Mining Bus Location, Passenger Count and Fare Collection Database for Intelligent Transit Applications

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Industrial Partner: Metro Transit

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Outline

- Description of Data Obtained from Metro Transit
- Potential Applications of Data Mining
  - Bus scheduling and planning
  - Transfer and Access Analysis
- Summary and On-going Research
Summary of Data from Metro Transit

Obtained 1-Month of Bus AVL/APC/AFC Data

- 120+ routes, 1600+ time points (TP)
- 15,000+ stops; 10,500+ nearside stops (67%)
- 4.2 million Automatic Vehicle Location (AVL) raw data
- 3.4 million Automatic Passenger Count (APC) processed records (0.5 million at time point), about 30% of fleet equipped with APC
- 2.1 million fare collection (GoTo Card) transaction data
Time Points and Stops

Stop Level

- Board/Alighting Available on APC Equipped Buses (25-30%)
- Smart Card Transaction Time
- Match APC Data to Each Stop by Location
- Arrival/Departure Time Unknown (AVL Poll Every Minute)

In addition to the data at the stop level:
- Check-In/Check-Out Time Available

Time Point Level
Challenges

How to transform the massive data into useful information and support decision-making

Data | Information | Applications
Transit Performance Analysis Framework

Database Model
- Schedule Data
- AVL Data
- APC Data
- Farecard Data

Transit Database

Arterial Traffic Data

Measures
- Running Time
- Dwell Time at Stop
- Delay at Signal
- Transfer Activity

Applications
- Route Performance
- Anomaly Detection
- Ridership Analysis
- Schedule Adjustments
- Bus Travel Time
- TSP Deployment Suggestions
- Visualization
- Real Time Service Management

Environmental Factors (Accidents, Incidents, Weather, etc.)
Potential Applications

- **Route Performance Analysis (TP or Stop Level)**
  - Study delay caused by signal
  - Minimize holding at TP and improve speed & productivity

- **Transfer Activity and Access Behavior Analysis**
  - Use AVL and AFC data to infer boarding location
  - Origin and destination analysis
  - How far do people travel to access transit?

- **Many others, such as TSP**
  - Run time schedule decision support
Application I Route Performance Analysis

• TP or Stop Level Dwell Model

• Segment / Link Travel Time Analysis

• Route Model
Prototype of TP Level Analysis GUI

Time Point Analysis

Link Analysis

Route Analysis
Bus Arrival Adherence at Time Point FAUN

Adherence: 84%

Graph: Nov08-16E-FAUN-All-Arrival Adherence (901)

Arrival (min) - Late(+), Early(-)

Early
Late
Bus Dwell Time Variation During Time of Day at Time Point FAUN

![Graph - Adherence](image.png)

**Nov08-16E-FAUN-All-Dwell (24)**

- **Dwell-AVG**
- **Dwell-85 Percentile**
- **Dwell-15 Percentile**
- **Dwell**

**Time of Day (hr)**

**Dwell Time (Min)**

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Actual and Scheduled Link Travel Time
From FAUN To SNUN

Nov2008-16E-All-FAUN->SNUM - Travel Time (24)
Example Route On-Time Performance Measure

Route 16

On-time Adherence 89%

All Routes

On-time Adherence 90%
Time-Space Diagram

- On time
- Early
- Late
- Time of Day (hr)
- Headway
- Slope = Average Speed
- Dwell Time

Bus Location (Mile)

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Time Point FAUN and SNUN

- **FAUN** - Fairview & University
- **SNUN** - Snelling & University

- **16 E - Nearside Stops**
- **16 E - Farside Stops**
- **Midway Hospital**
Application II — Transfer & Access Analysis

- Transfer Activities
- Transit Access Behavior
GoTo Card Transaction Analysis, User X

158 Trips, 79 Transfers, 79 Tap On
GoTo Card Transfer Analysis, User X

- Route 675 Headway at Peak Hours: 30 min.
- Route 18 Headway at Peak Hours: 8-10 min.
- AM Transfer Time from Route 18 to 675: 13 min.  
  (Min=2 min., Max=38 min. <Miss Earlier Bus?>)
- PM Transfer Time from Route 675 to 18: 4 min.  
  (2 Outliers, 54 min. and 57 min., attend other activities in downtown Minneapolis after returning from work?)
UMN MetroPass - Access to Transit Analysis

- Geocode UMN MetroPass Addresses Using 2005 Twin Cities Street Map From Metropolitan Council
- Compute Traveling Distance from Address to all Tap-On Transaction Locations
- Distribution of Traveling Distance to Access Transit
- Single User Origin to Destination Information
UMN MetroPass Distribution of Access Distance

Mean=4262.59 m (2.65 mile), Median=414 m (0.25 mile), 5th-percentile=44 m (0.03 mile), 95th-percentile=25721 m (16 mile), 99th-percentile=38684 m (24 mile), Maximum=58014 m (36 mile)
MetroPass Access to Transit Analysis, User UM1
MetroPass Transit O-D Analysis, User UM1

Nov2008-Smart Card-Access Distance Distribution - Single User (31)

- Tap On (A)
- Tap On (B)
- Tap On (C)

Travel Distance to Access Transit (mile) vs Frequency %

Access Distance Distribution - Single User
Summary

- Developed a transit data analysis methodology to process AVL/APC and AFC (GoTo Card) data systematically
- Opportunities in assisting transit agencies to evaluate the performance of transit network systematically
- Transfer activities and access behavior analyses utilizing the results from the transit data processing
Ongoing Work

- Develop a route based transit simulation model to evaluate,
  - Schedule
  - Route productivity and reliability
  - Stop spacing
  - Limited stop services
  - Recovery time
  - Bus Rapid Transit (BRT) and/or TSP

- A tool to support transit planning and scheduling
Thank You!

Metro Transit

Bus Arrival Info.

Automatic Fare Collection

Signal Priority

The Digital Technology Center
a center of the Institute of Technology

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