Summary of Implementation

Before deploying the new application, further testing of the proposed algorithm is recommended. To date, the algorithm has been tested at only two dual-loop stations on the I-5 corridor in the Seattle area. Additional testing with loop amplifiers from diverse manufacturers and under varied weather conditions and roadway geometries may confirm both the compatibility of the ALEDA system with hardware from different manufacturers and its performance under severe weather conditions.

Additional improvements are needed in user interface design and hardware selection to make the ALEDA system a standard tool for staff to tune-up dual-loop detectors with sensitivity problems.

We have briefed the WSDOT staff on the research findings and presented the ALEDA system at the World Congress of Intelligent Transportation Systems in San Francisco in November 2005. Two scientific papers describing the new findings in this research have been published in the Journal of Transportation Research Board.

Report Title and Number

- Improving Dual-Loop Truck (and Speed) Data: Quick Detection of Malfunctioning Loops and Calculation of Required Adjustments
- WA-RD 647.1

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research notes

Improving Dual-Loop Truck (and Speed) Data: Quick Detection of Malfunctioning Loops and Calculation of Required Adjustments

Background

The Washington State Department of Transportation (WSDOT) has made a substantial investment in the installation of inductance loop detectors on its freeway network. These detectors are cut into the pavement and provide a major data source for traffic management, roadway design, and traffic analysis (see photo). Almost half of the loop detector stations on the Seattle area freeway network are equipped with dual-loop detectors for the purpose of measuring speed and classifying vehicle length. As vehicles pass through a dual-loop detector station, their speed can be determined and they are classified according to their length (see Figure 1). However, the accuracy of current dual-loop data quality is hindered by several uncontrollable environmental factors, pavement conditions, and the lack of an effective tool for dual-loop detector maintenance and tune-up. Roughly 80 percent of dual-loop detectors in the Greater Seattle area are subject to various malfunctions. To enhance the accuracy and reliability of dual-loop data, we conducted

a study to develop and test an algorithm for quick detection of malfunctioning dual-loop detectors and calculation of required adjustments.

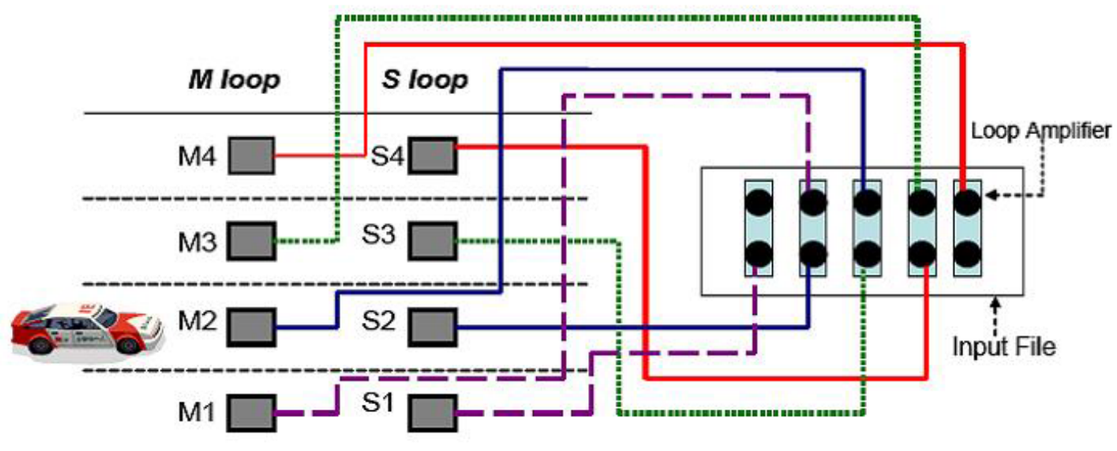

Figure 1

As an extension of the previous study, this research project aims to develop a method for identifying and correcting such dual-loop sensitivity problems. Their elimination will enhance the reliability of the dual-loop detection system and can help WSDOT obtain more accurate speed and truck count data from the existing dual-loop detectors.

The Problem

The major cause of the poor performance of a dual-loop detector appears to be the remarkable difference in lane occupancy between the direct measurements of the two single-loop detectors that form a dual loop. When the occupancy difference calculated from the direct measurements of the two single loops exceeds a certain threshold, the current WSDOT dual-loop algorithm discards the vehicle from the data set prior to the length calculation and classification operations. Any of the following factors can generate such occupancy discrepancies:

- incorrect mode setting for one or both single-loop detectors in a dual-loop system;
- inconsistent sensitivity levels for the two loops; and
- other hardware malfunctions.

Many factors affect the sensitivity of a single-loop detector and this makes it a difficult job to determine the appropriate sensitivity level. These factors include operator experience, detector-specific standards, roadway material, construction method, and environmental conditions. The procedures now used to adjust loop sensitivity cannot usually achieve favorable results — hence the need for a new tool for identifying and correcting dual-loop sensitivity problems.

What We Did

We applied major traffic engineering concepts and advanced data acquisition and analysis technologies to design and build a special computer-based system, named Advanced Loop Event Data Analyzer (ALEDA) (see Figures 2 and 3). We designed ALEDA to detect and correct inappropriate loop sensitivity settings, the primary cause of inaccurate dual-loop data. ALEDA is expected to fix dual-loop sensitivity problems to improve the performance of the WSDOT's existing dual-loop sensor network.

ALEDA corrects the dual-loop sensitivity problems by repeating the steps of identification and correction for both sensitivity discrepancies and unsuitable sensitivity levels until both problems are eliminated.

The system test at the ES-172R station (located on Interstate 5 Southbound near the Metro Base) on December 8, 2004 showed that use of the proposed algorithm effectively corrects the sensitivity problems of dual-loop detectors and significantly enhances the quality of dual-loop data. The difference (as a percentage) between the vehicle counts from single loops and the dual-loop detectors dropped from 95 percent to nearly 0 percent after the dual-loop tune-up using ALEDA (see Figure 4).

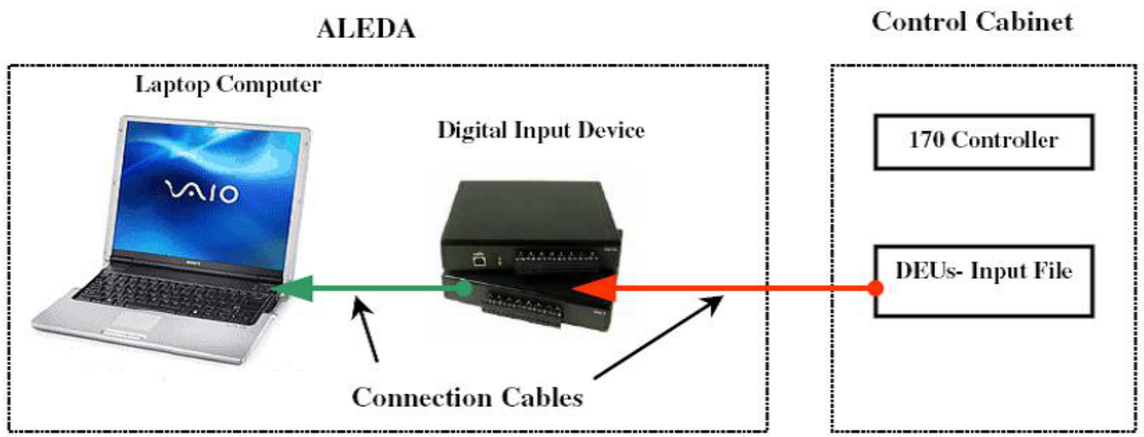

Figure 2
Advanced Loop Event Data Analyzer (ALEDA)

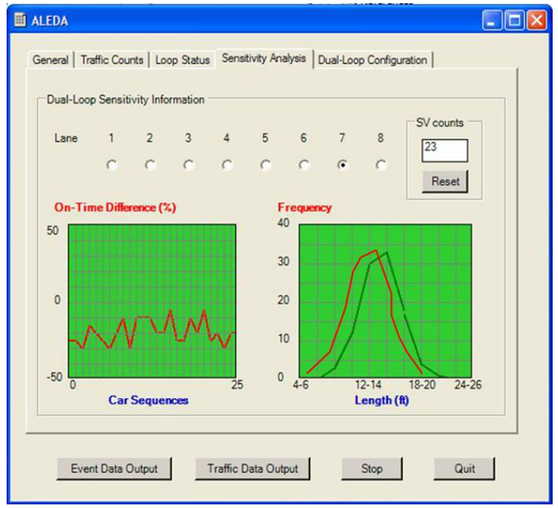

Figure 3

What We Learned

Our research revealed that sensitivity problems are the primary cause of undercounting vehicle volumes from dual-loops. Vehicles with sufficiently large on-time inconsistencies are dropped from the vehicle classification process by the current algorithm. The dual-loop on-time differences represent the sensitivity discrepancies between the two single loops.

The sensitivity discrepancy problem can be resolved by adjusting the sensitivity levels at loop amplifiers following a review of the results of the analysis function in ALEDA. Speed estimates should be significantly more accurate when sensitivity discrepancy is removed from a dual-loop detector system.

After a sensitivity discrepancy is eliminated, the next task is to determine a suitable sensitivity level for both single-loop detectors of a dual-loop system so as to accurately measure vehicle lengths. Since vehicle lengths follow a certain statistical distribution, the features of this distribution can be applied to identify the correct dual-loop sensitivity level.

What the Researcher's Recommend

The results from this project lead to several recommendations:

- An enhanced analysis function to provide a refined set of possible solutions based on the sensitivity discrepancy should be developed. For example, intermittent fluctuations of dual-loop on-time differences may arise from the cross chattering of loop amplifiers.
- The effectiveness of ALEDA depends on the physical conditions of dual-loop detectors. For example, the sensitivity discrepancy problem cannot be corrected if the sensitivity difference between the two single loops is beyond an adjustable range. Also, a tune-up is normally an approximate solution rather than a perfect one due to the discrete values of sensitivity levels available on a loop detector. We thus recommend a software solution implementing the proposed algorithm to avoid the constrained sensitivity adjustments of discrete levels at loop detectors.
- Finally, the current dual-loop algorithm used by the WSDOT throws away many potentially useful vehicle measurements. A new dual-loop algorithm robust enough to address loop detector noises and capable of correcting imperfect vehicle measurements would further improve speed and truck count data.

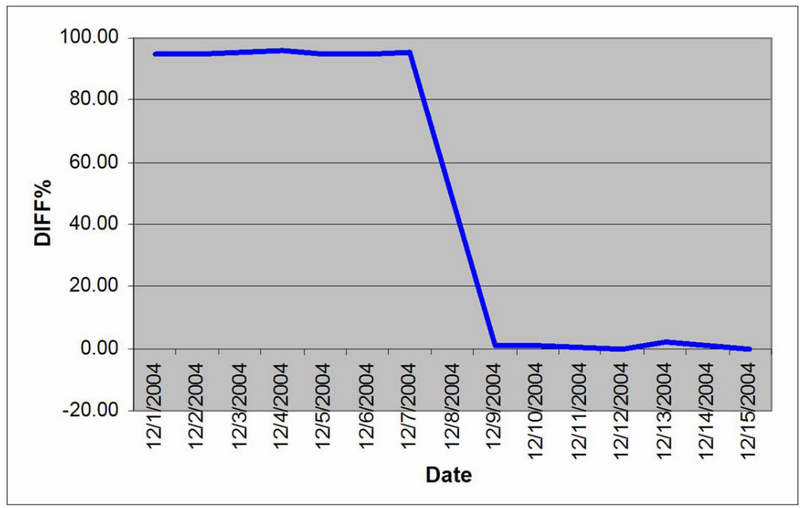

Figure 4