Absenteeism Prediction and Extra-Board Driver Scheduling for Metro Transit

Xiaochen Zhang

University of Minnesota
Joint work with Qie He (UMN) and Soniya Somani

November 1, 2018
Outline

- Motivation
- Existing Results
- Prediction Model
- Experiment Results
The Minneapolis Metro Transit operates 127 bus routes with over 250,000 annual riders. Its extensive network of bus service employs more than 1500 operators at five garages.
Assigned runs of regular drivers can be open work because of absences, personal day-off, and injuries.

- According to the U.S. Bureau of Labor Statistics (2018), the absence rate was 3%, and the lost worktime rate was 1.7% in transportation occupations in US for 2017.

The amount of open work can vary a lot daily and seasonally.

**Figure: Number of Open Work**

![Figure: Number of Open Work](image-url)
### Motivation

#### Table: Goal and Performance of Call Driver Utilization YTD October 2017

<table>
<thead>
<tr>
<th>Metric</th>
<th>Nicollet</th>
<th>Heywood</th>
<th>Ruter</th>
<th>South</th>
<th>East</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>65%</td>
<td>65%</td>
<td>65%</td>
<td>65%</td>
<td>65%</td>
<td>65%</td>
</tr>
<tr>
<td>Utilization</td>
<td>58.5%</td>
<td>81.4%</td>
<td>56.1%</td>
<td>53.8%</td>
<td>69.5%</td>
<td>62.2%</td>
</tr>
</tbody>
</table>

#### Table: Goal and Performance of Late Pullouts YTD October 2017

<table>
<thead>
<tr>
<th>Metric</th>
<th>Nicollet</th>
<th>Heywood</th>
<th>Ruter</th>
<th>South</th>
<th>East</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Lost Pullouts</td>
<td>4</td>
<td>25.2</td>
<td>14.6</td>
<td>1.8</td>
<td>2.8</td>
<td>48.7</td>
</tr>
</tbody>
</table>
Existing Results

General Absenteeism Prediction:

- Job satisfaction [Schaumberg and Flynn, 2017] [Cohen and Golan, 2007]
- Prior absent history [Ivancevich, 1985]
- Driver information such as age [Markussen et al., 2011], gender [Markussen et al., 2011] [Laaksonen et al., 2008].
Existing Results

Absenteeism Prediction in Transportation:

- Individual level absence likelihood prediction [Strathman et al., 2009] [Strathman et al., 2012]
- Aggregated level absence prediction [Diab et al., 2014]
- ...
Prediction Model

Figure: Frequency of Different Absence Types
Hierarchical Prediction Model

1. Logistic regression on each layer
2. Features
   - Work information (month, day of the week, start hour)
   - Driver information (gender, age, sick carry)
   - Weather information (precipitation)
Hierarchical Prediction Model

Test Procedure:

1. Individual absence likelihood:

\[ p_{\text{absence}} = p_{\text{planned}} + (1 - p_{\text{planned}}) p_{\text{sick}} + (1 - p_{\text{planned}})(1 - p_{\text{sick}}) p_{\text{unplanned}} \]

2. Aggregated number of absences: Add up all the absence probabilities
## Experiment Results

Table: Basic Statistic and Errors in 2016

<table>
<thead>
<tr>
<th>Avg Number of Pieces of Work</th>
<th>Avg Number of Open Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>1705</td>
<td>173</td>
</tr>
<tr>
<td>Mean Squared Error (Individual)</td>
<td>Mean Aggregated Error</td>
</tr>
<tr>
<td>0.05143759</td>
<td>9.2388</td>
</tr>
</tbody>
</table>
Experiment Results

**Figure**: Comparison Between Predicted and Realized Values of Summer 2016

![Graph showing comparison between predicted and realized values of Summer 2016](image_url)
Figure: Coefficients of Months in Planned Absence Model
Figure: Coefficients of Day of the Week in Unplanned Absence Model
Summary

We

- Developed a hierarchical prediction model helping dispatcher predict daily absenteeism.
- Provided insights on important features for absenteeism.

Future Application:

- Help to decrease the absence rate
- Realtime open work assignment algorithm
Thank you!