Spatial Planning of Urban Communities via Deep Reinforcement Learning

Yu Zheng, Yuming Lin, Liang Zhao, Tinghai Wu, Depeng Jin, Yong Li
Tsinghua University

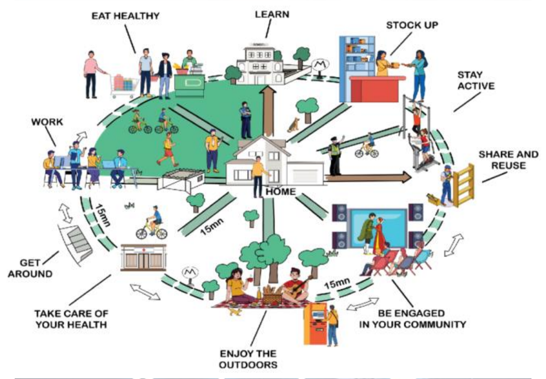
Urban Planning, 15-minute city, and AI

Current issues of centralized urban planning

- traffic congestion
- climate change (CO2, NO2 emissions)
- inequality
- health risk

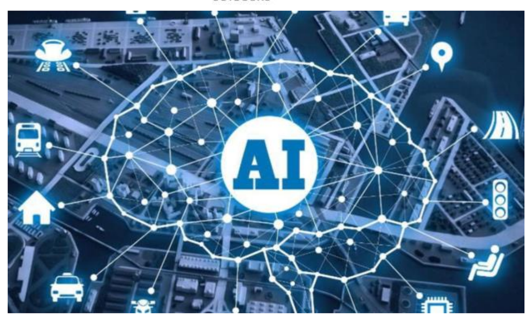
A new trend of urban planning: 15-minute city

- high spatial efficiency
- more accessible to basic urban services
- more sustainable and inclusive

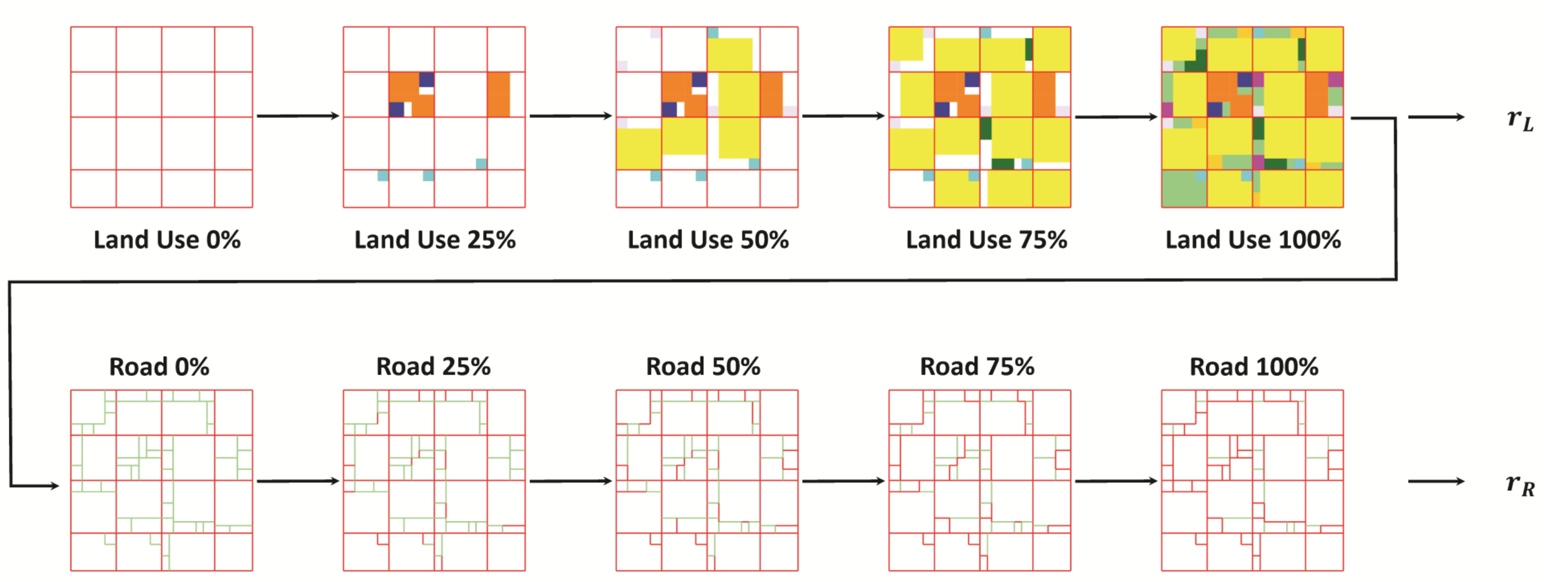


Why AI for urban planning

- accuracy in complex and multi-objective tasks
- efficiency and flexibility in generating adaptive plans
- success in similar planning tasks: Go, chip design



Community Spatial Planning as a Sequential Decision Problem



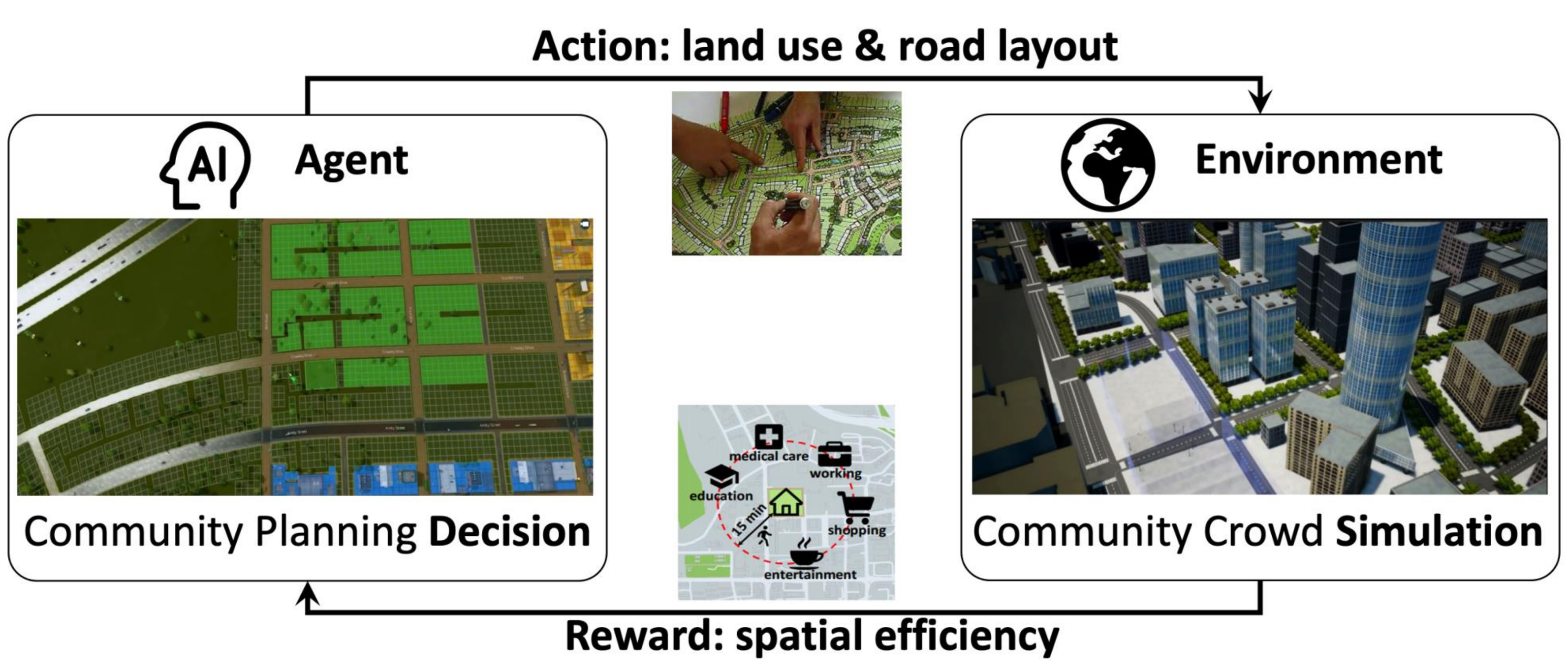
Stage I: Land Use Planning

- place one facility at each step
- reward: accessibility (15-min city)

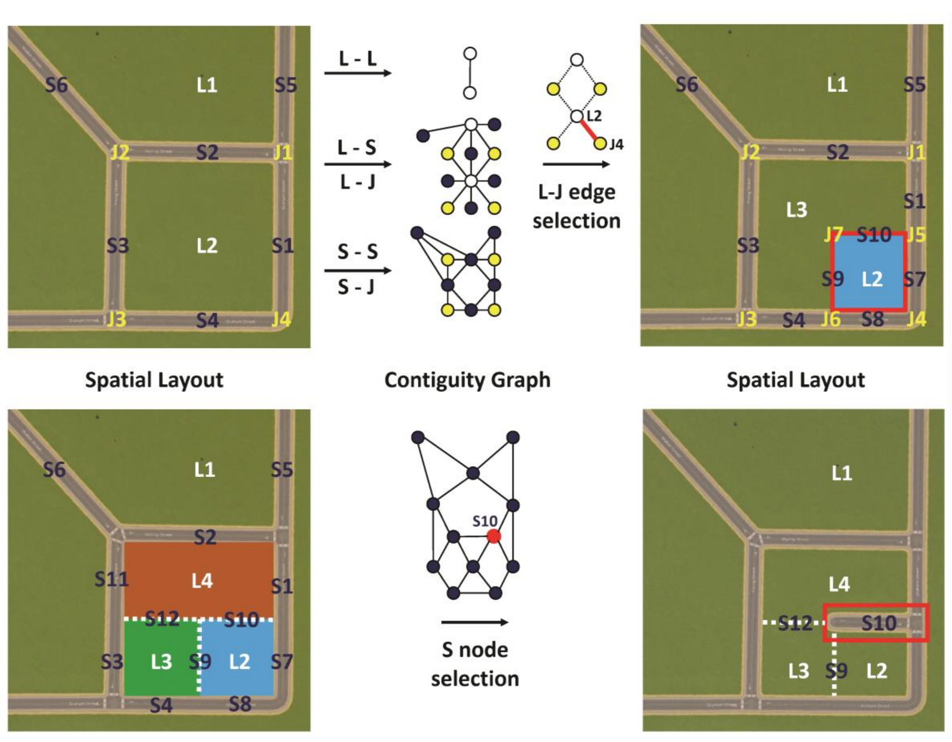
Stage II: Road Planning

- place one road segment at each step
- reward: traffic (density, connectivity)

Solving the Decision Problem with Deep Reinforcement Learning



Problem Reformulation with an Urban Contiguity Graph



Stage I: Land Use Planning

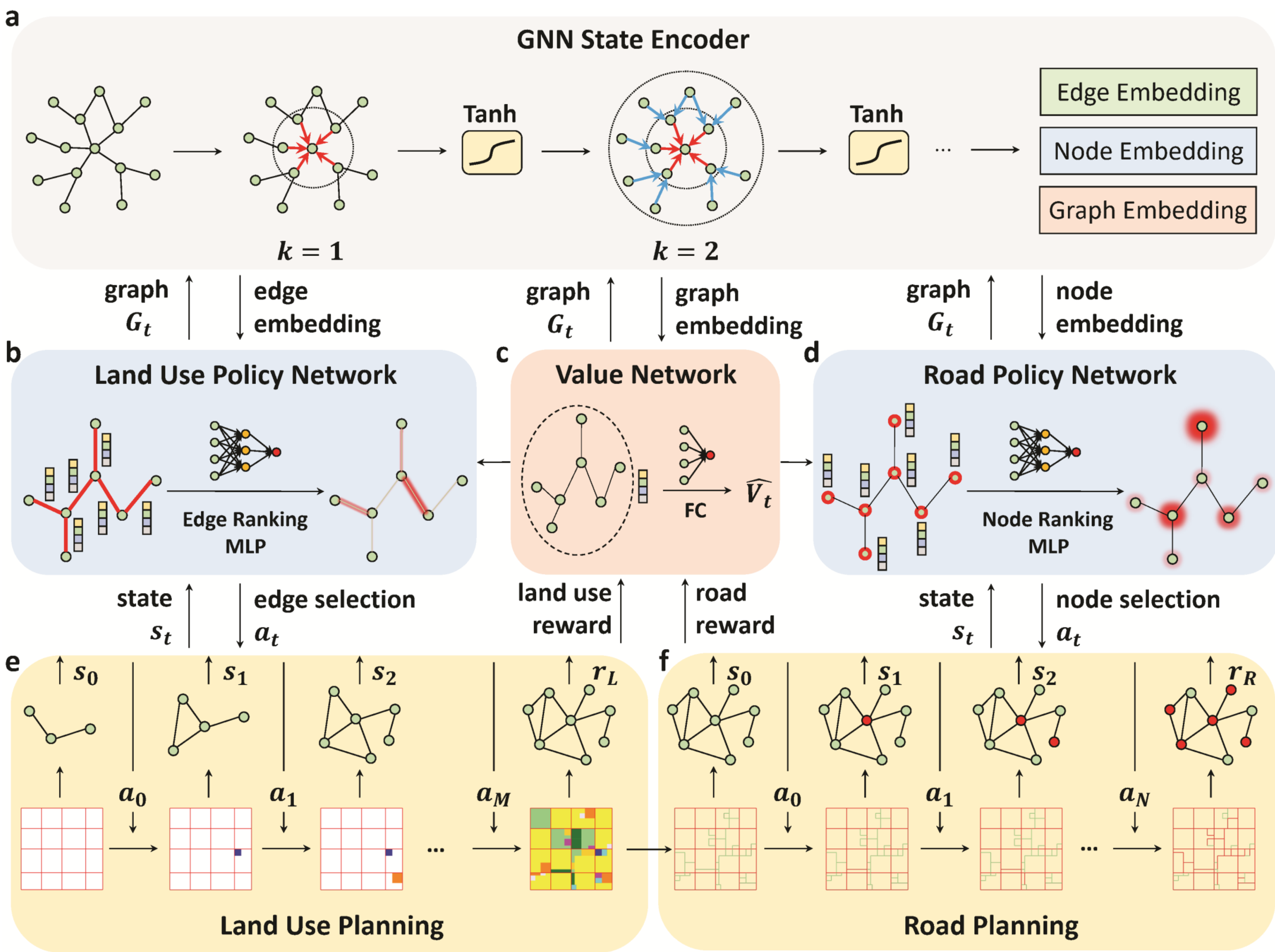
- edge selection on the graph
- topology changes after selection

Stage II: Road Planning

- node selection on the graph
- attribute changes after selection

Our Model

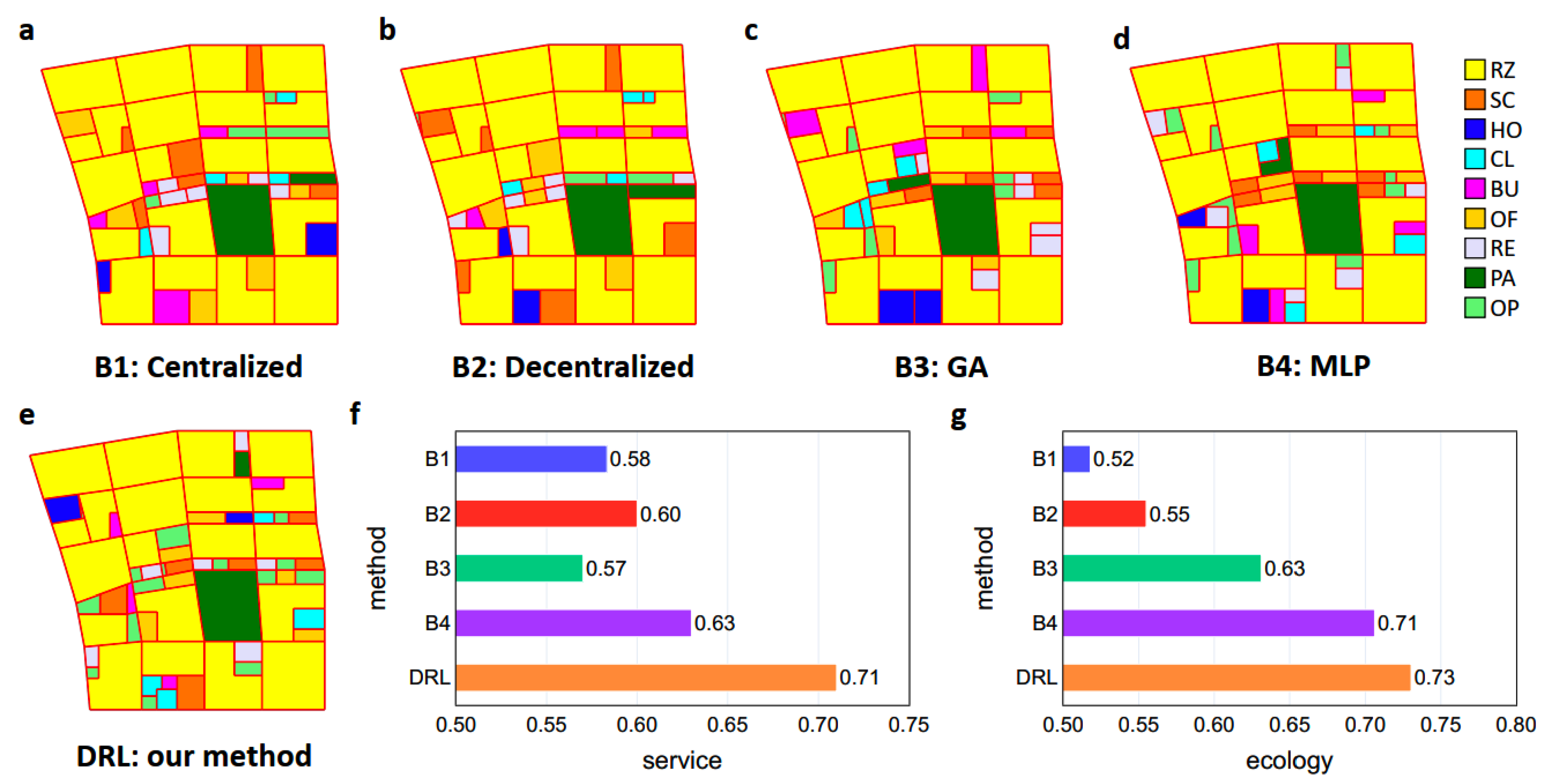
A Deep Reinforcement Learning Model with Graph Neural Networks



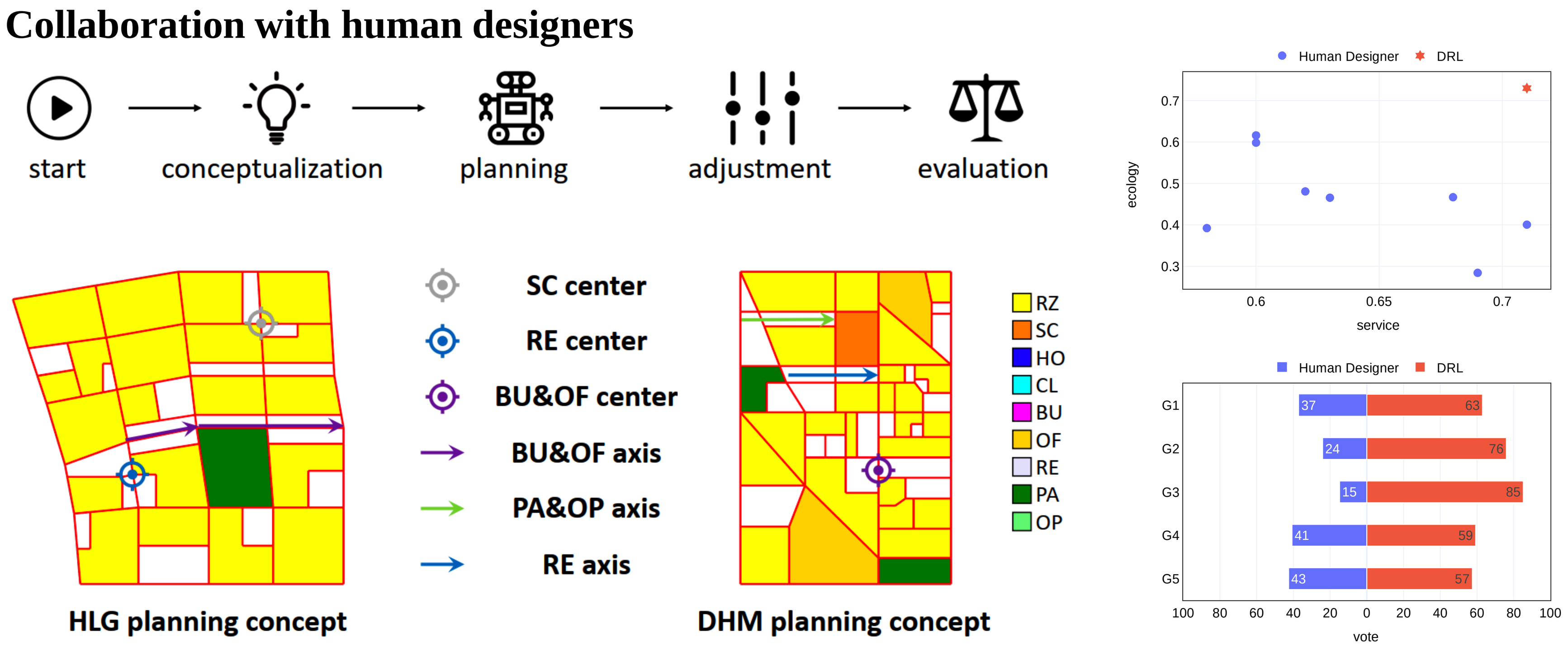
Results

Comparison with existing approaches

Method	Synthetic grid			Real-world HLG		Real-world DHM	
	Service	Ecology	Traffic	Service	Ecology	Service	Ecology
Centralized	0.4514	0.6090	0.5199	0.5833	0.5178	0.5533	0.5562
Decentralized	0.4867	0.6624	0.5008	0.6000	0.5549	0.6067	0.5248
GSCA	-	-	-	0.6100	0.4310	0.5355	0.4578
GA	0.5000	0.5008	0.6019	0.5700	0.6312	0.4333	0.5905
DRL w/ MLP	0.5625	0.7571	0.6857	0.6300	0.7061	0.6621	0.6104
Our method	**0.6833****	**0.9171****	**0.9384****	**0.7100***	**0.7303***	**0.7484****	**0.8976****
impr% over GA	36.66%	83.13%	55.91%	24.56%	15.70%	72.72%	52.01%
impr% over DRL w/ MLP	21.48%	21.13%	36.85%	12.70%	3.43%	13.03%	47.05%



Collaboration with human designers



Paper and Codes

Spatial Planning of Urban Communities via Deep Reinforcement Learning, Y. Zheng, Y. Lin, L. Zhao, T. Wu, D. Jin, Yong Li, in ***Nature Computational Science***.

GitHub: https://github.com/tsinghua-fib-lab/DRL-urban-planning