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LibCity: An Open Library for Traffic Prediction

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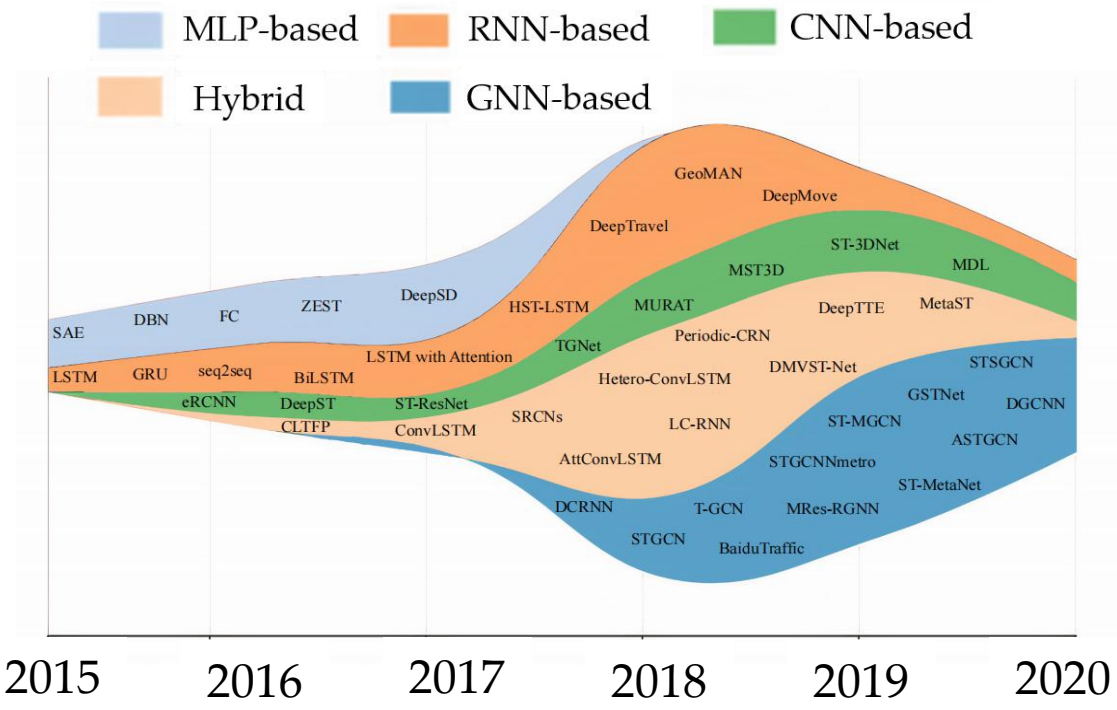
Background – Traffic Prediction

- **Traffic Prediction:** Estimating the future states of a traffic system using its historical data.
  - Traffic Speed **Prediction**
  - Traffic Flow **Prediction**
  - On-Demand Service **Prediction**
  - Next Location **Prediction**
  - Traffic Accidents **Prediction**
  - Travel Time **Estimation** (ETA)
  - ……



Ref: https://github.com/LibCity/Bigscity-LibCity-PaperList

A large number of **deep-learning-based** traffic prediction models have been proposed in recent years. **However……**

Background – Why do we propose LibCity ?

However, the increasement of new models has led to confusion in the research community……

Challenge 1

- It is ***difficult to reproduce*** these models, which is caused by the **poor open-source status.**

Challenge 2

- It is ***difficult to evaluate (compare)*** models, which is caused by the **non-standard datasets** and **opaque experiment setups**.

Difficult to **innovate**

- *The two challenges slow the development speed of traffic prediction.*

The traffic prediction field **needs a set of standard datasets and baselines,** like "ImageNet" in the computer vision field.

Goal – What does LibCity want?

- **"ImageNet" for traffic prediction**: building a ***Unified, Comprehensive, Extensible*** evaluation environment for the traffic prediction models.

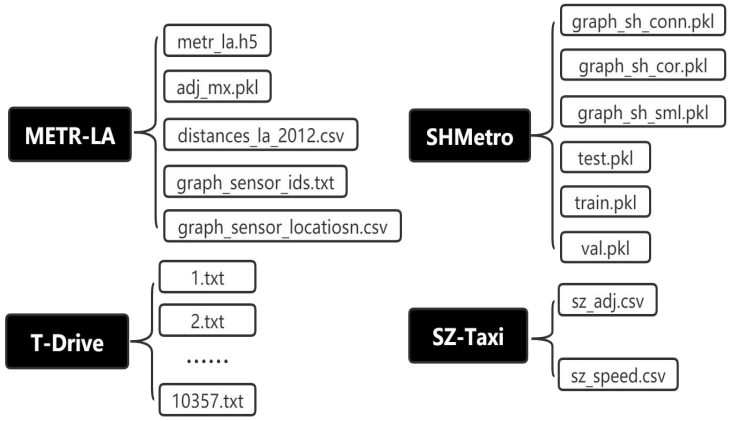
  - ***Unified***: Build a systematic pipeline to implement, use and evaluate traffic prediction models in a unified platform.
  - ***Comprehensive***: Cover mainstream traffic prediction tasks, reproduce classic baseline models, and integrate multiple spatiotemporal datasets.
  - ***Extensible***: Allow users to flexibly insert custom components into the library.

Open Source link: https://github.com/LibCity
Homepage link: https://libcity.ai

LibCity Modules – Standard Data Formats

- LibCity converts the inconsistent data formats of the different datasets as **standard atomic data formats**.

Inconsistent Dataset Format



Standardize

Standard Atomic Dataset Format

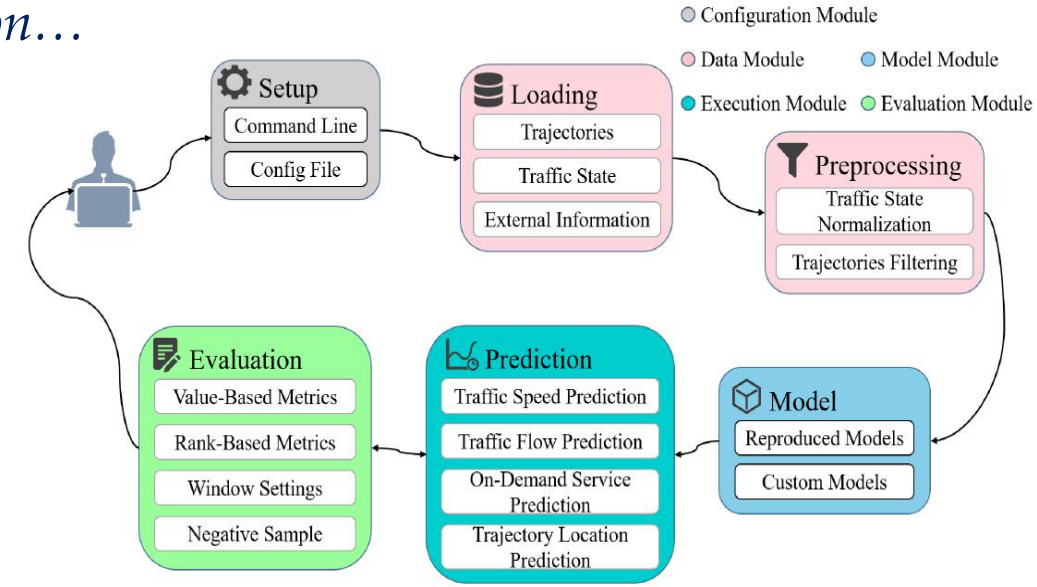
(A dataset consists of 5 basic atomic files)

xxx.geo	Store geographic entity attribute information.
xxx.usr	Store traffic user information.
xxx.rel	Store the relationship information between entities, such as road networks.
xxx.dyna	Store traffic condition information.
xxx.ext	Store external information, such as weather, temperature, etc.

LibCity Modules – Modular Task Flow

Data Modules → **Task Modules** → Model Modules → Application Modules

- LibCity deconstructs a traffic prediction task as a modular flow.
  - **Loading datasets:**
    - *Trajectories, traffic states, external information…*
  - **Data preprocessing:**
    - *Normalization, data filtering…*
  - **Model selection:**
    - *Traffic speed prediction models*
    - *Traffic flow prediction models, ……*
  - **Train and performance evaluation**
    - *Value-based metrics, Rank-based metrics, …*



Modular Task Flow

LibCity Modules – Rich Baseline Models

- Implemented a rich baseline model library in LibCity.
  - **5 classes of deep-learning-based models**
    - Traditional, CNN-based, RNN-based, GCN-based, Attention-based
  - Defined **standard model templates** for 9 types of tasks
    - Flow prediction, speed prediction, demand prediction, next-location prediction…

Table 1: The implemented models in LibCity.

Task	Traditional	CNN-based	RNN-based	GCN-based	Attention-based
Traffic flow prediction	AutoEncoder	ST-ResNet, ACFM, STDN	FC-RNN, Seq2Seq	AGCRN, CONVGCN, STSGCN, ToGCN, Multi-STGCnet	ASTGCN, ResLSTM, CRANN, DGCN, DSAN
Traffic speed prediction	AutoEncoder	–	FC-RNN, Seq2Seq	DCRNN, STGCN, GWNET, MTGNN, TGCN, TGCLSTM, ATDM, GTS	GMAN, STAGGCN, HGCN, ST-MGAT
On-Demand service prediction	AutoEncoder	DMVSTNet	FC-RNN, Seq2Seq	CCRNN	STG2Seq
Trajectory next-location prediction	FPMC	–	RNN, ST-RNN, ATST-LSTM, SERM, DeepMove, HST-LSTM, LSTPM, CARA	–	GeoSAN, STAN

LibCity Modules – Rich Baseline Models

- LibCity compared the implemented models over standard datasets.

DATASET	BEST METHOD	PAPER
METR-LA	MTGNN	[KDD2020]Connecting the Dots: Multivariate Time Series Forecasting with Graph Neural Networks
PEMS-BAY	GWNET	[IJCAI2019]Graph Wavenet for Deep Spatial-Temporal Graph Modeling
PEMSD4	GWNET	[IJCAI2019]Graph Wavenet for Deep Spatial-Temporal Graph Modeling
PEMSD8	GWNET	[IJCAI2019]Graph Wavenet for Deep Spatial-Temporal Graph Modeling
T-Drive20150206	MTGNN	[KDD2020]Connecting the Dots: Multivariate Time Series Forecasting with Graph Neural Networks
TAXIBJ2015	AGCRN	[NeurIPS2020]Adaptive Graph Convolutional Recurrent Network for Traffic Forecasting
NYCTAXI202001-202003-3600	DCRNN	[ICLR2018]Diffusion Convolutional Recurrent Neural Network: Data-Driven Traffic Forecasting

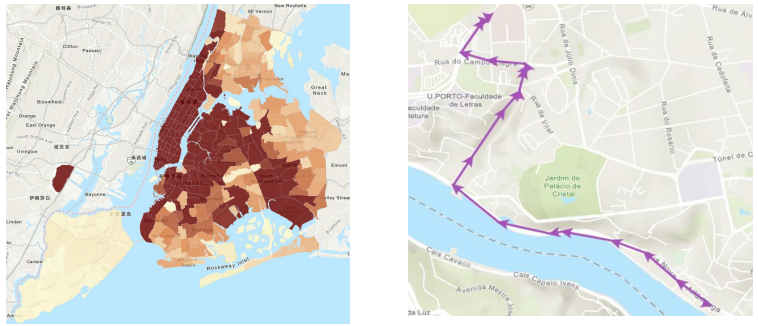
LibCity Modules – User-oriented Applications

Data Modules → Task Modules → Model Modules → **Application Modules**

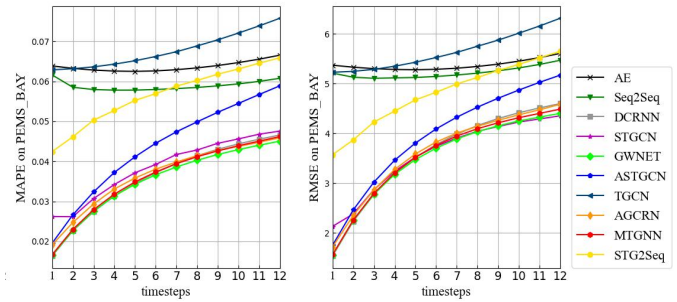
- LibCity contains 3 types of user-faced application tools.
  - Model evaluation pipeline tools (command-line)
  - Spatiotemporal data visualization tools
  - Experiment result visualization tools

```
16:45:52,787 - INFO - Start training ...
16:45:52,787 - INFO - num_batches:375
16:46:05,361 - INFO - epoch complete!
16:46:05,362 - INFO - evaluating now!
16:46:06,103 - INFO - Epoch [0/100] train_loss: 6.0138, val_loss: 5.0889, lr: 0.020000, 13.32s
16:46:06,105 - INFO - Saved model at 0
16:46:06,105 - INFO - Val loss decrease from inf to 5.0889, saving to ./libtraffic/cache/model_cache/RNN_METR_LA_epoch0.tar
16:46:18,531 - INFO - epoch complete!
16:46:18,532 - INFO - evaluating now!
16:46:19,269 - INFO - Epoch [1/100] train_loss: 4.7922, val_loss: 4.5311, lr: 0.020000, 13.16s
16:46:19,271 - INFO - Saved model at 1
16:46:19,271 - INFO - Val loss decrease from 5.0889 to 4.5311, saving to ./libtraffic/cache/model_cache/RNN_METR_LA_epoch1.tar
```

Command-line Tools



Data Visualization Tools

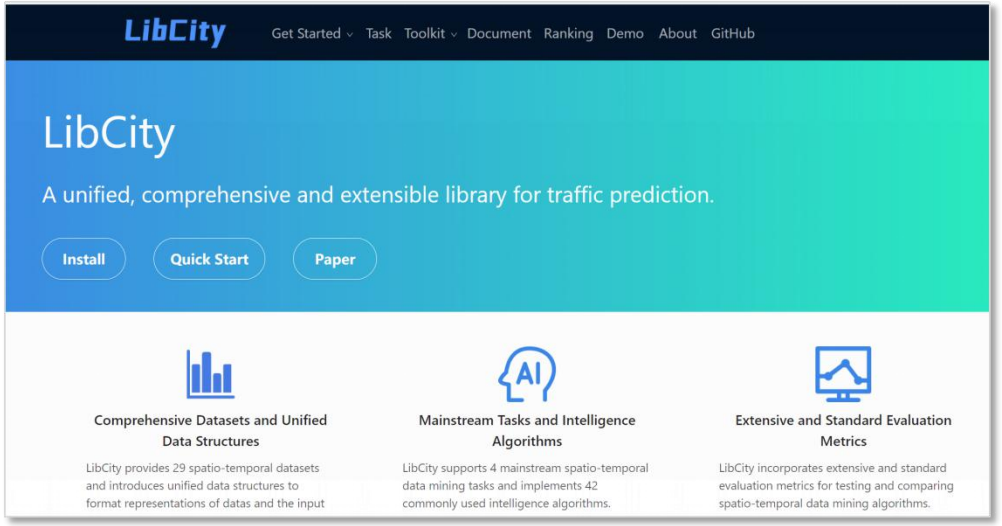


Experiment Result Visualization Tools

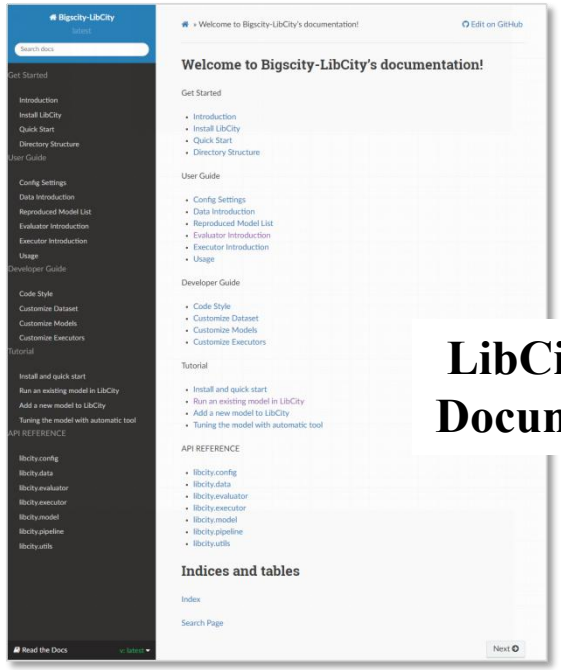
Libcity Modules – User-oriented Applications

Data Modules → Task Modules → Model Modules → **Application Modules**

- We also develop a project resource website – https://libcity.ai
- And maintenance detail online documentation
  - https://libcity.ai/Bigscity-LibCity-Docs/



LibCity Homepage



LibCity Online Documentations

Current State of Libcity

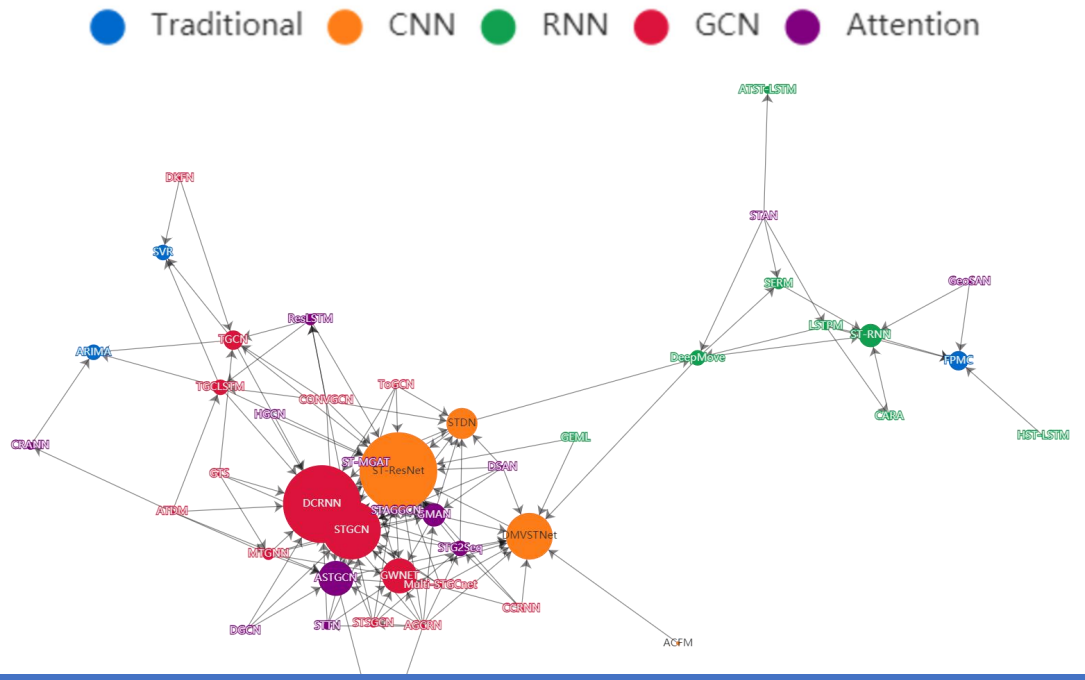
- Up to now, LibCity has covered **9 traffic prediction tasks**, **56 baseline models**, and integrated **32 spatiotemporal datasets.**

Supported Tasks List

Traffic Speed **Prediction,** Traffic Flow **Prediction,**
Traffic Demand **Prediction,** Next Location **Prediction,**
Traffic Accidents **Prediction,** Travel Time **Estimation,**
OD-Matrix **Prediction,** Road Representation,
Map Matching……

Datasets collected from 22 cities in 11 countries

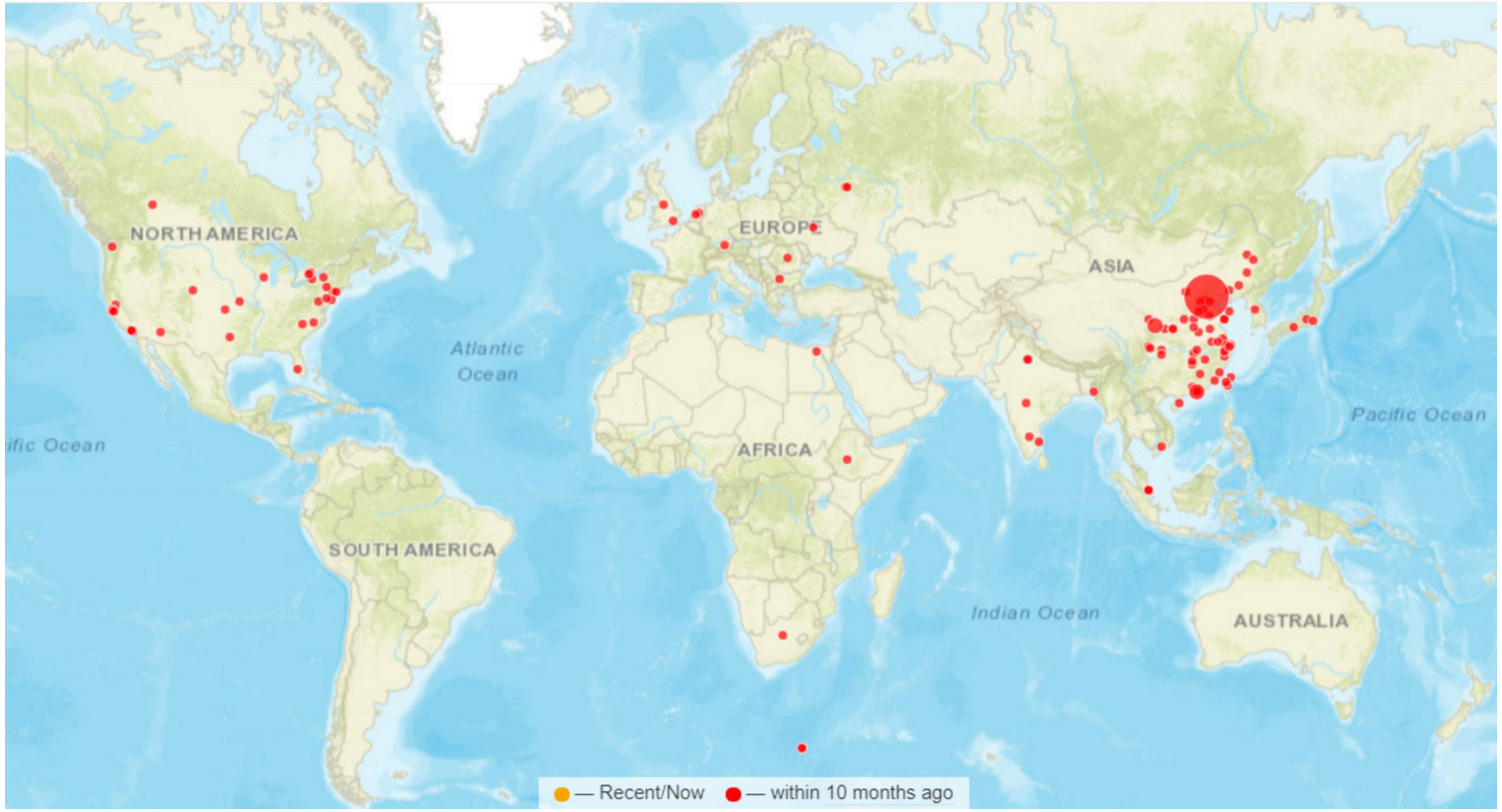
Citation Relation among the Models

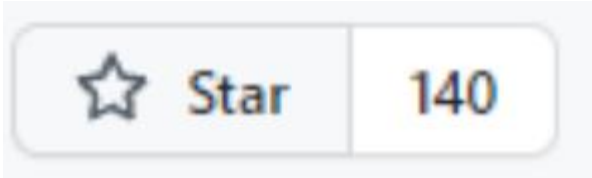


More importantly, **LibCity is an extensible framework**, which allows users to flexibly insert custom task, model, and dataset into the library.

Current State of Libcity

- LibCity has drawn much attention from 20 countries and got 140 stars on GitHub.com (top 3‰). More than 11 institutions use LibCity in their projects.





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