Cluster Analysis-Based Procedure to Identify Time-of-day Breakpoints for Coordinated Semi-actuated Traffic Signal System

Rui Guo, Ph.D. Candidate; Advisor: Dr. Yu Zhang
Department of Civil and Environmental Engineering, University of South Florida, Tampa

INTRODUCTION

• The basic premise behind traffic signal control is to develop signal timing plans that are best suitable for expected traffic conditions for particular dates or times.
• Considering the variation of the traffic in the day, it is necessary to determine a various number of cycle lengths with different phase plans and the times of day when they should be implemented.
• Current day plan schedules are usually determined roughly by traffic engineer or signal technician personnel based on their practical experience, which comes from the rough analysis of traffic flow data.
• In this paper, we study coordinated semi-actuated mode for multiple intersections in an arterial corridor and apply an advanced clustering analysis taking the time of traffic occurring into account as an additional dimension. The new method incorporates the hierarchical clustering and K-means clustering, which significantly improves the performance of the method.

LITERATURE REVIEW

Multiple types of documents were reviewed:
1. The Rough Approach—Expert decision based on practical experience.
2. The Typical Approach—Plot aggregate traffic volumes, and identify significant changes in traffic volume at the critical intersection
3. Current Studies—Genetic Algorithm(GA)
   Cluster Analysis
   Others(AIS, ANN, etc.)

Major challenges of applying cluster analysis-based approach:

• Adequate considerations of time-space features of traffic data
• A systematic procedural framework that could be easily implemented by traffic engineers

Our study fills in the gaps and tackles the challenges by proposing an improved advance cluster analysis and a framework for practical implementation.

METHODOLOGY

Cluster Analysis

In cluster analysis, traffic volume samples taken during a single TOD interval are “clustered” closely together according to their similarities, or, more accurately, the distance between them.

a) Consideration of Cluster Elements
   This is one of the most important steps in cluster analysis since data samples are usually multidimensional. To account for the difference in scale between all variables, the values should be standardized properly.

b) Selection of Cluster Numbers
   It is one of the most critical techniques in cluster analysis to determine the optimal number of clusters, which is correlated to the performance of day plan schedule.

c) Identification of TOD Breakpoints
   Clustering algorithm is also an important consideration involved in conducting a successful cluster analysis.

PROPOSED PROCEDURE

Data Collection

- 24 Hour Volumes
- 15 Minute Intervals
- Turning Movement Counts (TMCs)
- Cycle Length
- Off set

Cluster Analysis

- Consideration of Cluster Elements
- Selection of Number of Clusters
- Identification of TOD Breakpoints

Signal Optimization

- Spots
- Cycle Length
- Off set

Simulation

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4

Comparison of Performance Measure

RESULTS

Consideration of Cluster Elements

Due to the inherent continuous nature of traffic volume through the day, the time of traffic occurring is considered as one dimension in our study.

Selection of Cluster Numbers

Two criteria, the Silhouette measure and the Gap-statistic measure, are used in this paper for identifying the proper number of clusters.

Identification of TOD Breakpoints

The K-means clustering successfully identifies the traffic patterns based on average weekdays’ 15-minute traffic volumes and time of traffic occurring.

DATA COLLECTION

- 24 Hour Volumes were collected from a local major east-west arterial Hillsborough Avenue, Hillsborough County, Florida, by HNTB and Albeck Gerken, Inc. from March 9 to 15, 2010.
- Turning Movement Counts (TMCs) were collected by HNTB and Albeck Gerken, Inc. as well from March 23 to 30, 2010.
- Existing data of traffic signal timing and phasing were obtained from the ATMS now server of Hillsborough County.

Simulation & Improvement

Four scenarios are generated for the simulation analysis in order to fully investigate the effectiveness of the improved method and procedure.

CONCLUSION & FUTURE WORK

- An advanced cluster analysis was proposed to identify Time of Day breakpoints for coordinated semi-actuated signal timing mode where the operations of multiple intersections need to be considered simultaneously.
- The proposed methodology considers the time of traffic occurring as one dimension of the clustering and incorporates the hierarchical clustering and K-means clustering, which significantly improves the performance of the method.
- The results of traffic simulation reveal that the proposed procedure performs better than the existing TOD signal timing plans. This cluster analysis-based procedure has high potential for implementation in the real world.
- Efforts are needed to show how to estimate the number of clusters while both directions of the traffic are considered, and on performing sensitivity analysis for different cluster numbers.

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