The Netherlands Research School for Transport, Infrastructure and Logistics
TRAIL

11th TRAIL Congress
November 2010

LOOP DETECTOR ERROR AND ITS IMPACTS ON TRAFFIC CONTROL SCHEME

SCATS Case study in Changsha

Jie Li MSc, Prof. dr. Henk van Zuylen
College of Civil Engineering, Hunan University, China
Faculty of Civil Engineering and Geosciences, Department of Transport and Planning, Delft University of Technology, the Netherlands

ABSTRACT

Traffic volume is a critical parameter for signal control schemes. Loop detectors are widely used in practice to collect related traffic data. It is unavoidable that loop detectors produce some data errors and 80% correct rate is already considered as quite normal in reality. This paper will analyze the influence of loop detector error rate on the quality of traffic control schemes. A comparison between real traffic volume and loop detector data in Changsha (P.R China) will be represented. VISSIM and VRIGEN are being used to set up the simulation models and optimize traffic control structures respectively.

KEYWORDS

Data error, traffic volume, signal control, SCATS

INTRODUCTION

Single loop detectors, which can directly measure traffic volume, vehicle headways, and lane occupancy, became the most abundant traffic data source in practice. Actuated traffic control systems use the real time traffic adaptive approach to adjust cycle lengths, splits and offsets by measuring current traffic conditions. But the loop detector data often contain many errors or miss some values, which may result in problems for real time traffic control. This research subject includes two main questions: a) the algorithm used by the traffic controllers and b) how can the control systems deal with the data errors. Among them, evaluating loop data is essential and the first step of the work. Furthermore, the influence of the loop detector data error on the control system should be analyzed.

Since the application of electronic surveillance on roadways in the 60s of the last century, researches that evaluate detector output data have continued to be executed. Previous studies

(1) presented that the main causes of malfunction of inductive loop detector are improper installation, inadequate loop sealants, and wire failure. Extensive studies have been conducted to diagnose and correct loop data errors (2, 3 and 4). But no study was found to explicitly address the loop error impacts on traffic control scheme design. Therefore, this paper presents research efforts in identifying loop error and analyzing its impacts on establishment of traffic control schemes.

METHODOLOGY

In Changsha (P.R. China), there are about 1600 single loop detectors covering 99 urban intersections which are controlled by the SCATS (Sydney Coordinated Adaptive Traffic System). SCATS automatically collects data through in-road and/or overhead road sensors, and sends instructions to traffic signal controllers to manage signal timings. The traffic control goal of SCATS is to maximize traffic throughput, minimize delays and the number of stops (5). Traffic volume and lane occupancy are two critic parameters to SCATS. Changsha Municipality initiated a research project to evaluate loop data accuracy by using video ground truth data in 2010. The investigation was carried on a typical day (Friday, May 14, 2010). 15 video cameras were installed to record the traffic at 13 intersections from 8:00am to 10:00am synchronously. Video recorded ground-truth data have been applied to identify errors in the loop data which were obtained from the SCATS traffic control center at time intervals of 5 minutes.

DATA COLLECTION AND PROCESSING

Loop detectors are subject to various malfunctions that may introduce detection errors. As the previous investigations in other countries, also the traffic control central in Changsha can't receive all the data samples. The validation tests of loop data using the video data showed that loop detectors sometimes miss-detected vehicles, while they sometimes over counted vehicle volumes. Average Relative Error rate ε_i defined as $\varepsilon_i = | q_{Li} - q_{Vi} | / q_{Vi}$ is used as a statistic standard for the comparison in the whole investigation period, as shown in Fig. 1.

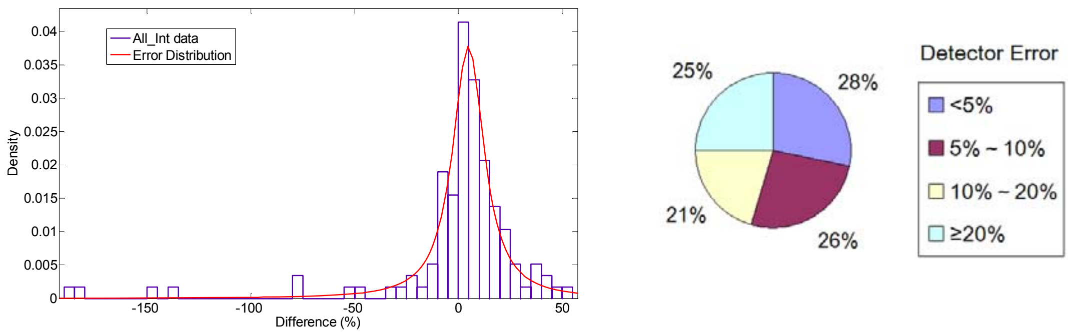

Figure 1: Loop Errors Distribution

The comparisons results imply the fraction of well working detector is not so high and about 25% detectors' data error are larger than 20%. Detector errors for through going lanes are less than for turning and mixed lane. No significant different detector errors exist between large size intersections and minor intersections.

The Degree of Saturation, the average occupancy time of a lane detector at an intersection, is another important parameter in SCATS traffic control system. In this study, image processing technology is used to track vehicle after conversion of the traffic movie into high frequency consecutive pictures. Virtual detectors are set in the converted pictures to induce vehicles' arrival time and departure time, furthermore the detectors' occupancy time can be measured. The pixels along the middle line of the object lane are extracted, as shown as the red line in following figure.

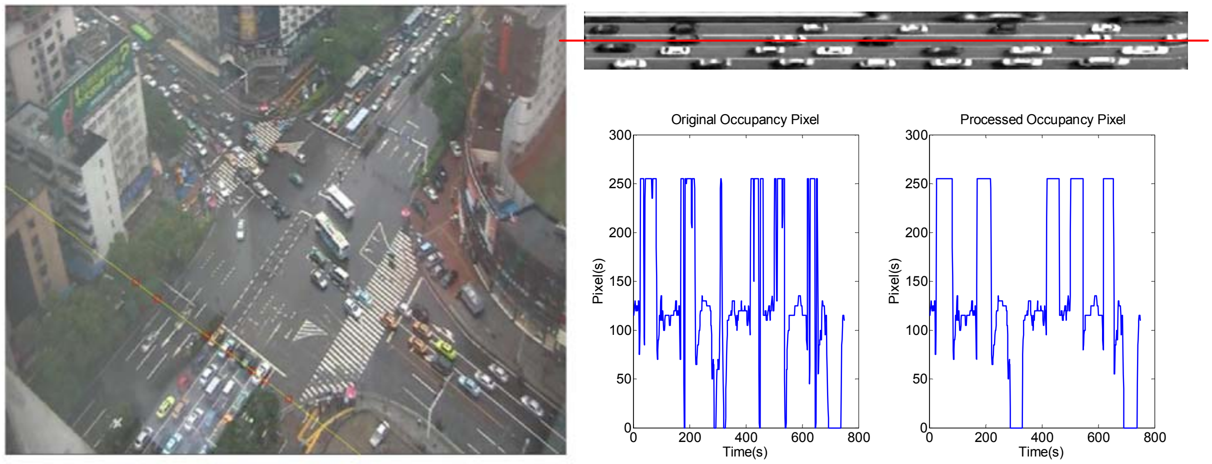

Figure 2: Occupancy Detecting

The original pixels still comprise lots of noise, as shown in the above left figure. In order to distinguish white vehicle (light color) and black vehicle (dark color) from pavement, some serious and careful restriction conditions have been used to highlight vehicle from street pavement. The results are shown in the above right figure. It is easy to detect 5 white vehicles and 2 black vehicles passing the stop ling during 15second, i.e. in 750 frames. The corresponding occupancy rate can be deduced from this analysis.

RESULTS DISCUSSION

In SCATS, traffic volume values are used to determine the dynamic traffic control cycle time and the coordination between intersections. The sensitivity of the traffic control is analyzed with the well known formula [6]:

$$TC_W = \frac{\alpha \times TLI_C + \beta}{(1 - \sum (q_i / s_i))} \qquad (1)$$

The summation in the denominator is performed over a conflict group, i.e. a set of signal groups that are mutually incompatible and have to receive green separately. For the minimum cycle time $\alpha = 1$ and $\beta = 0$, for the pre-timed control with minimum delay α is 1.4 to 1.5 and β is 4 to 5 [6]. There are three parameters in the above function, which are internal lost times TLI_C (a part of the yellow times, clearance times and start lag), saturation flow rate (capacity s), and volume (flow rate q). It is obvious that the sensitivity to errors in q and s is large, especially when the sum in the denominator in eq. (1) is close to 1. A case study is made for a fully saturated intersection in Changsha. The cycle time calculation results confirm that the lack of consistency due to over/under counting at various stations can induce a significant problem in the cycle time calculation process, especially in saturated flow situation. SCATS continuously adjusts traffic signal controllers to optimize flow by measuring the density of vehicles in each lane. The core of SCATS traffic control theory is the flow rate *DS* which is estimated by [5]:

$$DS = \frac{g-(T-G1\times n)}{g}$$

Where

G1: The time gap [s] of the maximum traffic volume, which is measured over a day

g: Green time [s]

T: Sum of unoccupied time [s] per green period

n: The number of passing vehicles per green period

The maximum traffic volume, defined as saturated flow in SCATS, is not a fixed value and can change everyday. The loop detector errors can result in miscalculations for *G1* and *T*, and then the flow rate (*DS*) will become incorrect. Therefore the traffic control that is automatically created by SCATS should be validated in practice.

CONCLUSIONS

Loop detector data are important in optimizing traffic control and management, both practically and theoretically. However, loop detectors are subject to various malfunctions that can result in erroneous measurements. This paper presents the traffic volume values errors through comparing loop detector data with video ground truth data. The impact of volume errors on the traffic control cycle time is evaluated. The causes for the loop errors cannot be pinpointed by simply examining the differences between the loop data and video ground truth data. Therefore, an in-depth analysis of loop error causes became necessary for the future study. The new investigation method is expected to collect high-resolution loop even data without interrupting the SCATS normal operation and the relation between loop error and lane occupancy will be revealed.

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