Customer-Oriented Evaluation Method of Railway Performance

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Outline

1. Background
2. Motivation
3. Data stored in ticketing gate
4. Definition of SCORE
5. Calculation Flow
6. Case Study
7. Result of SCORE
8. The feature of SCORE data
9. Visualization Tool
10. Demos
11. Conclusion & Future work
1. Background

• Transport network is being complex
• Passengers:
  – Demand higher quality service for transport
• Operators:
  – Want to respond passengers’ needs
  – Need to evaluate their operation
  – Seek to find a new solution for the train operation
• ICT environment is improving
  – The data of ticketing gates are gathered to the server
  – Smart card user have been increased
2. Motivation

- Improve quality of the transport service
- Establish the Key Performance Index (KPI) for transport operation from the view of passengers
  - Grasp the passengers behavior
  - Understand the effect for disruption
  - Find a new idea for the operation
  - (Praise the dispatcher)
- Obtain an insight of computer algorism for a next generation train control system
3. Data stored in ticketing gate

- Most of stations in Tokyo Metropolitan area installed auto ticketing gate
  - Recoding in and out time to Smart cards and tickets
  - Store the time and ID and transmit to the station server
- The station servers send the data to the center server
- A travel time for each passenger can be calculated
4. Definition of SCORE [1/3]

**SCORE** (Scale for Customer-Oriented Railway Evaluation)

Before the definition...

The distribution of passengers’ total extra time (additional time by the accident)

- **Starting time** (disruption occurred)
- **Ending time** (disruption finished)
- **Stopping time** (=> Sub SCORE I)
- **Reoperation time**
- **Recovery time** (=> Sub SCORE II)
- **Disruption time** (=> SCORE)
4. Definition of SCORE [2/3]

SCORE (Scale for Customer-Oriented Railway Evaluation)

\[ \text{SCORE} = \log \left\{ \sum_{ts=tss}^{tse} [T_{\text{extra}}(ts)] \right\} \]  \hspace{1cm} (*)

\[ T_{\text{extra}}(k, ts) = pn(k, ts) \times [tm(k, ts) - st(k, ts)] \]  \hspace{1cm} (1)

\[ T_{\text{extra}}(ts) = \sum_{k=1}^{n} [T_{\text{extra}}(k, ts)] \]  \hspace{1cm} (2)

\[ \text{Total}_{-}T_{\text{extra}} = \sum_{ts=tss}^{tse} [T_{\text{extra}}(ts)] \]  \hspace{1cm} (3)
4. Definition of SCORE  [3/3]

Other Effective Indicators

\[ T_{extra}(ts)_{pp} = \frac{T_{extra}(ts)}{pn(ts)} \] \hspace{1cm} (1)

\[ Sub \, SCORE \, I = \log\left\{ \sum_{ts=tss}^{tsr} [T_{extra}(ts)] \right\} \] \hspace{1cm} (2)

\[ Sub \, SCORE \, II = \log\left\{ \sum_{ts=tsr}^{tse} [T_{extra}(ts)] \right\} \] \hspace{1cm} (3)
5. Calculation Flow

- There are six steps to calculate the SCORE data

1. Input Disruption Information
   - Disrupted Line
   - Time of Occurrence
   - Re-operating Time

2. Datasets
   - Transfer Master Data
   - Direct or Parallel Line Master Data
   - Judge the Affected Origin and Destination Stations
   - Origin and Destination Stations Data

3. Transfer Log

4. Calculate the Travel Time
   - Normal Day Travel Time Distribution
   - Disruption Day Travel Time Distribution

5. Calculate the Extra Time

6. Calculate Indicators
   - Total Extra Time, Extra Time per Passenger
   - Rate of Affected Passenger
   - SCORE, SCORE I, SCORE II

Result Files

There are six steps to calculate the SCORE data.
6. Case Study

**Disruption Case**

<table>
<thead>
<tr>
<th>Case</th>
<th>Date</th>
<th>Time of Occurrence</th>
<th>Re-operating Time</th>
<th>Line</th>
<th>Disruption Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4³ Feb 2010</td>
<td>10:30</td>
<td>11:50</td>
<td>A</td>
<td>b/w sta. K and sta.O2</td>
</tr>
<tr>
<td>2</td>
<td>15³ July 2011</td>
<td>13:34</td>
<td>14:32</td>
<td>A,B</td>
<td>sta. T</td>
</tr>
<tr>
<td>3</td>
<td>23³ May 2011</td>
<td>7:12</td>
<td>8:17</td>
<td>A</td>
<td>sta. A</td>
</tr>
</tbody>
</table>

**Line Map**

**Dispatchers’ Operation**

<table>
<thead>
<tr>
<th>Case</th>
<th>Operation Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>- Stopped all sections on line A (No turn around operation)</td>
</tr>
<tr>
<td>2</td>
<td>- Turn around operation at sta. K (7 trains)</td>
</tr>
<tr>
<td></td>
<td>- Turn around operation at sta. I (2 trains)</td>
</tr>
<tr>
<td></td>
<td>- Operated b/w sta. S2 and sta. Y on line D instead of line B (8 trains)</td>
</tr>
<tr>
<td></td>
<td>- Direct operation from line C b/w sta. H1 and sta. S1</td>
</tr>
<tr>
<td>3</td>
<td>- Stopped all sections on line A (No turn around operation)</td>
</tr>
<tr>
<td>4</td>
<td>- Turn around operation at sta. K on line A (4 trains)</td>
</tr>
<tr>
<td></td>
<td>- Turn around operation at sta. H2 on line A (6trains)</td>
</tr>
<tr>
<td></td>
<td>- Turn around operation at sta. O1 on line B (1 train)</td>
</tr>
<tr>
<td></td>
<td>- Extra train departures from sta. H2 (6trains)</td>
</tr>
<tr>
<td></td>
<td>- Extra train departures from sta. K (4 trains)</td>
</tr>
</tbody>
</table>

*Turn around operation conducted*
7. Result of SCORE

<table>
<thead>
<tr>
<th>Case</th>
<th>Duration Time of Disruption</th>
<th>Actual Duration Time</th>
<th>SCORE</th>
<th>Sub SCORE I</th>
<th>Sub SCORE II</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1:20</td>
<td>2:00</td>
<td>6.08</td>
<td>6.00</td>
<td>5.32</td>
</tr>
<tr>
<td>2</td>
<td>0:58</td>
<td>0:48</td>
<td>5.64</td>
<td>5.64</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0:56</td>
<td>1:33</td>
<td>6.63</td>
<td>6.61</td>
<td>5.37</td>
</tr>
<tr>
<td>4</td>
<td>1:26</td>
<td>3:44</td>
<td>6.79</td>
<td>6.52</td>
<td>6.46</td>
</tr>
</tbody>
</table>

- Comparing Case 1 and Case 2, the SCORE of Case 1 is higher than the one of Case 2
  ⇒ Turnaround operation is effective for the passenger

- Comparing Case 3 and Case 4, the SCORE of Case 3 is lower than the one of Case 4
  ⇒ But, the Sub SCORE I of Case 3 is higher than one of Case 4,
    the Sub SCORE II of Case 3 is lower than Case 4,
  ⇒ Turnaround operation is effective!
  Especially, during the time of train operation stopping, the turnaround operation is much more effective
  But, after re-operating, it is more difficult to recovery when the dispatcher conduct a turnaround operation.
8. The features of SCORE data

- SCORE data becomes higher during peak time
- Compared in the same time period, the distributed SCORE data means a difference of the disruption influence and/or operational result.

Disruption during rush hour

Scatterplots of SCORE data
9. Visualization Tool

- The impact of the disruption can be seen as a heat map.
- The SCORE data set by the selected conditions can be compared with previous data.
10. Demos

How does the dispatcher review disruptions?
11. Conclusion and Future Work

- A new evaluation method for railway operation “SCORE(Scale for Customer Oriented Railway Evaluation)” proposed.
- SCORE enables the operator to enhance their operational quality from the viewpoint of passengers with the scientific skill.
- The visualization tool for understanding the train disruption was developed.
- SCORE has an enough potential for marketing, planning, making strategy and so on.
Fin.

Thank you!