AITVS: Advanced Interactive Traffic Visualization System

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1 Introduction

Transportation and the highway network form the backbone of the total public infrastructure system. As such, planning and monitoring for an effective transportation system is crucial in the building and maintenance of a region's economy and safety. However, demand for road travel continues to expand as population increases (particularly in the metropolitan areas) while new constructions have not kept pace. According to the Federal Highway Administration, it is forecasted that the volume of freight movement alone is to nearly double by 2020 [1]. Congestion and looming gridlock crises seriously threaten any region's mobility, safety and economic vitality. A crucial component in addressing these concerns is the development of specific technologies to monitor, model, and optimize traffic flow.

We have developed the ***A***dvanced ***I***nteractive ***T***raffic ***V***isualization ***S***ystem (AITVS), a web based traffic visualization system, to help mitigate these very concerns by providing novel and comprehensive visualization components to analyze and monitor traffic conditions. Existing transportation visualization applications exhibit some useful but limited tools for in-depth exploration and study. Hence, the current sets of traffic visualization systems [2-4] are only appropriate for use with travelers and commuters. As a consequence, they do not provide the critical instruments for comprehensive study and research as necessitated by traffic researchers and emergency planners alike. AITVS mitigates the shortcomings of existing systems by providing a rich set of multidimensional visual components (see Table 1) combined with fast user-response times. AITVS attributes its high-performance from the use of various database optimization techniques and the delegation of visual data processing to the application layer in order to achieve quick user-response times of 1-5 seconds for each graph query.

Table 1: AITVS features.

ITS	Visualization Features
AITVS	Volume x Time plot, Speed x Time plot, Occupancy x Time plot, Volume x Date plot, Speed x Date plot, Occupancy x Date plot, Volume x Station plot, Speed x Station plot, Occupancy x Station plot, Date x Day of Week plot, Station x Date plot, Station x Day of Week plot, Time x Day of week plot, Malfunction detectors, Prediction plots, extended range historical plots, roadmap with selectable station nodes

2 AITVS – Advance Interactive Traffic Visualization System

In general, the subjects of analysis in a multidimensional data model are a set of numeric measures. Each of the numeric measures is determined by a set of dimensions. In a traffic data, for example, the measures are speed, volume, and occupancy, with time and space being its dimensions. Dimensions are hierarchical by nature. For example, the time dimensions can be grouped into 'Week,' 'Month,' 'Season,' or 'Year'. Similarly, the space dimensions can be grouped into 'Station,' 'County,' 'Freeway,' or 'Region.' Given the dimensions and hierarchy, the measures can be aggregated into different combinations. For example, for a particular highway and a chosen month, the weekly traffic volumes can be analyzed. The concept of data cube is the engine behind AITVS. A data cube is used to generate the union of a set of alphanumeric summary tables corresponding to a given hierarchy. Based on this concept, AITVS organizes the album of generated visualization using a given hierarchy to support browsing via roll-up, drill-down, and other operations on aggregation hierarchy.

The AITVS was developed as the work of Virginia Tech's Spatial Data Management Group. AITVS is a multiple view system, which has been defined as a system that uses two or more distinct views to support the investigation of a single conceptual entity. Multiple views can provide utility in terms of minimizing some of the cognitive overhead engendered by a single, complex view of data. The system presents information in various formats to observe and analyze traffic trends. In the underlying data structure, the spatial information has been modeled as a spatial data warehouse to facilitate the use of a query engine for the on-line analytical processing in the

AITVS architecture follows a three-tier structure. It integrates the visualization engine, the web server, and the

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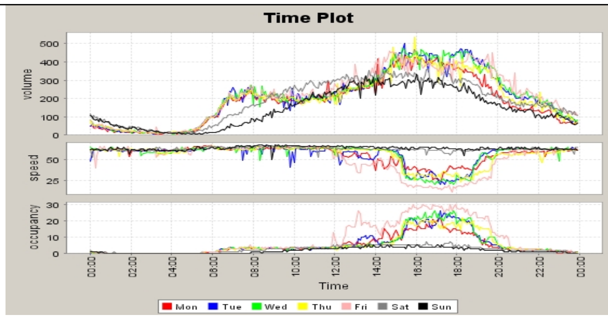

Figure 1(A)

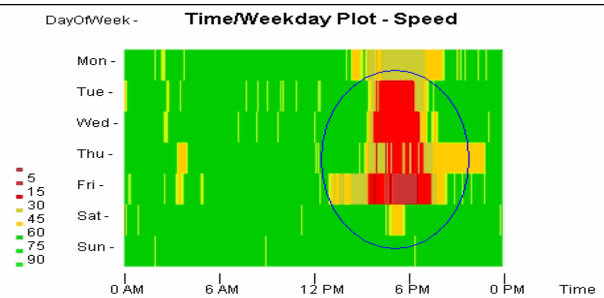

Figure 1(B)

Figure 1: Time of Day vs. Day of Week Plot: Shows speed, volume, and occupancy of all seven days in a week for each time of day.

database server. These three components together provide a web-based visualization system. The data cube engine is developed with Java and runs under J2EE compatible web server. AITVS generates on-the-fly JPEG images and HTML in order to furnish the web interface. We have developed a dedicated service running at the backend to process real-time raw traffic data and to store the data into the database. The overall user response time of the system is from one to five seconds. Historic data is stored in the database and can be accessed for any selected time by the users. The standard web-based interface provides users with convenient access to the system. The AITVS provides six distinct and essential visualization components that comprehensively cover the various performance metrics of a roadway system. The visualizations are as follows: Time Plot, Date Plot, Highway Station Plot, Highway Stations vs. Time Plot, Highway Stations vs. Day of the Week Plot, and Time vs. Day of Week Plot.

3 Demonstration

We will demonstrate six sets of visualization modules. Figure 1 (depicts one of our six visualization modules) corresponds to the **Time of Day vs. Day of Week Plot**. In Figure 1(A), the X-axis indicates the time and the Y-axis shows volume, speed, and occupancy, respectively. This graph amalgamates values for each day of the week in Feb 2005. We can observe a recurrent afternoon (4-6PM) rush hour commute during the weekdays as indicated by the peaks (volume and occupancy plots) and valleys (speed plot) on the series graph. Figure 1(B) depicts the identical traffic data, with the X-axis as time, Y-axis as the days of the week, and the colors as speed values. Here, the red region at around 4-6PM indicates afternoon rush hour which corresponds to the peaks and valleys mentioned above in Figure 1(A). The graph also indicates that for an average Friday in Feb 2005, afternoon rush hour start early at 2PM. For both visualization components, users may select the highway station node and aggregated range of dates.

4 Discussion

The concepts of visualization have proven to be highly useful for identifying patterns in large spatial data sets. We have developed these techniques in AITVS and applied them to analyze traffic data. These interactive visualization techniques make the knowledge discovery process much less burdensome, thus facilitating the usage of the transportation data. In addition to visualization, data mining techniques can be employed for data analysis and filtration. One such technique is the identification of outliers, which plays an important role in automatically recognizing abnormal situations and non-recurrent congestions. Future direction of this work will address issues in supporting adaptive user interfaces based on users' expertise and requirements. AITVS can be accessed at http://spatial.nvc.cs.vt.edu/traffic

5 References

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