Problem Statement: Given $T$ observations of historical demands from $|V|$ regions, predict the demand values of these regions in the next time step.

$$f: \mathbb{R}^{|V| \times T} \rightarrow \mathbb{R}^{|V|}$$

Our Solution

**Spatio-Temporal Multi-Graph Convolution Network (ST-MGCN)**
- Encodes non-Euclidean correlations among regions into multiple graphs.
- Learns temporal gates to utilize global contextual information.
- 10+\% error reduction than SOTA methods on real-world large scale datasets.

Region-level Ride-hailing Demand Forecasting

<table>
<thead>
<tr>
<th>Applications</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher vehicle utilization</td>
<td>Multimodal non-Euclidean correlations among regions</td>
</tr>
<tr>
<td>Better Vehicle Dispatching</td>
<td>Complicated temporal dependencies among timestamps</td>
</tr>
<tr>
<td>Early congestion warning</td>
<td></td>
</tr>
</tbody>
</table>

ST-MGCN Framework

**Model Architecture**
- Encode pairwise correlations between regions using multiple graphs.
- Capture spatial dependency with multi-graph convolution.
- Generate predictions.

**Data Statistics**

<table>
<thead>
<tr>
<th>Region</th>
<th>Beijing</th>
<th>Shanghai</th>
</tr>
</thead>
<tbody>
<tr>
<td># Regions</td>
<td>1296</td>
<td>896</td>
</tr>
<tr>
<td>Duration</td>
<td>10 month</td>
<td>10 month</td>
</tr>
<tr>
<td># Samples</td>
<td>19M</td>
<td>13M</td>
</tr>
</tbody>
</table>

**Baselines**
- Historical Average (HA), LASSO, Ridge regression, Auto-regressive models (VAR), STAR, Gradient boosted machine (GBM).
- Spatio-temporal Residual Network (ST-ResNet); Deep Multi-view Spatio-temporal Network (DMVST-Net); Diffusion Convolutional Recurrent Neural Network (DCRNN); Spatio-temporal Graph Convolution Network (ST-GCN).

**Performance Comparison**

- ST-MGCN outperforms baselines by more than 10\% on both datasets.

**Effects of Spatial and Temporal Dependency Modeling**
- Removing either graph component results in significantly worse results.
- With CGRNN, ST-MGCN achieves the best performance.

**Effect of Incorporating Multiple Graphs**
- ST-GCN+ and DCRNN+: variants of ST-GCN and DCRNN with three graphs.
- With multiple graphs, both ST-GCN+, DCRNN+ achieve improved performance.