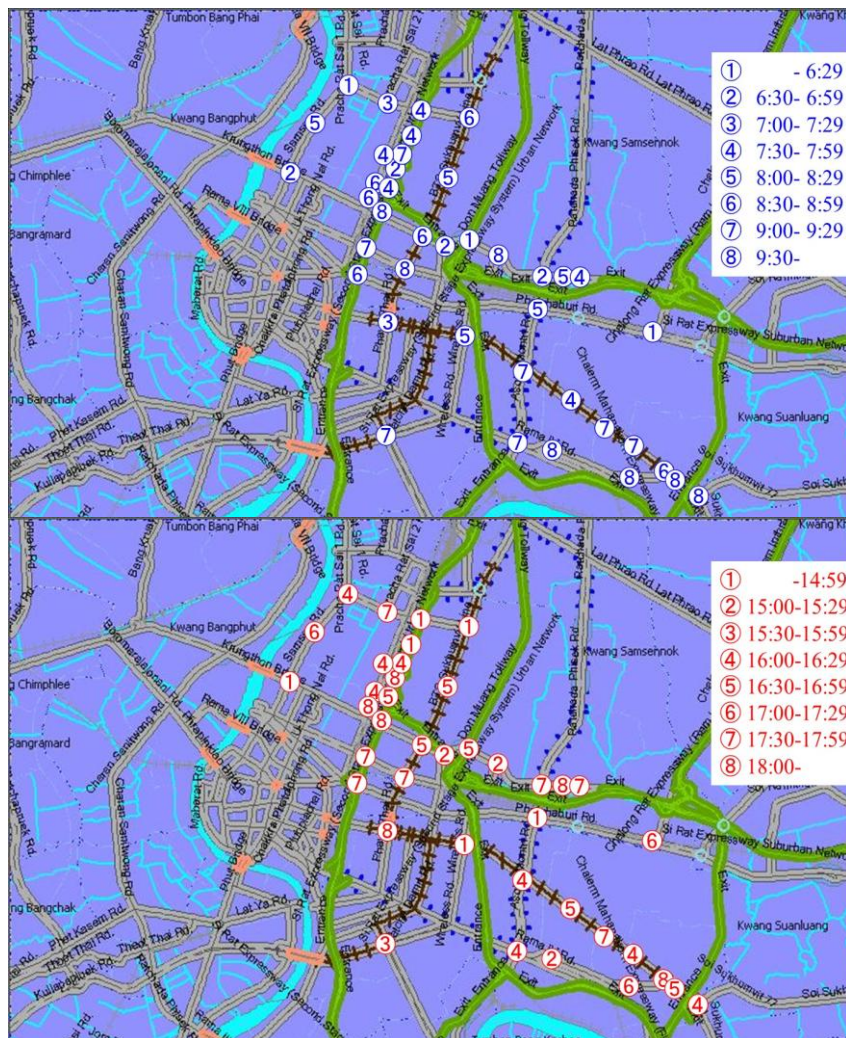


Figure 8. Peak periods at each intersection

3.3 Detailed traffic analysis on lane-by-lane basis

The advantage of Bangkok traffic monitoring system is the collection of data on the lane basis. This enables us to examine the traffic demand and use of each lane of the approach. Figure 9 exemplifies a graph showing the data at lane-by-lane level.

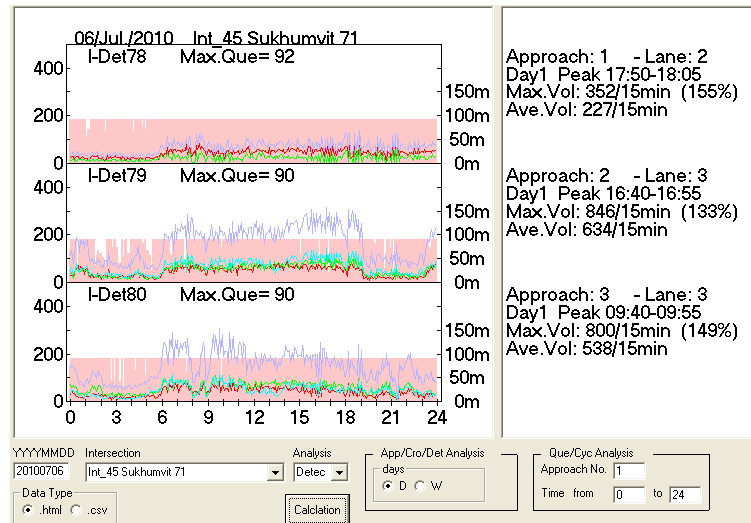


Figure 9. Example of lane-by-lane data (Sukhumvit 71 on 06/07/2010)

Generally, the lane-by-lane analysis is not performed when only the overall picture of traffic condition is needed. Nonetheless, the detailed analysis on lane usage reveals the lane utilization. From Figure 9, graph lines with different colors indicate traffic volume on each lane. With the knowledge on the turn restriction on each lane, the graph lines can be used to determine whether the use of lane is optimal.

3.4 Analysis on “balanced” and “unbalanced” lane usage

To quickly understand the characteristics of lane usage, the comparison of traffic volumes among lanes in the approach can be considered. A balance of lane utilization can be observed. The “balanced” is defined as traffic volumes on two more lanes in the same direction are similar or not. If so, a “balanced” is called, otherwise “unbalanced”. Figure 10 illustrates the method for identifying the balance usage.

From data analysis at 45 intersections, traffic characteristics fall into unbalanced lane usage during peak periods in most intersections. This suggests that the signal operations as well as the lane regulation must be considered in order to get better traffic flow efficiency.

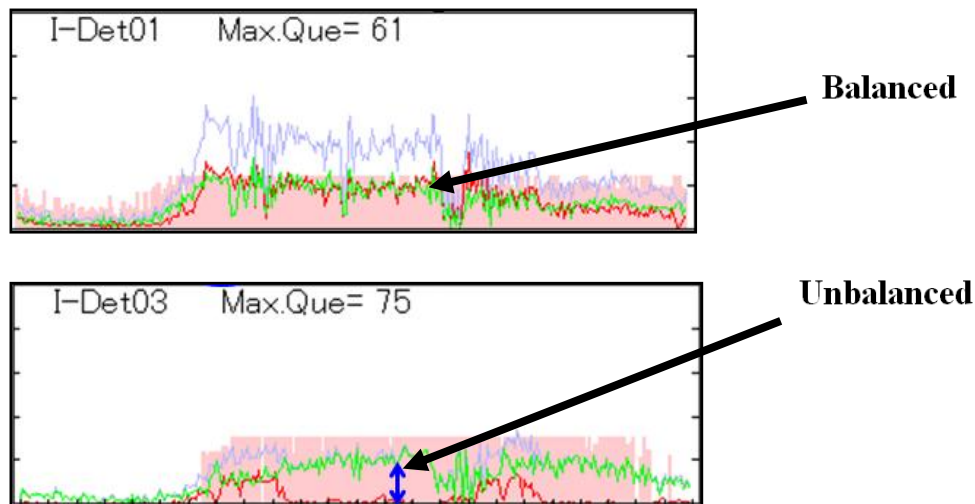


Figure 10. Balanced vs. unbalanced lane usage

3.5 Estimated Cycle Length

This data can be used for estimating the cycle time of a signal at each intersection. Since this traffic data collection system is independent with the traffic signal control system, the period of green time and red time of each signal phase and a cycle length of the signal at the intersection is not stored or reported. Nonetheless, the cycle time can be estimated from the traffic movement at the beginning of two green time periods. An example of the result of cycle time estimation is shown in Figure 11.

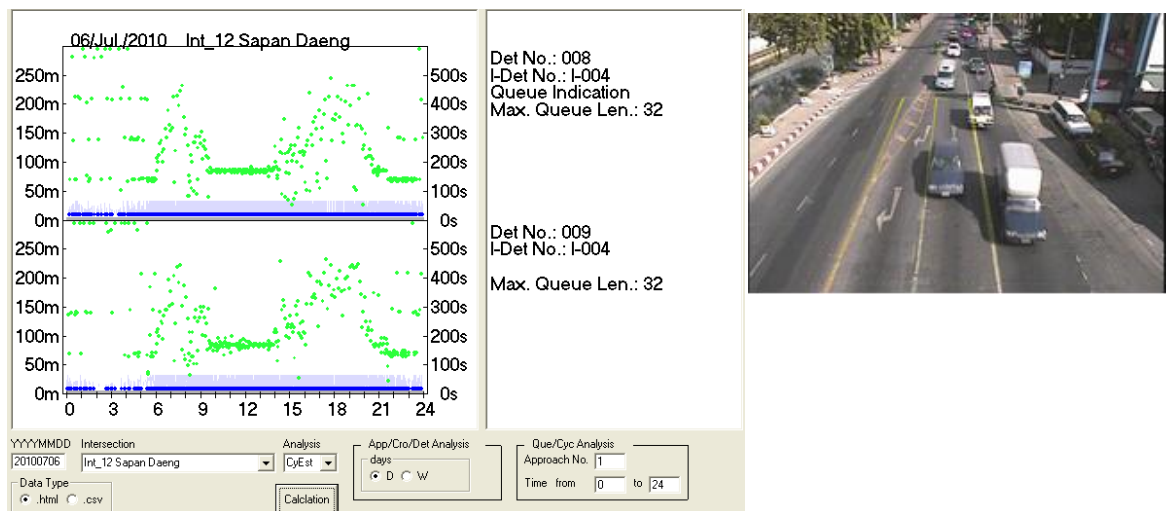


Figure 11. Example of Cycle length estimation

From the database, it can be seen that 20 intersections (Ex. Kiakguy Int., Sang Hee Int., Sapan Dang Int. and Sawankalok Int.) are manually controlled with around 500 seconds of cycle length and most of other intersections are controlled with around 400 seconds of cycle length in the peak periods.

3.6 Discussion on Bangkok traffic

The analyses of Bangkok traffic data reveal the characteristics of Bangkok traffic. Moreover, the data collection is carried out continuously and the data can be retrieved in real-time. The data show that each intersection has its own traffic patterns. The traffic database can give accurate traffic parameters for a specific location. Generally, the traffic volumes at most intersections are heavy, leading to congestion for a long period of time of day. Queue monitoring shows that queues are accumulated on road sections, implying that the road network experiences oversaturation during those time periods.

Since the system is not connected to the traffic signal control system, the signal timings (cycle time and green time) are not normally recorded. Nonetheless, the cycle length can be estimated based on queue formation characteristics. The signal timings are crucial for determining roadway capacity (service flow) and the collection of signal timings can show the performance of signal operation.

As found from the traffic analyses, the duration of cycle time at 45 intersections in Bangkok is long. In common practice in Western countries, the maximum duration of the cycle time is 180-240 seconds. In Thailand, however, the duration of cycle time of 400 seconds or more is commonly seen.

4. IDEAS FOR FUTURE WORK

The installation and use of Bangkok traffic monitoring system gives rich data collection and valuable information for traffic operation. The system can give many pieces of traffic analyses and knowledge on network-wide road traffic condition. Moreover, the system estimates and records the actual operations, such as the duration of cycle time from the manual operations by police officers.

One observation from the data analysis is that the manual control by police results in very long cycle length. The field observation reveals that the police tend to give “mercy” extension of green time to traffic which is currently receiving green duration (Figure 12). As generally known, “too” long cycle time causes excessive delay and long queue to entire intersection operation. The traffic monitoring system can detect long cycle time and may be used for coordinating the manual operation not to have too long cycle time (preferably 300 seconds or less).

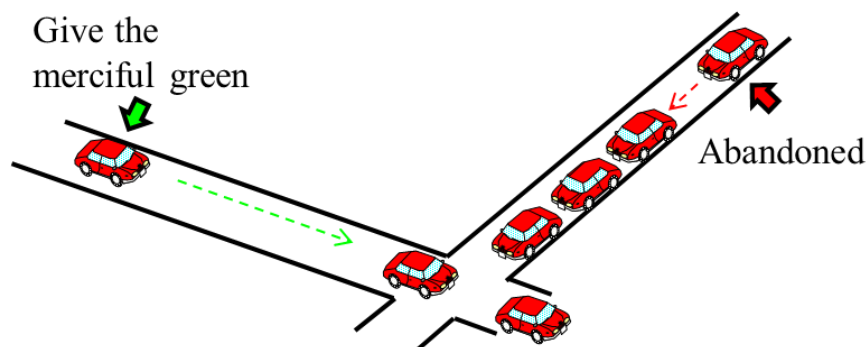


Figure 12. Common “mercy” extension of green in manual traffic signal control

The traffic monitoring system is capable of obtaining knowledge of traffic throughout the network. This is beneficial in that a strategic plan for network-wide traffic control can be carried out. With the ability to accurately predict traffic movement and congestion patterns on the network, the network-wide traffic management can efficiently be conducted.

- Amount of traffic can be predicted based on the level of traffic in the surrounded area and historical traffic patterns
- Traffic control can be coordinated so that it prepares capacity for the predicted traffic.

For instance, for morning peak period, the amount of traffic at the city center can be predicted knowing the amount of in-bound traffic at border intersections. Operations at intersections would aim to increase capacity to heavy traffic directions. Likewise, for the evening peak period, the border intersections can prepare capacity to accommodate amount of traffic out-bound from the city center.

As the locations of image processing detectors are at the stop lines of intersections and the capability of collecting traffic data in real-time, the data from detectors could be used as input to any adaptive traffic signal control system. In Bangkok, a demonstration project was conducted in September 2009 at Kiek Kai intersection. The adaptive signal controller was installed at this intersection and the system utilized the data from the detectors. The project demonstrated that the traffic monitoring system could also be further utilized as data collection for adaptive signal control.

5. CONCLUSION

This paper describes the traffic monitoring system which has been implemented in Bangkok by Royal Thai Police. The system provides traffic surveillance at 45 intersections covering a large area of road network in Bangkok. The 145 image processing detectors collect traffic volume, speed, vehicle type, queue length and traffic image and the data are gathered at a central control center. The system is capable of collecting historical data as well as real-time monitoring by traffic operators. The system provides data as well as tools to disclose knowledge of traffic.

A sample of traffic data from the system was obtained and analyzed. Amount and distribution of traffic flow can be obtained. From the Bangkok traffic data, traffic on streets are heavy throughout the day. The system helps identify the locations of congestion and traffic patterns. The historical data give understanding on the trends and effects of traffic management. The analyses can be done at lane-by-lane or aggregate intersection basis. Some important notices about Bangkok traffic can be found from Bangkok traffic analyses. Traffic behaviors such as lane utilization (balanced or not) is observed. The cycle time of signal by manual control is generally long, and this can cause inefficient traffic operations. This gives some ideas for further development. The real-time data collection can be used for determining proper traffic management strategies, which consider network-wide traffic movement and prediction. The signal control can be improved through adaptive signal control utilizing the data from the monitoring system.

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