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Original Research Paper

Estimating intersection turning volumes from actuated traffic signal information

Ali Gholami[*], *Rasool Andalibian*, *Zong Tian*

Department of Civil and Environmental Engineering, University of Nevada, Reno, NV 89557, USA

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ABSTRACT

Actuated traffic signals usually use loop detectors. The current practice in many cities is to install four consecutive loop detectors in each lane to reduce the chance of undetected vehicles. Due to practical reasons, all four loop detectors in each lane and other detectors referring to the same phase are spliced together. Thus, it is possible for several vehicles to be counted as one single car. This way of detector wiring to the cabinet reduces the accuracy of detectors for collecting traffic volumes. Our preliminary studies show cases with an error greater than 75 percent. Therefore, the purpose of this paper is to provide a simple method to obtain turning volumes from signal information in actuated non-coordinated traffic signals without using loop detector data. To produce the required data, a simulation was performed in VISSIM with different input volumes. To change turning volumes, a code was developed in COM interface. With this code, the inputs did not have to be changed manually. In addition, the COM code stored the outputs. Data were then exported to a single Excel file. Afterwards, regression and the adaptive neural fuzzy inference system (ANFIS) were used to build models to obtain turning volumes. The accuracy of models is defined in terms of mean absolute percent error (MAPE). Results of our two case studies show that during peak hours, there is a high correlation between actuated green time and volumes. This method does not need extensive data collection and is easy to be employed. The results also show that ANFIS produces more accurate models compared to regression.

1. Introduction

Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. This data helps identify critical flow time periods and determine the influence of large vehicles or pedestrians on vehicular traffic flow. Manual counts are typically used to gather data for determination of vehicle classifications, turning movements, direction of travel, and vehicle occupancy. Most applications of manual counts require small samples of data at any given location.

The automatic count method provides a means for gathering large amounts of traffic data using permanent or

* *Corresponding author*. Tel.: +1 775 221 1365.
E-mail address: ali.gholami32@gmail.com (A. Gholami).

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portable counters. The majority of signalized intersections operate under some form of actuated control, and in that intersection approaches (or lanes) have some type of inductive loops. The new loop detector (also called loop amplifier) and signal controller equipment now provide the ability to collect traffic count information from the same loops used for actuated controls on intersection approaches. The potential to extract traffic counts from an existing signalized intersection loop detection system provides the opportunity to collect data with minimal costs. There are many benefits of collecting traffic counts from loops at signalized intersections including the low cost. However, there are also several issues that reduce loop detector accuracy and reliability for collecting automatic turning volumes, including variations among transportation agencies in terms of signal loop placement, layout and wiring, potential variations in methods of data extraction based upon the type of technology and/or detector manufacturer used, and loop maintenance issues.

This paper tries to provide a simple method to obtain turning volumes from signal information in actuated non-coordinated traffic signals without using loop detector data. The two case study intersections are located in Reno, Nevada. Because of simplicity, this method can be used in agencies without any other equipment or changing the loop system configuration.

2. Literature review

Very few efforts are reported in regard to the use of local traffic detectors for systematic volume data collection. Some researchers have investigated freeway loop detector errors (Chen et al., 2007; Chen and May, 1987; Dailey, 1993; Jacobson et al., 1990; May et al., 2004; May et al., 2005; Middleton et al., 2006; Nihan, 1997; Nihan et al., 1990; Payne and Thompson, 1997; Rajagopal and Varaiya, 2007; Vanajakshi and Rilett, 2004). However, due to the significance of speed and space, headway of vehicles on loops and freeway detecting loops have different characteristics and accuracy compared to intersection loops. Some cities, including Seattle, San Antonio, and Toronto provide real-time or stored travel information on selected freeways and arterials based on information received at their traffic management centers from their network of inductive loop detectors.

Metropolitan Toronto reported the development of a prototype transit and traffic information system (Berinzon, 1993). The goal was to incorporate freeway and arterial SCOOT data into a complete user information data system. The system is called COMPASS and is employed on some sections of the Queen Elizabeth Way (QEW) and Highway 401 (Turner et al., 1999). In this system, data is collected at 20 s intervals and aggregated to 5 min, 15 min, 1 h, daily and monthly time periods. Volume, occupancy and speed data are archived for the 20 s and 5 min time intervals while only volume data is archived.

The San Antonio TransGuide program has been warehousing traffic information from over 300 detector stations located on freeway mainline segments and ramps. Speed, volume, and occupancy data are all stored in their database (Turner et al., 1999).

Institute of Transportation Engineers (ITE) reports that four cities, Nashua, NH; Fremont, CA; Minneapolis/St. Paul, MN; and Bellevue, WA are collecting traffic counts using their loop detector systems (ITE Traffic Engineering Council, 2007).

Nashua has mostly National Electrical Manufacturer's Association (NEMA) Standard TS1 cabinets. The initial thought for collecting data at one intersection was to utilize the present loops at the STOP line of all approaches. These loops were known to be working after detailed testing by the city's maintenance and operations staff. However, after reviewing the signal layout plans for the intersection and comparing the functionality of available upstream 6 ft by 6 ft system loops with the present loops, the conclusion was made to use the system loops. Data was extracted from the controller using a field laptop every 10 d during the desired data collection period (ITE Traffic Engineering Council, 2007).

In Fremont, CA, data was collected from the system loops and stored in and managed by the traffic signal controller. The controller was programmed to configure each system loop and determine how the collected data is grouped. Loops were typically set up to collect traffic volume and occupancy data, which were summarized in 15 min intervals, very similar to traditional tube counts for collecting average daily traffic. Fremont has standardized its traffic signals with the use of National Electrical Manufacturers Association's (NEMA) TS2 traffic signal controllers and controller cabinets (ITE Traffic Engineering Council, 2007).

In 1993, the Minnesota Department of Transportation (Mn/DOT) began collecting loop detector counts on the instrumented part of the Twin Cities metropolitan freeway System. The system now consists of 648 directional miles and 4300 inductive loop detectors. Both volume and occupancy were recorded and achieved in 30 s intervals. Loop detector data from traffic signals has always been available using the signal controller proprietary software, but the data was difficult to retrieve and analyze. In 2005, Mn/DOT began retrieving loop detector data from the field, and then storing the data in a format that could be easily analyzed. The data was stored on a server in binary format that could be retrieved by anyone at Mn/DOT. Tools were developed to allow the users to retrieve data for numerous loop detectors over a given period (hours to months). This data can then be averaged, smoothed, and graphed.

Bellevue, WA, also similar to Nashua and Fremont, used advanced loops located about 100–140 ft from the STOP line to measure the volume and occupancy data of an approach. If the approach roadway had more than one lane, the combined traffic flow of that approach was measured. At some locations with heavy turning volumes or uneven lane distribution, separate measurements for each movement were made. A remote communication unit in the signal cabinet transmitted the raw data back to the central signal computer in the TMC (ITE Traffic Engineering Council, 2007).

North Carolina conducted a test at several locations in the state and concluded that there was a high level of similarity between manual counts and the 6 ft by 6 ft stretch loop counts. Therefore, they recommended that North Carolina begin using stretch (far) loops for traffic counts by rewiring cabinets and installing detector amplifiers with count outputs on an as-needed basis. They did not recommend the use of