Application of Digital Tachograph Data for Commercial Vehicle Safety in Korea

Korea Transportation Safety Authority
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What is Digital Tachograph?
What is Digital Tachograph (DTG)?

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<thead>
<tr>
<th>영역</th>
<th>항목</th>
<th>데이터건수</th>
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</thead>
<tbody>
<tr>
<td>운행기록정보</td>
<td>TripKey, DTG 모델명, 차대번호, 자동차 등록번호, 일일주행거리, 누적주행거리, 차량속도, 브레이크 신호, 분당 엔진회전수 (RPM), 차량 위치 정보</td>
<td>약 3,600억 건</td>
</tr>
<tr>
<td>운행기록통계</td>
<td>엄중범 급출발, 급가감속, 급회전 등 위험운전행동 발생 통계</td>
<td>약 3.6 억건</td>
</tr>
</tbody>
</table>

교통안전법 제55조에 의거하여 사업용 차량(버스, 택시, 화물차)에 운행기록장치 장착이 의무화 됨.
### What is Digital Tachograph (DTG)?

<table>
<thead>
<tr>
<th>Column name</th>
<th>Length</th>
<th>Remarks</th>
<th>Column name</th>
<th>Length</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip Key</td>
<td>27</td>
<td>Brake Signal</td>
<td>Model Name</td>
<td>20</td>
<td>GPS X</td>
</tr>
<tr>
<td>VIN (Vehicle Identification Number)</td>
<td>17</td>
<td>Unidentified</td>
<td>Licence Plate Number</td>
<td>12</td>
<td>Unidentified</td>
</tr>
<tr>
<td>Vehicle Type</td>
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<td>Azimuth</td>
<td>Business Registration Number</td>
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<td>Unidentified</td>
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<tr>
<td>License Plate Number</td>
<td>5</td>
<td>Acceleration Speed X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business Registration Number</td>
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<td>Acceleration Speed Y</td>
<td>5</td>
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<tr>
<td>Driver Code</td>
<td>18</td>
<td>Communication Status Code</td>
<td>Travel Distance for One Day</td>
<td>4</td>
<td>Travel Area Code</td>
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<tr>
<td>Total Travel Distance</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>RPM</td>
<td>5</td>
<td>Company Code</td>
<td>Speed</td>
<td>3</td>
<td>Travel Date</td>
</tr>
<tr>
<td>Speed</td>
<td>3</td>
<td>Unidentified</td>
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</tr>
</tbody>
</table>
Application 1: Prediction for Hazardous Section of Gyeongbu Expressway
Data

Traffic Status
- Traffic Volume (VDS)
- Travel Speed

Driver
- Digital Tacho Graph
- Risk Driving Behavior

Environments
- Road Center Line Data
- Altitude
Correlation Analysis

between Traffic Accident Rate and Risky Driving Behavior
Prediction for Risky Driving Behavior

Digital Tacho Graph Data

Potential Risky Driving Behavior

Critical Value

Actual Risky Driving Behavior

Predicted Risky Driving Behavior

<table>
<thead>
<tr>
<th>Actual Risky Driving Behavior</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td>YES</td>
<td>Actual Risky Driving Behavior</td>
<td>Actual Risky Driving Behavior</td>
</tr>
<tr>
<td>NO</td>
<td>Potential Risky Driving Behavior</td>
<td>Normal Driving Behavior</td>
</tr>
</tbody>
</table>

Using Machine Learning (SVM: Support Vector Machine) Model
Prediction of Hazardous Section by Risky Driving Behavior Type

Analysis Data

- Integrated Data
  - Bus DTG
  - VDS Volume
  - VDS Avg. Speed
  - Altitude

Pre Processing

- Correlation Analysis
  - Independent Variable: Integrated Data
  - Dependent Variable: Risky Driving (Y/N)
    - Continuous Variable: t test
    - Nominal Variable: Chi-Square Test
- Remove unnecessary variables
- Standardization Continuous Variable
- Generate data for analysis
  - Risky Driving Data + integrated Data
  - Risky Driving Behavior Rate 1:1
  - 70% Studying 30% Validation

Big Data Analysis

- Support Vector Machine
  - Kernel Trick
    - Radial Basis
    - Sigmoid
    - Linear
    - Polynomial
- Regression Analysis
  - Ridge Logistic Regression

Model Validation

- Total Integrated Data
- Calculation Target Rate
- Selection Best Model
Prediction Result by Sudden Lane Changing

Northbound

Southbound
Prediction for Hazardous Section with Abnormal Driving Behavior

Hypothesis
Drowsy Driving: Abnormal Driving Behavior
Abnormal Driving Behavior: Speeding pattern, RPM, Braking
Prediction Results of Driving Behavior using LSTM Deep Learning
Pridiction Model for Hazardous Section to Drive

Y (Risk Index) = Sudden Acceleration Risk Index * 0.261 + Sudden Deceleration Risk Index * 0.383 + Sudden Lane Changing Risk Index * 0.356
Prediction Results for Hazardous Section to Drive
### Prediction Results for Hazardous Section to Drive

<table>
<thead>
<tr>
<th>순위</th>
<th>위험지수</th>
<th>상세 내역</th>
<th>지도</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NorthBound</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 1 | 0.610 | 부산기점 403.1km  
- 위험지수: 0.610  
- 5년간 사고건수: 24  
  (사망:4,중상:12,경상:22,부상:116)  
- 과속 위험지수: 0.003  
- 급가속 위험지수: 0.092  
- 급감속 위험지수: 0.372  
- 급진로변경 위험지수: 0.147  
- 이상행동 위험지수: 0.673 | ![NorthBound 1.png](attachment:image1.png) |
| 2 | 0.498 | 부산기점 420.1km  
- 위험지수: 0.498  
- 5년간 사고건수: 0  
  (사망:0,중상:0,경상:0,부상:0)  
- 과속 위험지수: 0.043  
- 급가속 위험지수: 0.206  
- 급감속 위험지수: 0.251  
- 급진로변경 위험지수: 0.041  
- 이상행동 위험지수: 0.799 | ![NorthBound 2.png](attachment:image2.png) |
| 3 | 0.452 | 부산기점 403km  
- 위험지수: 0.452  
- 5년간 사고건수: 3  
  (사망:0,중상:13,경상:4,부상:9)  
- 과속 위험지수: 0.005  
- 급가속 위험지수: 0.091  
- 급감속 위험지수: 0.261  
- 급진로변경 위험지수: 0.101  
- 이상행동 위험지수: 0.494 | ![NorthBound 3.png](attachment:image3.png) |
| **South Bound** | | | |
| 0.518 | 부산기점 421.6km  
- 위험지수: 0.518  
- 5년간 사고건수: 0  
  (사망:0,중상:0,경상:0,부상:0)  
- 과속 위험지수: 0.000  
- 급가속 위험지수: 0.261  
- 급감속 위험지수: 0.040  
- 급진로변경 위험지수: 0.217  
- 이상행동 위험지수: 0.823 | ![SouthBound 1.png](attachment:image4.png) |
| 0.463 | 부산기점 391.9km  
- 위험지수: 0.463  
- 5년간 사고건수: 0  
  (사망:0,중상:0,경상:0,부상:0)  
- 과속 위험지수: 0.027  
- 급가속 위험지수: 0.015  
- 급감속 위험지수: 0.282  
- 급진로변경 위험지수: 0.167  
- 이상행동 위험지수: 0.050 | ![SouthBound 2.png](attachment:image5.png) |
| 0.414 | 부산기점 403.2km  
- 위험지수: 0.414  
- 5년간 사고건수: 7  
  (사망:1,중상:30,경상:7,부상:22)  
- 과속 위험지수: 0.000  
- 급가속 위험지수: 0.019  
- 급감속 위험지수: 0.116  
- 급진로변경 위험지수: 0.279  
- 이상행동 위험지수: 0.363 | ![SouthBound 3.png](attachment:image6.png) |
Prediction Results for Hazardous Section to Drive
Prediction Results for Hazardous Section to Drive
Future Application

- Expendig Analysis Area
  - Using Nationwide Data

- Standardized Model
  - Modeling for General Area

- Application to Safety Management
  - Using Analyzed Data

Hazardous Section Alert Service

Establishment Safety Facility Installation Policy
Application 2: COSAS
Consulting Oriented Safety Assistance System
Introduction to COSAS (Consulting Oriented Safety Assistance System)
Road Safety Grade Model (1/3)

Road SPF Development

\[ EPDO_{predicted} = AADT^{\beta_1} + length^{\beta_2} \times \exp(\text{intercept} + ddra\beta_3 + lanes\beta_4) \]

- To build SPF, poisson model was selected.

Dependent variable

- EPDO: the predicted traffic accident severity (2015~2016)

Explanatory variable

- AADT: annual average traffic volume
- length: length of the segment
- ddra: sum of 11 hazardous driving behavior from Digital tacho Graph data (2015~2016)
- lanes: number of lanes
Road Safety Grade Model (2/3)

Road Safety Grade Model Development

- Estimating road safety grade model using SPF-based mean EPDO of reference group.
- Road safety grade is divided into four grades such as A through D.
Service

Road Safety Grade Model (3/3)

도로안전등급

<table>
<thead>
<tr>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>A</td>
<td>D</td>
</tr>
</tbody>
</table>

도로안전순위: 110,745 / 691,797 (상위16.01%)
SSM (surrogate Safety Measure) for Commercial Vehicle Drivers

- **Regression equation**

\[ ePDO = \beta_0 + \beta_1 \text{AGE} + \beta_2 \text{EXPERIENCE} + \beta_3 \text{JOB CHANGE} + \beta_4 \text{VIOLATION} + \beta_5 \text{PREVIOUS CRASH} \]

- ePDO: ePDO by drivers (fatalities: 12, Injured: 3)
- AGE: Age of drivers
- EXPERIENCE: Months of driver experience
- JOB CHANGE: Number of job changes of drivers
- VIOLATION: Number of traffic violations of drivers
- PREVIOUS CRASH: Crash history (Last 3 years)

- **Variables**

1) Drivers’ Basic Information
   - Age
   - Gender (excluded because female drivers are extremely rare in the DB)
   - Driver experience (in Months)

2) Drivers’ driving records
   - Violation
   - Crash history
   - Job changes

3) Dependent Variable: Equivalent Property Damage Only (ePDO)
   - \( ePDO = 12 \times \text{Fatalities} + 3 \times \text{Injured} + 1 \times \text{Property Damage Only} \)
SSM (Surrogate Safety Measure) for Commercial Vehicle Company

- **Variables**
  1) **Driving Distance**: Digital Tachograph (DTG)
  2) **Dangerous Driving Behavior Events** *(11 categories)*
     - Speeding, Long-term speeding
     - Rapid Start, Rapid Acceleration
     - Rapid Stop, Rapid Deceleration
     - Abrupt Steering, Abrupt Overtaking
     - Abrupt Turns (Left/Right), Abrupt U-turns
  3) **Dependent Variable**: Equivalent Property Damage Only (ePDO)
     - $ePDO = 12 \times \text{Fatalities} + 3 \times \text{Injuries} + 1 \times \text{Property Damage Only}$
Service: Commercial Vehicle Company & Driver Safety Grade

<table>
<thead>
<tr>
<th>Service: Commercial Vehicle Company &amp; Driver Safety Grade</th>
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</thead>
<tbody>
<tr>
<td><strong>Safety Grade</strong></td>
</tr>
<tr>
<td><strong>Service</strong></td>
</tr>
<tr>
<td><strong>Grade</strong></td>
</tr>
<tr>
<td><strong>Remarks</strong></td>
</tr>
</tbody>
</table>

- **Safety Grade**: B
- **Service**: Commercial Vehicle Company & Driver Safety Grade
- **Grade**: B
- **Remarks**: Note 1: 2018-10 - 2019-09
  - **11 단위 차량 운행 중**: 45%
  - **11 단위 차량 운행 중**: 55%
  - **11 단위 차량 운행 중**: 65%
  - **11 단위 차량 운행 중**: 75%

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**Safety Grade**: B

  - **11 단위 차량 운행 중**: 55%
  - **11 단위 차량 운행 중**: 65%
  - **11 단위 차량 운행 중**: 75%
  - **11 단위 차량 운행 중**: 85%

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**Safety Grade**: B

  - **11 단위 차량 운행 중**: 65%
  - **11 단위 차량 운행 중**: 75%
  - **11 단위 차량 운행 중**: 85%
  - **11 단위 차량 운행 중**: 95%

---

**Safety Grade**: B

  - **11 단위 차량 운행 중**: 75%
  - **11 단위 차량 운행 중**: 85%
  - **11 단위 차량 운행 중**: 95%
  - **11 단위 차량 운행 중**: N/A
Future Plan

General User Service
Policy Support
Expanded Management
Q & A