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Probabilistic Fine-grained Urban Flow Inference with Normalizing Flows

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Background

Fine-grained urban flow inference (FUFI) aims to infer the coarse-grained (CG) urban flow map to the corresponding fine-grained (FG) one, which plays an important role in efficient traffic monitoring and management in smart cities. In FUFI, the C-G map can be obtained with only a small number of monitoring devices, greatly reducing the over-head of deploying devices and the costs of maintenance, labor, and electricity.

Challenges

- Strict structural constraints, i.e., the sum of traffic flow within a certain region (subregions)in the inferred FG map is strictly equal to the sum of traffic flow in their corresponding superregion in the original CG map.
- The inference results are greatly affected by external factors (e.g., time and weather)

Contributions

- We propose UFI-Flow, a new model for addressing the FUFI problem. It mitigates the ill-posed problem and distribution fusion lost problem that widely existed in prior solutions.
- An augmented distribution fusion mechanism ADF is proposed to fuse the influence of external factors on the inferred flow distribution to improve performance.
- We conduct experiments on a two-scale FUFI dataset and our model significantly outperforms state-of-the-art baselines.

Methods

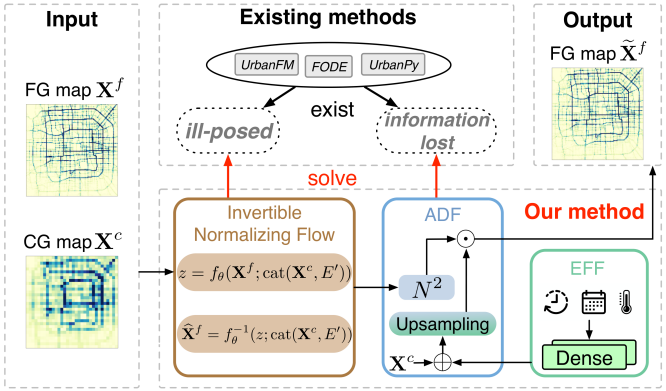


Figure 1: Overview of the proposed UFI-Flow architecture

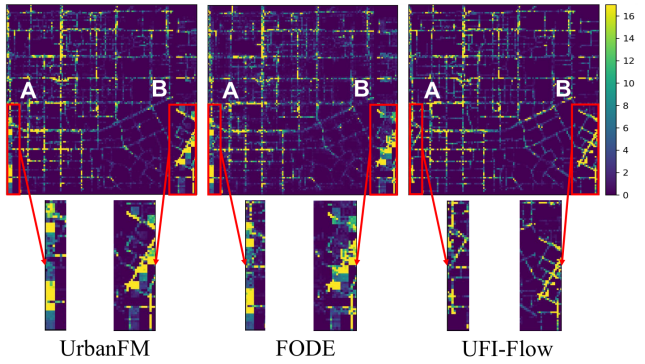
Experimental results

Table 2: Performance Comparison. The best performances are in bold and the second best performances are underlined.

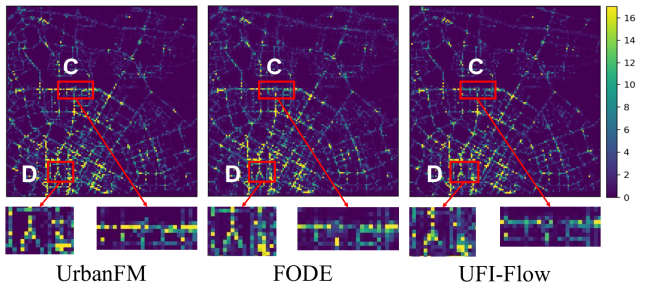
Dataset	DiDi-Xi'an			Taxi-BJ		
Metric	RMSE	MAE	MAPE	RMSE	MAE	MAPE
SRCNN	6.312	3.380	2.099	4.297	2.491	0.741
VDSR	5.182	2.702	1.741	4.159	2.213	0.467
SRResNet	5.063	1.799	0.922	4.164	2.457	0.713
UrbanFM	5.038	1.346	0.350	3.950	2.011	0.327
FODE	<u>4.860</u>	1.413	0.464	<u>3.860</u>	<u>1.963</u>	<u>0.313</u>
UrbanPy	5.210	<u>1.321</u>	<u>0.293</u>	3.950	1.995	0.329
UFI-Flow	**4.091**	**1.134**	**0.192**	**3.845**	**1.927**	**0.285**

Error visualization

Figure 2 shows the inference error between the generated FG map and the ground truth on the dataset. Brighter colors indicate larger errors compared to ground truth. To better visualize the inference errors, we focus on several selected areas, which marked as A, B, C and D. It is observed that UFI-Flow has much less bright pixels than baselines (UrbanFM and FODE).



(a) Error visualization on DiDi-Xi'an.



(b) Error visualization on Taxi-BJ.

Figure 2: Inference error visualization.