“Bike Sharing”+”Deep Learning”

A bike sharing system provides convenient and sustainable urban mobility to users, while a government solves problems such as traffic congestion, environment, resident health, etc. The general types of bike sharing system are dock-based and dockless systems, where a dock refers rental and return area for users. A dock-based system requires to install a number of bike docks at user accessible areas determined by comprehensive analyses on Point of Interest (PoI) and existing transportation systems. A dockless system provides better flexibility to user mobility by alleviated docking restriction that occurs additional maintenance cost due to sidewalk blocking or bike damage. The imbalance problem of bike supply-demand is inevitable for both system types as user mobility is accumulated based on topographical characteristics or spatial interests. A current solution for this problem frequently operates bike collecting and reallocating with other vehicles to rebalance bike distribution despite of its time intensive and high-cost operations.

Early studies on bike sharing system have correlated user demands with factors such as weather, built environment, public transportation, station level, socio-demographic effects, temporal factors, and safety [3, 4]. Most of related studies using Deep Learning (DL) targeted to optimize the imbalance problem by predicting user demand, bike supply, or their gap based on historical bike sharing data. The models conduct convolutional neural networks to learn spatial characteristics of target region data and recurrent neural network families to utilize temporal characteristics of mobility [5]. These models have evolved to improve prediction accuracy through graph neural networks [6] or clustering techniques [7] which extract the correlation of the docks or various influential factors. In recent studies, the prediction models improved accuracy performance using fusion layers and residual connections on multiple input data such as geographical or meteorological information, and mobility patterns [5][8]. The limitation of these studies is that prediction results or performances of deep learning models are mainly presented rather than focused on rebalancing problem which remains as a challenging task.

Datasets for model training and testing contains only bike rental and return location of the user trips, due to difficulties of collecting or analyzing huge amount of urban data. However, GPS tracking data of the user trips can improve user's experience of sharing bike. The bike sharing datasets in various regions such as New York, Washington DC, Chicago, Singapore, and Taipei are available online although detailed route information (i.e., GPS coordinates) are not included in the datasets. The GPS information enables real-time inference application to provide location-based services, since the data can specify the current locations of bikes (or users). For example, real-time movement pattern can track bike conditions or user emergencies, and can approximate optimal rebalancing strategy that includes location, quantity, or time by predicting bike flows. Moreover, accumulated GPS data with DL analysis can specify lower interest area of target city for urban reconstruction, and commercial district developments.

[1] Haoran Zhang, Xuan Song, Yin Long, Tianqi Xia, Kai Fang, Jianqin Zheng, Dou Huang, Ryosuke Shibasaki, Yongtu Liang, Mobile phone GPS data in urban bicycle-sharing: Layout optimization and emissions reduction analysis, Applied Energy, Volume 242, Pages 138-147, 2019.

[2] https://www.bbc.com/future/article/20210112-the-vast-bicycle-graveyards-of-china

[3] McKenzie, Grant. "Docked vs. dockless bike-sharing: Contrasting spatiotemporal patterns (Short Paper)." 10th international conference on geographic information science (GIScience 2018). Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik, 2018.

[4] Ezgi Eren, Volkan Emre Uz, A review on bike-sharing: The factors affecting bike-sharing demand, Sustainable Cities and Society, Volume 54, 2020.

[5] X. Li, Y. Xu, Q. Chen, L. Wang, X. Zhang and W. Shi, "Short-Term Forecast of Bicycle Usage in Bike Sharing Systems: A Spatial-Temporal Memory Network," in IEEE Transactions on Intelligent Transportation Systems, doi: 10.1109/TITS.2021.3097240.

[6] H. Zhu et al., "RedPacketBike: A Graph-Based Demand Modeling and Crowd-Driven Station Rebalancing Framework for Bike Sharing Systems," in IEEE Transactions on Mobile Computing, doi: 10.1109/TMC.2022.3145979.

[7] TAVARES, Bárbara; SOARES, Cláudia; MARQUES, Manuel. A Cluster-Based Trip Prediction Graph Neural Network Model for Bike Sharing Systems. arXiv preprint arXiv:2201.00720, 2022.

[8] M. Xu, H. Liu and H. Yang, "A Deep Learning Based Multi-Block Hybrid Model for Bike-Sharing Supply-Demand Prediction," in IEEE Access, vol. 8, pp. 85826-85838, 2020, doi: 10.1109/ACCESS.2020.2987934.