TPGNN-FedGPR: Triple Level Privacy-preserving Graph Neural Network for Federated Geographic POI Recommendation

Wenlong SHI, Jing ZHANG, Youqin CHEN, Xiucai YE, Hao LIAO

Frontiers of Computer Science, DOI: 10.1007/s11704-025-50721-5

Problems & Ideas

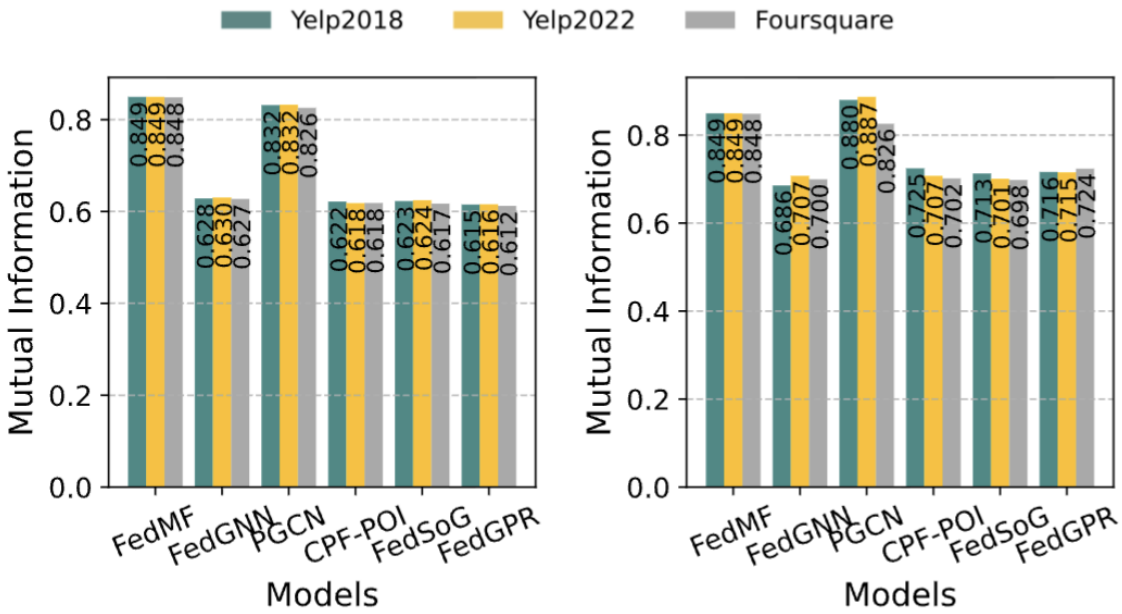
- Problems of existing (centralized / federated) POI recommendation approaches:
  - Centralized POI recommendation violates data-locality/privacy constraints.
  - Existing federated solutions still suffer from sparsity/cold-start, DP-induced utility loss, and high communication overhead.
- Ideas: A geography-aware federated GNN is proposed that integrates triple-level privacy protection and communication-efficient client selection to jointly improve recommendation utility under privacy constraints.

Method	Yelp2018		Yelp2022		Foursquare	
	MAE	RMSE	MAE	RMSE	MAE	RMSE
FedMF	1.650	2.074	2.188	2.691	1.953	2.317
FedGNN	1.209	1.525	1.226	1.552	1.078	1.411
P-GCN	1.591	2.016	1.985	2.334	1.906	2.355
CPF-POI	1.058	1.499	0.971	1.303	1.051	1.504
FedSoG	0.957	1.200	0.944	1.205	1.033	1.336
TPGNN-FedGPR	**0.899**	**1.147**	**0.921**	**1.178**	**0.883**	**1.272**
Improvement	6.1%	4.4%	2.4%	2.3%	14.5%	4.8%

Performance Comparison (MAE and RMSE). GNN-based models consistently outperform MF-based methods. Our proposed TPGNN-FedGPR achieves the best overall performance, with notable improvements over the strongest baseline (FedSoG): 6.1%/4.4% (MAE/RMSE) on Yelp2018, 2.4%/2.3% on Yelp2022, and 14.5%/4.8% on Foursquare.

Main Contributions

- Contributions:
  - A geographic-enhanced embedding strategy is proposed to alleviate the cold-start problem by incorporating spatial correlation;
  - A triple-level privacy-preserving mechanism is designed to resist membership inference and gradient inversion attacks;
  - A fuzzy clustering-based client selection method is employed to lower communication cost and accelerate convergence.



Comparison of mutual information of each model. FedGPR consistently achieves the lowest embedding gradient MI (avg. 0.614), indicating superior privacy protection over FedGNN (avg. 0.628), CPF-POI (avg. 0.619), and FedSoG (avg. 0.621) (Fig. 2(a)). While FedGNN attains the lowest model gradient MI via stronger noise (e.g.,0.686) (Fig. 2(b)), it incurs greater accuracy loss.