Mapcube and Mapview
Two Web-based Spatial Data Visualization and Mining Systems

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Introduction: Spatial Data Analysis

- Discover useful information from spatial data sets
  - Frequent and interesting spatial patterns for post processing (knowledge discovery)

Knowledge Discovery Tools
- Spatial data clustering, classification
- Spatial outlier detection
- Spatial data visualization
- Spatial association: co-location rule
  - Drought & fire & pine tree
- Time-related spatial pattern: trends, sequential patterns analysis
  - Land use and land cover
Introduction: Spatial Data Analysis

- Advanced spatial analysis tools
  - Handle explosive growth of spatial data
  - Automatically transform the processed data into useful information and knowledge
  - Support of visualization and data mining process
  - Support interactive user control over spatial data processing
  - Easy to utilize and disseminate results
Introduction

- **Mapcube & Mapview**
  - Web-based spatial data analysis tool
  - Implemented in Java + CGI + MySQL
  - Integrate data mining techniques with interactive graphical interface
  - Identify spatial patterns and temporal trends
Mapcube

A web-based spatial analytical software

- High performance spatial visualization system for traffic data
- Support various visualization utilities
  - Traffic video
  - Highway time map
  - Traffic video comparison
  - 2-D data cube map
- Support outlier detection

Applications

- Decision-making for transportation managers
- Commuting route selection for commuters
- Traffic model establishment for researchers and planners
Spatial-Temporal Dimensions

- Available
  - $T_{TD}$ : Time of Day
  - $T_{DW}$ : Day of Week
  - $T_{MY}$ : Month of Year
  - $S$ (traffic application) :
    - Station, Highway, Regions

- Others
  - Weather, Seasons, Event types, ...
Traffic Dimensions

- Station
- Time of day
- Date (Day of Week)
Subsets of Dimensions

\[ T_{TD} T_{DW} T_{MY} S \]

\[ T_{TD} T_{DW} S \]

\[ T_{TD} T_{DW} \quad T_{DW} S \quad ST_{TD} \]

\[ T_{TD} \quad T_{DW} \quad S \]
Dimension Pair: $T_{TD} - T_{DW}$

Configuration:
- X-axis: Time of day; Y-axis: Day of week
- $f(x,y)$: Avg. volume over all stations for Jan 1997

Trends:
- Evening rush hour broader than morning rush hour
- Rush hour starts early on Friday.
- Wednesday - narrower rush hour
**Dimension Pair: S-T**

**Configuration:**
- X-axis: Time of day
- Y-axis: Highway I-35W North Bound
- f(x,y): Avg. volume over all stations for 1/15, 1997

**Trends:**
- 3-Cluster
  - North section: Evening rush hour
  - Downtown area: All day rush hour
  - South section: Morning rush hour
- S-Outliers
  - station ranked 9th
  - Time: 2:35pm
- Missing Data
Dimension Pair: $S-T_{TD}$

- Show traffic volume of a specific station of a highway in color graph
- Display the traffic volume of a specific station during a date
Dimension Pair: $T_{DW-S}$

Configuration:
- X-axis: stations on I35W South; Y-axis: day of week
- $f(x,y)$: Avg. volume over all stations for Jan-Mar 1997

Trends:
- Busiest segment of I-35W South is b/w Downtown MPLS & I-62
- Saturday has more traffic than Sunday
- Outliers – highway branch
T_{TD} T_{DW} S: Comparison of Traffic Video

Configuration: Traffic volume on Jan 9 (Th) and 10 (F), 1997

Trends:
- Evening rush hour starts earlier on Friday
- Congested segments: I-35W (downtown MPLS – I-62);
  I-94 (MPLS – St. Paul); I-494 (intersection I-35W)
Configuration:
- Outer: X-axis (month of year); Y-axis (highway)
- Inner: X-axis (time of day); Y-axis (day of week)

Trends:
- Morning rush hour: I-94 East longer than I-35 W North
- Evening rush hour: I-35W North longer than I-94 East
- Evening rush hour on I-94 East: Jan longer than Feb
MapView

- A spatial analysis software
  - Facilitate the observation and study of the US census data.
  - Support the visualization of census data, as well as spatial outlier detection.
  - Support five spatial outlier detection algorithms.
    - Spatial Statistics (Z-value algorithm)
    - Moran Scatterplot
    - Scatterplot
    - Iterative Ratio Algorithm
    - Iterative Z-value Algorithm

- A Web-based GUI Application
  - Developed in Java
  - Graphical representation of US Census Data
  - Interactive user interface
An execution example of MapView

Select a county to display its population in 2001 and its neighbors
An execution example of MapView

User input for the number of spatial outliers
An execution example of MapView

Display result in a new window and mark the detected spatial outliers
West Nile Virus Data Set

West Nile Virus Map (Veterinary) 2002
Conclusions

- Huge amount of spatial data set
- Data **visualization** and data **mining** are useful tools for discovering useful information
- Cube-view: a visualization software for traffic data
  - Provide roll-up, drill down, slice operations on spatial-temporal dimensions
  - Observe the summarization of **spatial patterns** and **temporal trends**
- Map-view: a spatial analysis tool for census data
  - Support various spatial outlier detection algorithms
  - Discover abnormal spatial patterns
Future Directions

- **Spatial Granularity**
  - Provide zoom-in, zoom-out functionalities
  - Support other data warehouse operations, such as drill-down, roll-up, slice, and dice

- **Spatial-Temporal outlier detection**
  - Support mining temporal data

- **3D visualization: Java 3D**

- **Other Spatial Data Mining**
  - Spatial association rule (co-location rule)

- **Include Other Data Sets**
Future Directions

- Compute and display local statistics
  - Spatial auto-correlation
  - Moran’s index
- Support different classification methods
  - Equal distance
  - Equal number
- Other Visualization Techniques
  - Parallel coordinates
  - Scatterplot
  - Histogram
  - Pie chart
Links

- Cubeview: [http://europa.nvc.cs.vt.edu/~ctlu/Project/MapView/index.htm](http://europa.nvc.cs.vt.edu/~ctlu/Project/MapView/index.htm)
- Mapview: [http://europa.nvc.cs.vt.edu/~ctlu/Project/MapCube/mapcube.htm](http://europa.nvc.cs.vt.edu/~ctlu/Project/MapCube/mapcube.htm)
Related Publications

- Chang-Tien Lu, Dechang Chen, Yufeng Kou, Detecting Spatial Outliers with Multiple Attribute, IEEE International Conference on Tools with Artificial Intelligence, 2003
Q & A

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