METHODOLOGY (Continued)

**Subject to:** collision detection rate should be greater than 80%; average number of classified incidents per day should be less than one.

**Traffic Prediction Formulation:**

- Structure of recurrent neural network (RNN):
  - Two direct temporal dependencies:
    - The nature of time series: the speed distribution of the next 15-minute period (t + 1) is dependent on the speed distribution of the present 15-minute period (t).
    - Repeating time-of-day and day-of-week traffic patterns: the speed distribution of the next 15-minute period is dependent on the speed distribution of the 15-minute period of the same time of day and same day of week in the past week (t − m, where m = 60 × 24 × 7/15 − 1 = 671).
- Look-back steps of 3 accounting for the dynamics of traffic accumulation/dissipation.

**Data Description:**

- **Traffic detector data (provided by Virginia Department of Transportation):** continuously register the passing through vehicles and place them into different speed intervals.
- **Collision data (provided by Virginia Department of Motor Vehicles):** time and location of each reported collision.
- **Transportation:** continuously register the passing through vehicles and place them into different speed intervals.

**Definition and Assumption:**

- Incidents refer to all types of traffic disruptive events leading to nonrecurrent changes in their surrounding traffic flow characteristics.
- Incident detection accuracy (in terms of both detection rate and false alarm rate) is positively related to the collision detection accuracy.
- **Balancing Problem:** Objective: maximize the fraction of detected collisions to classified incidents.

**Motivation:**

- A need of processing information collected from roadway infrastructures and distributing real-time traveler information for proactive congestion and safety mitigation.
- Traffic detectors are widely used by different transportation agencies and are accessible as a prevailing source of descriptive traffic information.

**Limitations of Past Studies:**

- High-frequency (e.g., 30 second) flow, density and speed data required; no alternative measures explored.
- Incident data are assumed to be all inclusive requiring extensive manual efforts for inspections/verifications.

**Objective:**

Leverage existing traffic detector systems for automatic incident detection (AID) with traffic detector data in relatively low time resolution and with incomplete incident data.

**RESULTS**

**Statistics of Standardized RMSEs:**

![Graph](image)

**Detection Results:**

- Over 85% of the collisions can be detected.
- Detected collisions consist 5.3% of the classified incidents.
- Incident time occupies 1.3% of the total testing period.

**Limitation and Future Research Direction:**

- Only one incident type—collision—was analyzed. Data libraries of other types of traffic disruptive events, e.g., inclement weather and work zones, should be mined.
- Further classify incidents into different categories based on their spatial and temporal characteristics.

**Table 1. Comparison of Detection Results Between the proposed LSTM-RNN Algorithm and a Benchmark Algorithm**

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Number of Documented Collisions</th>
<th>Number of Detected Collisions</th>
<th>Collision Rate</th>
<th>Number of Classified Incidents</th>
<th>Collision to Incident Fraction</th>
<th>Incident Time Fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSTM-RNN Algorithm</td>
<td>282</td>
<td>241</td>
<td>65.5%</td>
<td>4554</td>
<td>0.053</td>
<td>0.013</td>
</tr>
<tr>
<td>Benchmark Algorithm</td>
<td>282</td>
<td>231</td>
<td>81.9%</td>
<td>11763</td>
<td>0.202</td>
<td>0.087</td>
</tr>
</tbody>
</table>

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**Figure 4. Statistical distributions of the standardized RMSE.**

**Figure 5. Illustration of incident detection.**

**CONCLUSIONS**

- Over 85% of the collisions can be detected.
- Detected collisions consist 5.3% of the classified incidents.
- Incident time occupies 1.3% of the total testing period.

**Reference:**