



2026GeoAI



中国科学院地理科学与资源研究所
Institute of Geographic Sciences and
Natural Resources Research, CAS

Identifying urban renewal based on multi-source data fusion

Presenter Name: Ci Song

Department: State Key Laboratory of Resources and Environmental Information System

Institute of Geographic Sciences and Natural Resources Research,

Chinese Academy of Sciences

June 4th, 2026

Introduction

Urban renewal implementations processes are crucial foundations for not only understanding the evolutionary patterns of urban development, but also making effective decisions in urban renewal planning.

Methodology

We integrate multi-source data including remote sensing images, project license, POI data and street view images, and construct two learning models, MTURI and FBURI, to identify different types of urban renewals.

Results

Based on the proposed models, we successfully identify three types of urban renewal: physical renewal, functional renewal, and upgrading renewal and find spatial patterns at different scales.

Conclusions

The fusion-based model can effectively enhance the precision and stability of urban renewal identification, offering empirical support for typical renewal pattern induction and regional differentiated urban governance..

Introduction——China's urban renewal

**Time
Phase**

Large-scale demolition
and reconstruction

Rapid urbanization
development

From speed to quality

human-centered high-
quality development

Period 1: 1990s

Solving housing shortages

Period 2: 2000-2010

“Three-old renovation”

Period 3: 2010-2020

Living environment improving

Period 4: After 2020

Comprehensive upgrading

illegal buildings
demolish



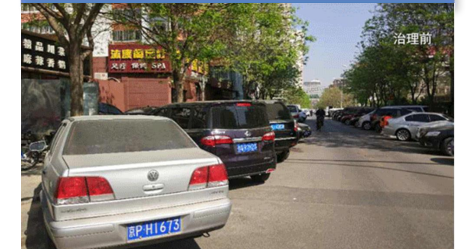
Old residences
renovation



Environment
upgrading



Fine-grained
governance



Housing supply

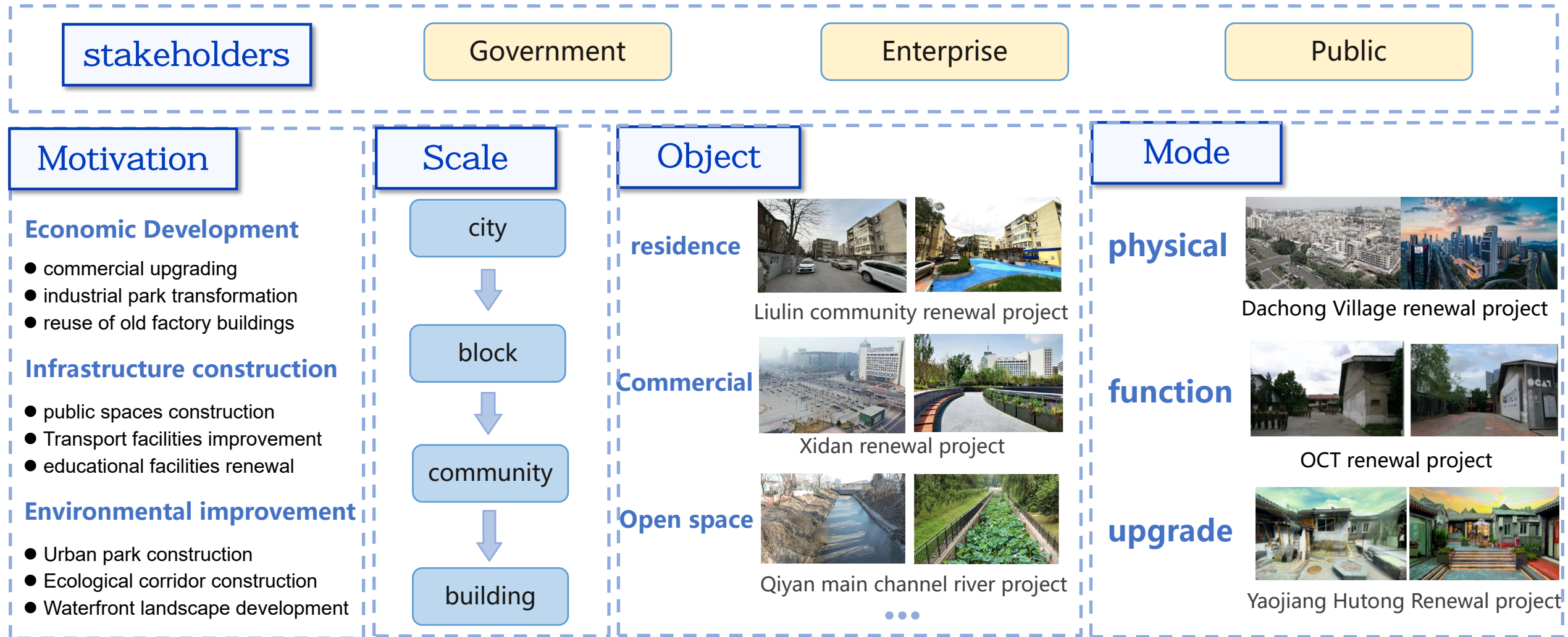
Development

High-quality

SDGs

Identifying different types of urban renewal are crucial foundations for not only understanding the evolutionary patterns of urban development, but also making effective decisions in urban planning.

Complexity of urban renewal



How to comprehensively understand the multi-types urban renewal process?

Multi-Source Data of urban renewal

Survey Data

Land Transaction



Construction Project License

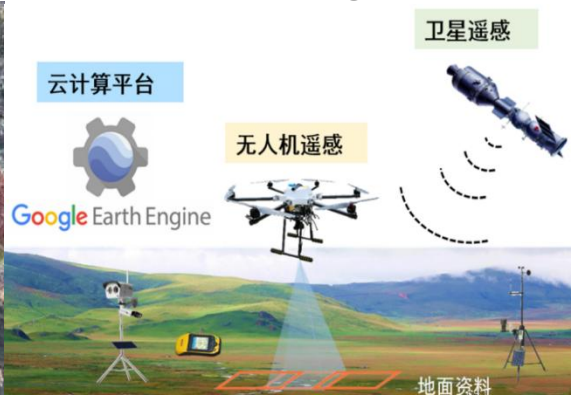


Earth Observation data

RS Images



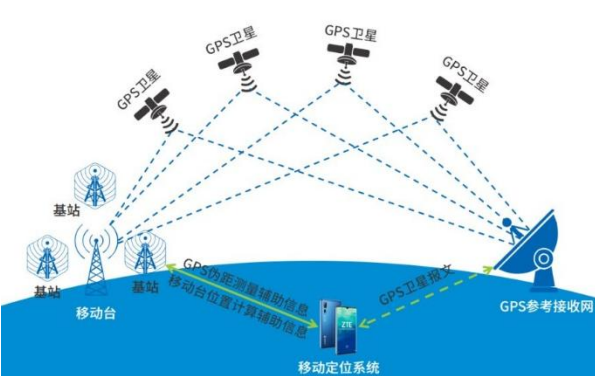
UAV Images



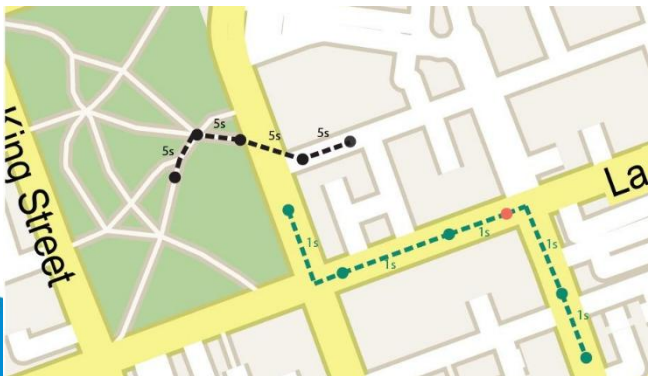
Information about individual renewal Project

Location-Based Service Data

GNSS location record



Cellphone signaling



Land use and land cover change

Social Network Data

Point/Area of Interests



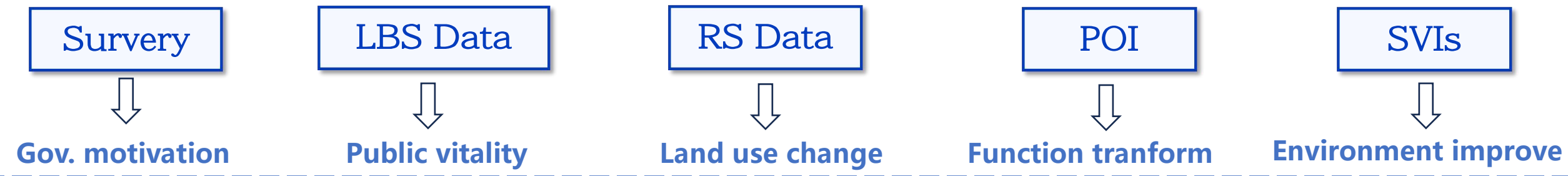
Street View Images



Transformation of function or vitality

Human perception and street scape information

An example——“Xidan The New”

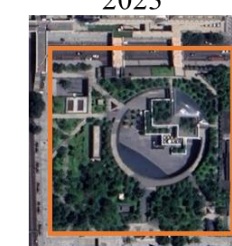
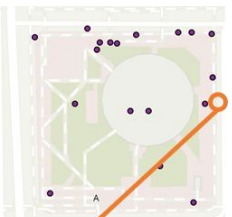
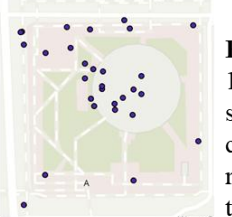




西单文化广场 1999



西单更新场 2021

Remote Sensing data	2015  Pre-renewal	2017  Preparation	2018  Early Construction	2019  Under Construction	2020  Completion	2023  Operation
	2015  POI Count: 67. Includes 49 retail and dining facilities (mostly small-scale shops), primarily distributed along the streets surrounding the plaza.	2019  POI Count: 19. Consists exclusively of gates and plaza entrances/exits. Small shops were demolished due to construction and renovation.		2022  POI Count: 30. Includes 18 shopping and dining services (dominated by cafes and trendy brands), mainly clustered around the sunken plaza.		
	Street view images	Dominated by small roadside stalls with disorderly vehicle parking.  2015.9		Under construction and renovation process with storefronts temporarily closed.  2017.4		Improved shop quality with refined window displays and an orderly street environment.  2022.12

“Xidan The New” Project

How to fuse multi-source data for identifying and analyzing spatiotemporal patterns of urban renewal?

Motivation

Theoretical



Broadens the research perspectives of urban renewal

methodological



A framework to fuse multi-source data for improving precision of urban renewal identification

Application



provides a scientific basis for refined urban renewal policies

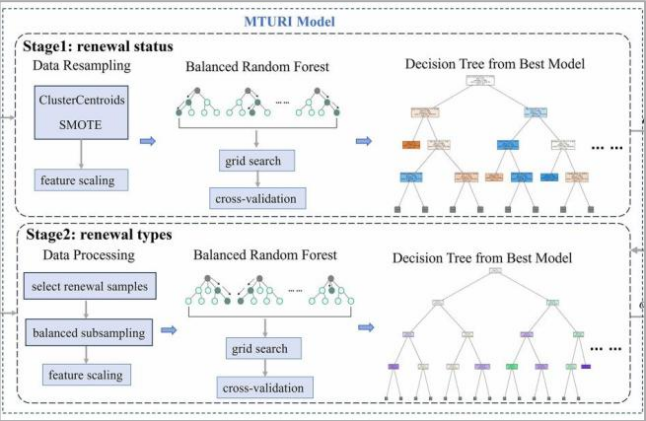
Three Difficulties in Data Fusion

- **Semantic complexity** : spatial morphology, functional attributes and environmental characteristics from different types of urban renewals need to be defined by unified semantic expression.
- **Multimodal Data** : Numeric values, texts and images from multi-source data need to be integrated by a unified encoding and fusion model.
- **Scale differences** : Spatial resolution, temporal frequency and sampling coverage need to be aligned across multi-source data.

MTURI

(Multi-Type Urban Renewal Identification)

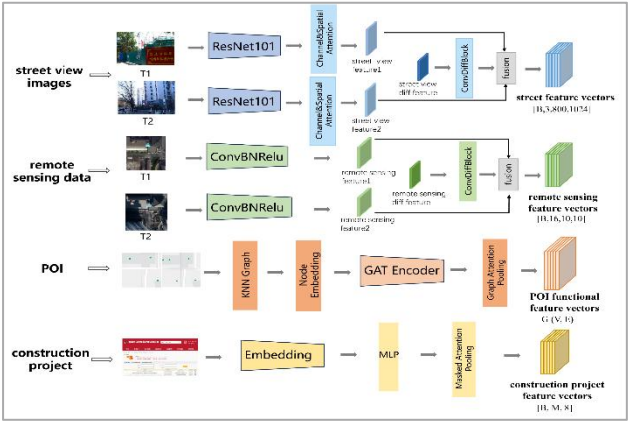
- Street View Images Data
- Feature-Based ML model
- Streetscape Scale



FBURI

(Fusion-Based Urban Renewal Identification)

- Multi-source Data Fusion
- Transform + GAT model
- Multi-type urban renewal Identification



SBURI

(From street scale to community scale)

- Old residential community
- Aggregation from point to block
- Different renewal pattern

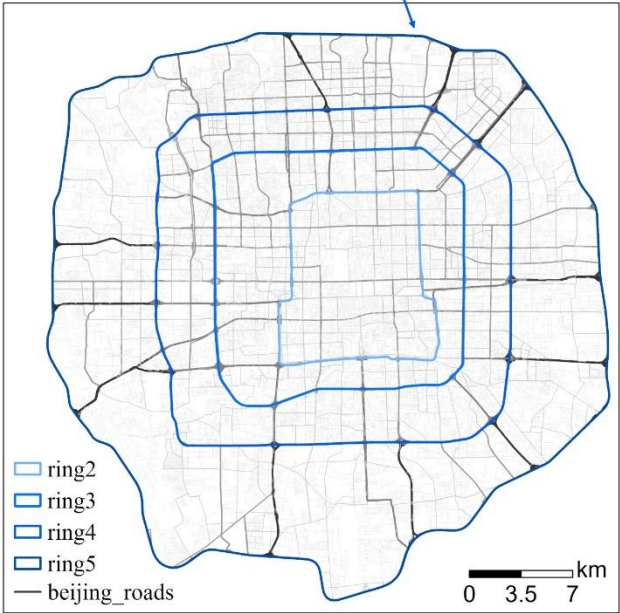
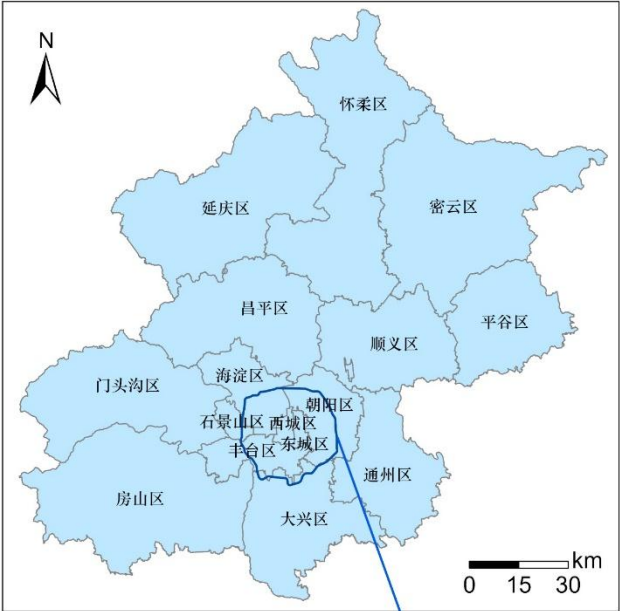


Study Area and Data

Study Area: region within 5th Ring Road in Beijing

Multi-source Data:

Data source		Introduction	Data fields
Urban renewal data	RS images	Landsat(5,7,8,9): 30m×30m Sentinel-2: 10m×10m Period: 2013—2023	Band (Blue, Green, Red, NIR, SWIR1, SWIR2) Indices (NDVI, NDMI, NDBI, IBI, NBR, NDSI, TCB, TCG, TCW, TCA)
	Project License	Beijing Municipal Commission of Housing and Urban Rural Development, 2006-2021	License ID, Function, Construction Location, construction unit
	POI records	2014-2022	Name, PCode, Categories, etc.
	Street View Images	Baidu SVIs 2013-2023	RoadName, loc, heading, etc.
Basic Data		Road Network, Administrative Boundary	



Street view data Sampling

Major Road

↓

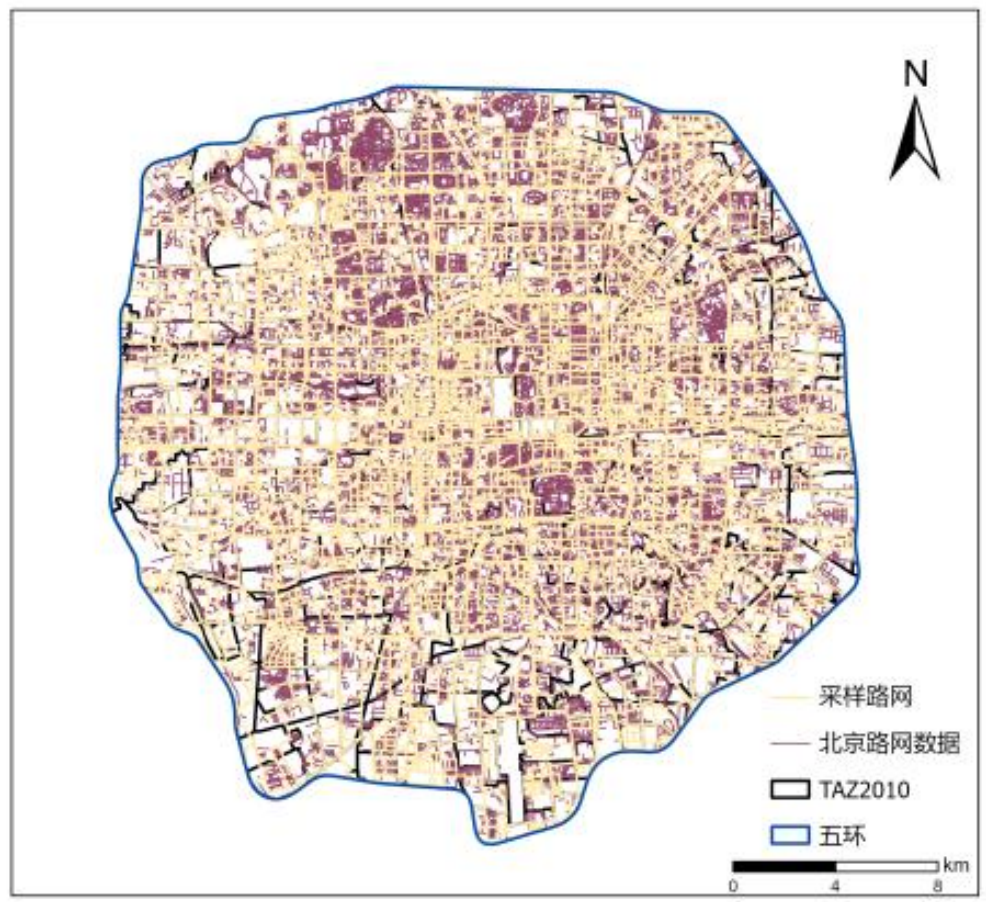
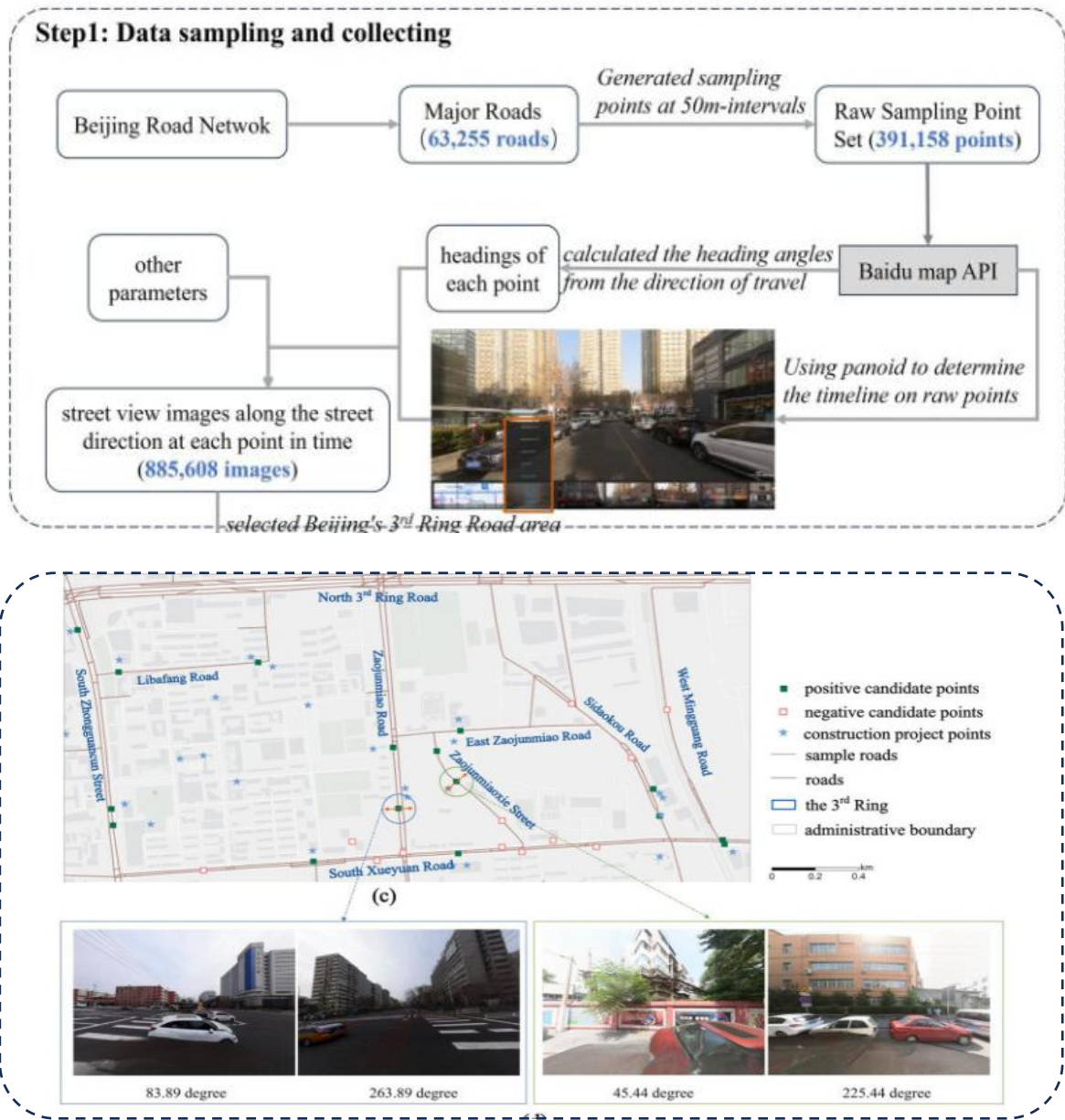
View point

↓

Different years

↓

Street view images



Samples

- 391,158 sample points (50m-intervals)
- 885,608 images
- 2013-2023
- 1024×800

Three types urban renewals

Base Year: 2017

- Beijing Master Urban Plan (2016-2035)
- Measures of Shenzhen Municipality on Urban Renewal

- ‘Development through Reduction’ Policy



Physical Renewal: building construction or demolition



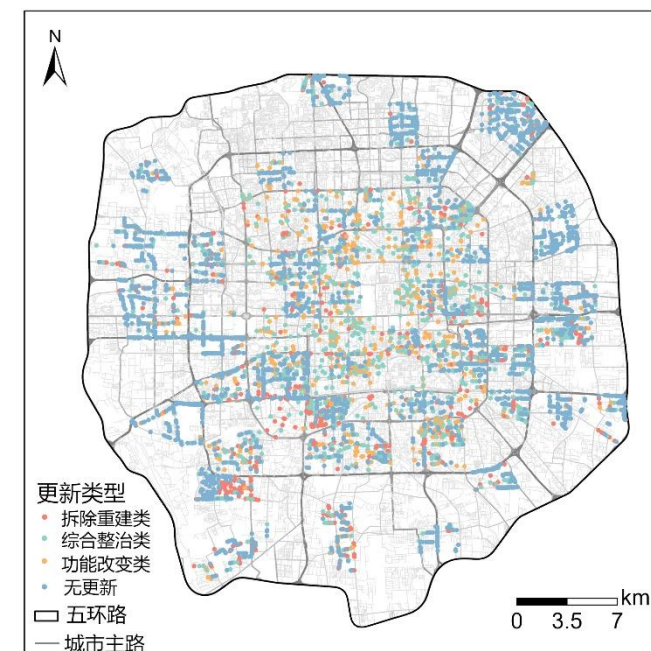
Upgrading Renewal: improving the living environment or streetscape



Functional Renewal: change in building use, such as commercial modernization



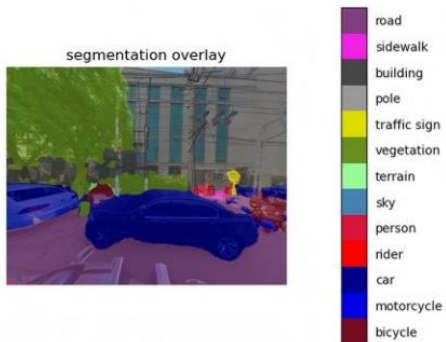
No Renewal: no change



Labeling

- 8000 image pairs
- 3600 Labels

MTURI Model (Feature-based)



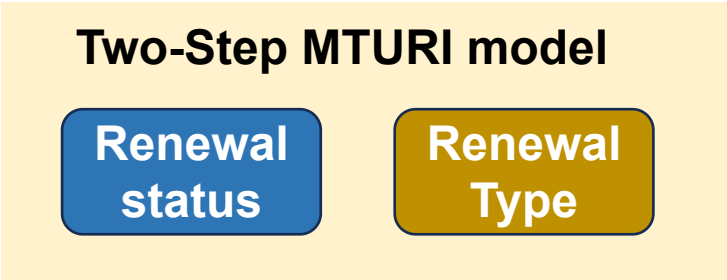
segmentation



Text semantic

Table 1. Formulas and introductions for the street environment.

	Indices	Formula	Brief introduction
Built feature description	Facade_ratio	$Facade_ratio = P_{facade}$	Facade_ratio is the pixel ratio of building facade.
	Wall_ratio	$Wall_ratio = P_{wall}$	Wall_ratio is the pixel ratio of the building's exterior walls.
	Fence_ratio	$Fence_ratio = P_{fence}$	Fence_ratio is the pixel ratio of the building's fence.
	Building_ratio	$Building_ratio = P_{facade} + P_{wall} + P_{fence}$	Building_ratio is the pixel ratio of the proportion of all building area.
	Building_level	$\begin{cases} 1, & 0 \leq Building_ratio < 0.1 \\ 2, & 0.1 \leq Building_ratio < 0.2 \\ 3, & 0.2 \leq Building_ratio < 0.3 \\ 4, & 0.3 \leq Building_ratio < 0.4 \\ 5, & 0.4 \leq Building_ratio < 0.5 \\ 6, & Building_ratio \geq 0.5 \end{cases}$	Building_level is divided into six levels based on the proportion of building area.
Built semantic characteristic	TextArea_ratio	$TextArea_ratio = P_{text}$	The area of the text boxes, (x0,y0) and (x1,y1) are the coordinates of the lower left and upper right corners of the text box, respectively.
	Text_info	$Text_info = \frac{1}{d} \sum_{j=1}^d \left(\frac{1}{N} \sum_{i=1}^N h_{i,j} \right)$	d is the dimension of the BERT model. N is the number of tokens in the text. h _{ij} represents the value of the jth dimension of the token h _i output by the BERT model.
Street environment perception	Greenness	$Greenness = P_{vegetation}$	Greenness refers to the coverage of vegetation in human-eye observation. P _{vegetation} denotes the proportion of vegetation pixels.
	Openness	$Openness = P_{sky}$	Openness is the degree of sky visibility and refers to the composition of sky elements. P _{sky} denotes the proportion of sky pixels.
	Enclosure	$Enclosure = P_{building} + P_{vegetation} + P_{fence} + P_{wall}$	Enclosure is the degree to which a street canyon is visually enclosed by buildings, walls, trees and other vertical elements. P _{building} , P _{vegetation} , P _{fence} , P _{wall} , respectively, denote the proportion of building, vegetation, fence and wall pixels.
	CDI	$CDI = 1 - \sum_{i=1}^I \left(\frac{p_i}{\sum_{j=1}^I p_j} \right)^2$	CDI refers to color diversity index of the image. p _i is the total amount of pixels occupied by the color elements of class i. I is the total number of color types defined.



- No renewal
- Physical renewal
- Functional renewal
- Upgrading renewal

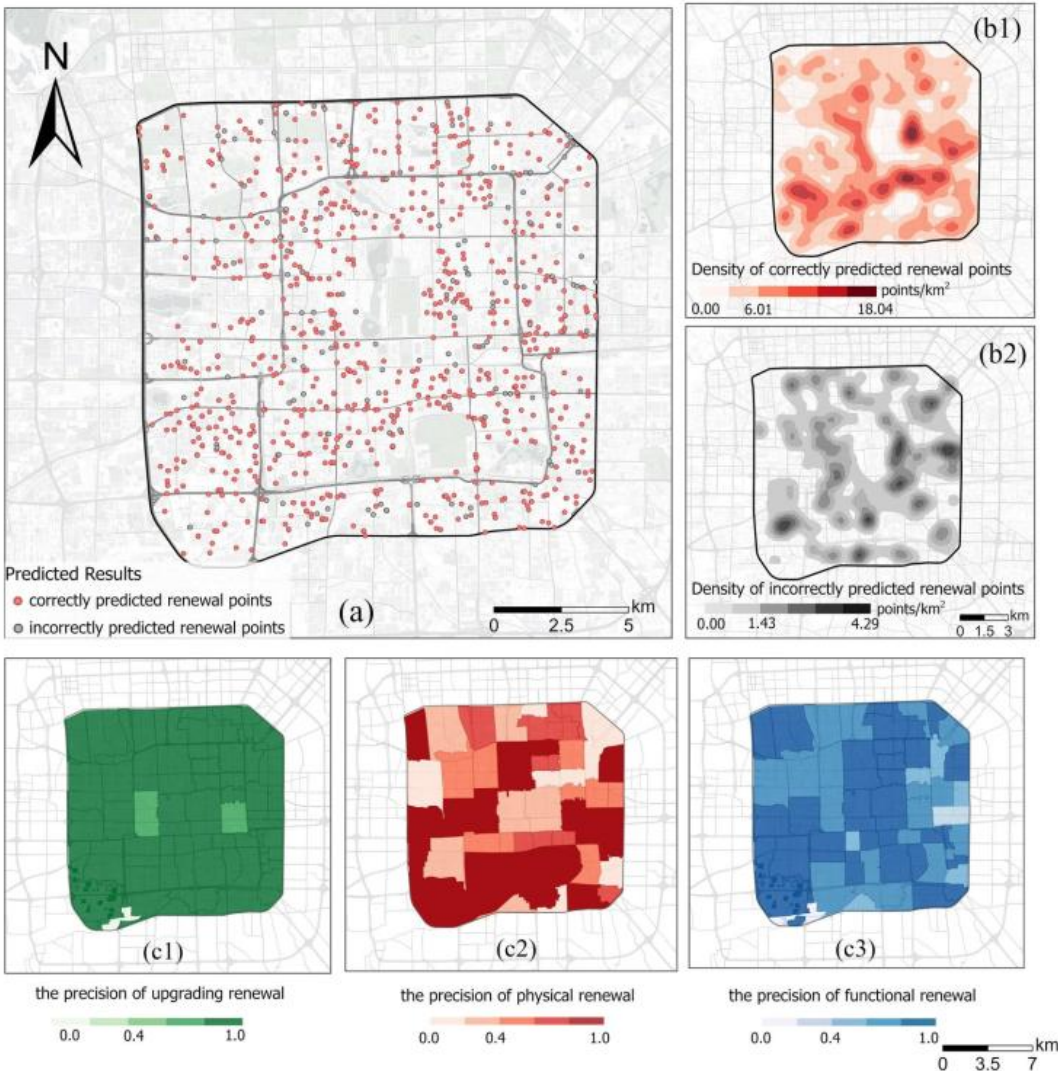
Results——The 3rd Ring in Beijing

■ Over 80% accuracy in predicting urban renewal status and types.

Table: Prediction results

Renewal	Category	accuracy	precision	recall	F1-score
Y or N	Yes	0.90	0.70	0.90	0.80
Type	Upgrading	0.86	0.95	0.71	0.82
	Physical	0.93	0.73	0.99	0.84
	Functional	0.88	0.81	0.91	0.86

- **High precision:** Second Ring Road and junctions of East, West and South Third. Distinct visual features.
- **Low precision:** Hujialou Subdistrict along East Third Ring Road and Guang'anmenwai near West Third Ring Road. Complex environments and obscure renewal features.



Urban renewal identification result

Feature Analysis

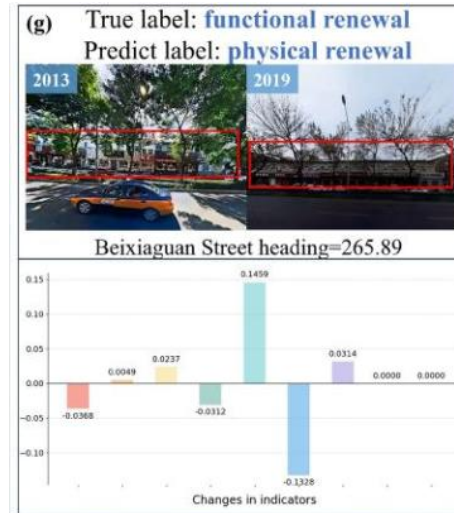
Table 3. Statistical analysis of changes in indicators for three renewal types and their predicted results.

Indicator	p/n	Physical renewal		Functional renewal		Upgrading renewal		t-test significance		
		Mean (Q1-Q3)	Std	Mean (Q1-Q3)	Std	Mean (Q1-Q3)	Std	$p-f$	$p-u$	$f-u$
change_facade _b _ratio	p	0.156 (0.057-0.217)	0.138	0.104 (0.035-0.150)	0.085	0.120 (0.034-0.185)	0.101	***	**	*
	n	0.069 (0.046-0.092)	0.065	0.127 (0.031-0.184)	0.129	0.124 (0.050-0.177)	0.106	-	-	-
change_fence _b _ratio	p	0.023 (0.001-0.036)	0.035	0.012 (0-0.011)	0.031	0.020 (0.001-0.022)	0.035	***	-	**
	n	0.003 (0.002-0.005)	0.005	0.013 (0.001-0.010)	0.036	0.017 (0-0.017)	0.029	-	-	-
change_wall _b _ratio	p	0.013 (0-0.012)	0.026	0.002 (0-0.001)	0.007	0.010 (0-0.009)	0.021	***	-	***
	n	0.023 (0.012-0.035)	0.033	0.004 (0-0.001)	0.010	0.009 (0-0.004)	0.023	-	-	-
change_openness	p	0.144 (0.040-0.221)	0.116	0.092 (0.013-0.144)	0.097	0.091 (0.005-0.134)	0.102	***	***	-
	n	0.052 (0.0280-0.075)	0.066	0.101 (0.014-0.186)	0.105	0.115 (0.022-0.194)	0.105	-	-	-
change_enclosure	p	0.143 (0.045-0.212)	0.123	0.099 (0.026-0.148)	0.090	0.121 (0.040-0.173)	0.108	***	*	**
	n	0.077 (0.052-0.101)	0.069	0.124 (0.045-0.148)	0.112	0.122 (0.023-0.181)	0.107	-	-	-
change_greenness	p	0.076 (0.015-0.106)	0.085	0.054 (0.009-0.079)	0.065	0.097 (0.024-0.138)	0.107	**	*	***
	n	0.011 (0.001-0.014)	0.010	0.068 (0.009-0.085)	0.106	0.057 (0.008-0.081)	0.071	**	*	-
change_CDI	p	0.129 (0.051-0.184)	0.110	0.121 (0.046-0.168)	0.105	0.126 (0.043-0.177)	0.114	-	-	-
	n	0.055 (0.052-0.058)	0.008	0.147 (0.044-0.222)	0.134	0.132 (0.049-0.171)	0.123	***	***	-
change_area_ratio	p	0.004 (0-0.003)	0.009	0.010 (0.002-0.012)	0.013	0.002 (0-0.001)	0.009	***	*	***
	n	0.008 (0.006-0.011)	0.007	0.005 (0-0)	0.020	0.008 (0-0.010)	0.013	-	-	-
text_similarity	p	0.070 (0-0)	0.224	0.362 (0-0.804)	0.402	0.028 (0-0)	0.130	***	*	***
	n	0 (0-0)	0	0 (0-0)	0	0.248 (0-0.619)	0.371	-	***	***

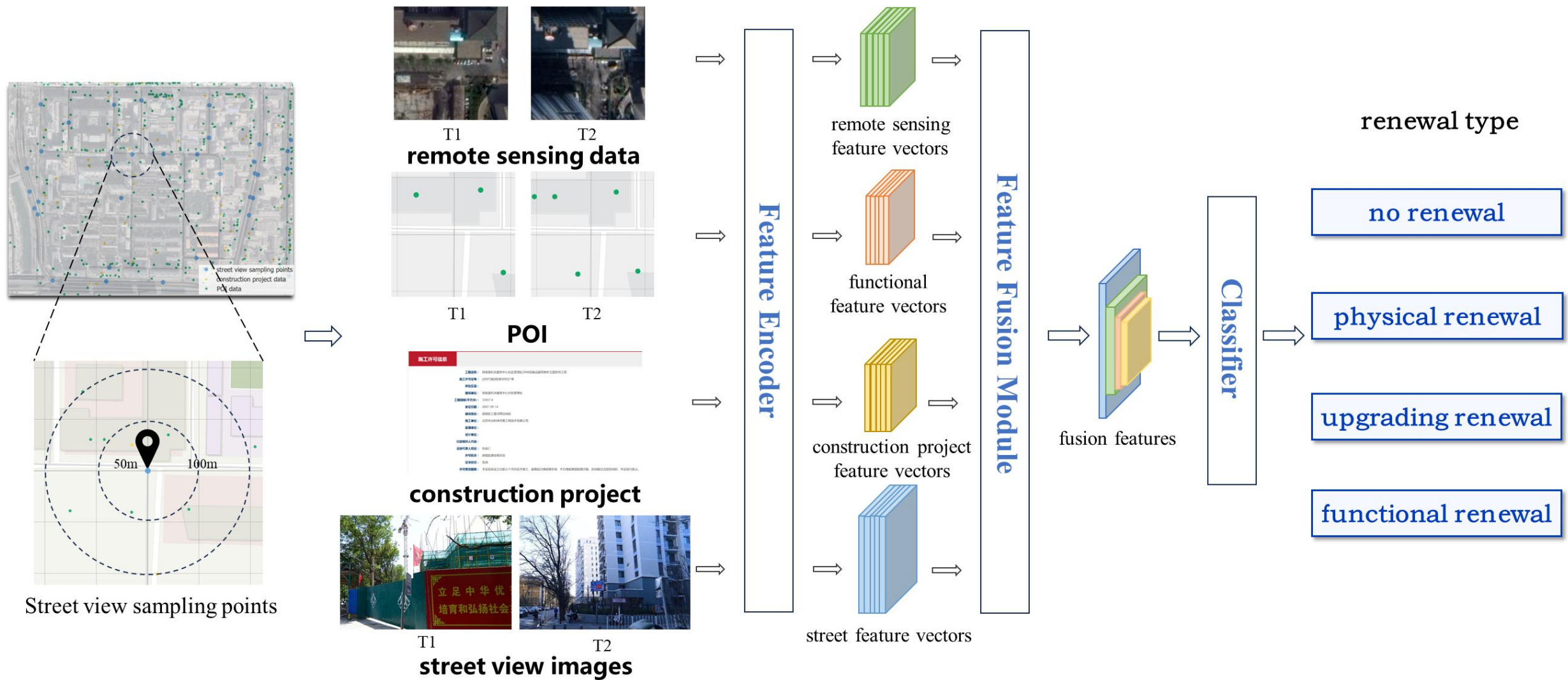
$p-f$ denotes the t -test between physical renewal and functional renewal. $p-u$ denotes the t -test between physical renewal and upgrading renewal. $f-u$ denotes the t -test between functional renewal and upgrading renewal. (-) Not significant.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Bold highlight the values that the paper explicitly identifies as having undergone significant changes.



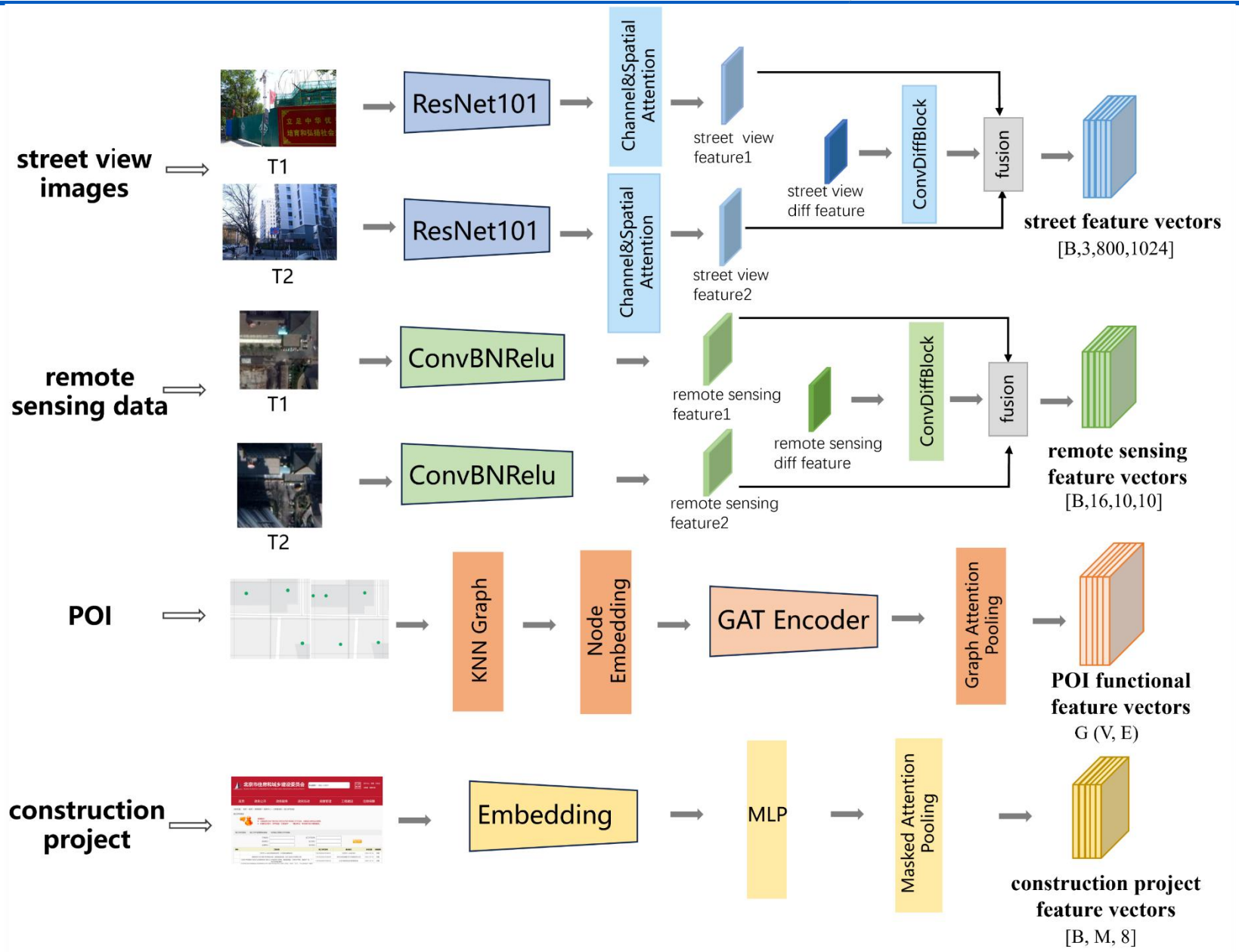
Multi-source Fusion Urban Renewal Identification Model (MFURI)

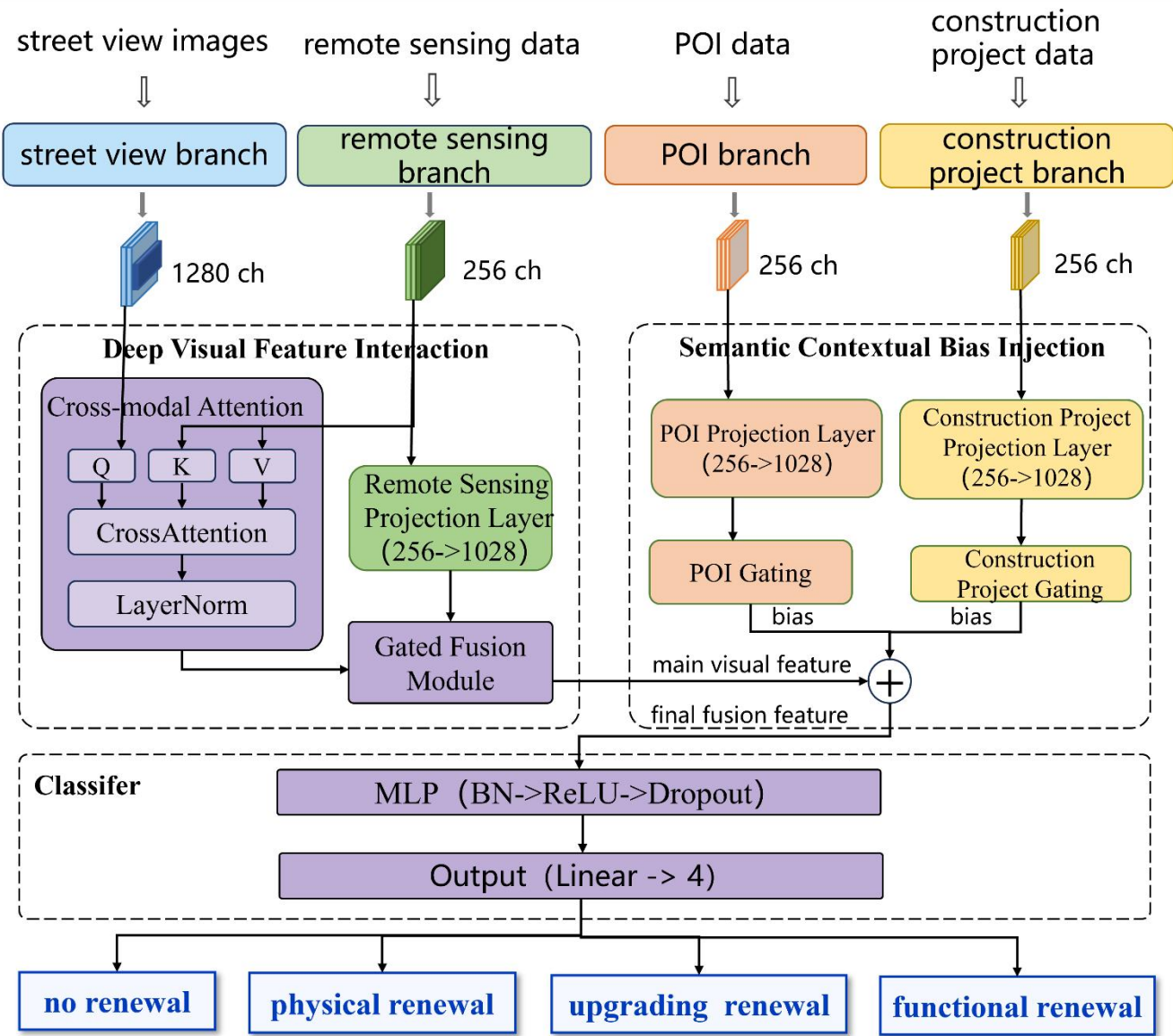


Encoding Framework

Build a feature extraction and encoding framework :

- street branch $\Rightarrow$ ResNet101
- remote sensing branch $\Rightarrow$ CNN
- POI branch $\Rightarrow$ GAT
- construction project branch $\Rightarrow$ MLP





Experiment

Area: Within 5th Ring Road

Year: 2013-2023

Nsamples: 8000, Training(80%)-Evaluating(20%)

Accuracy: 0.801, **F1-Score:** 0.776, **AUC:** 0.926

Results of different urban renewal types

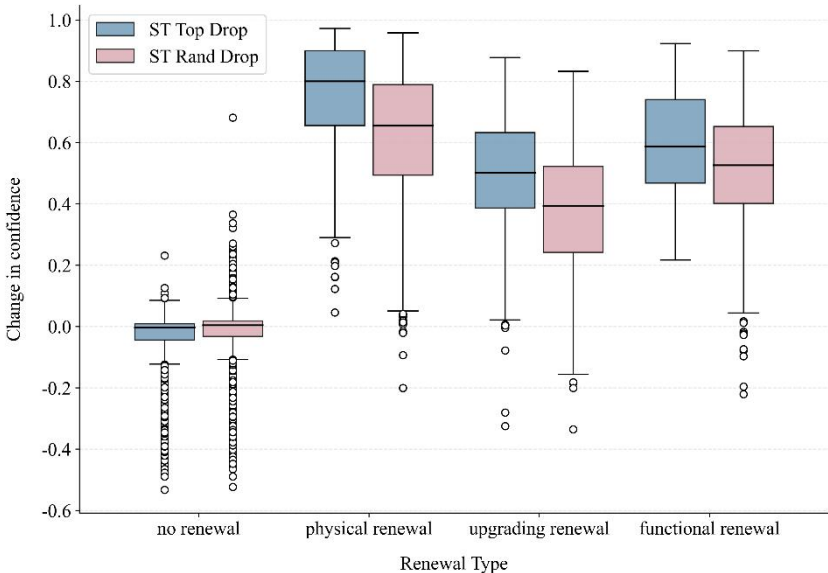
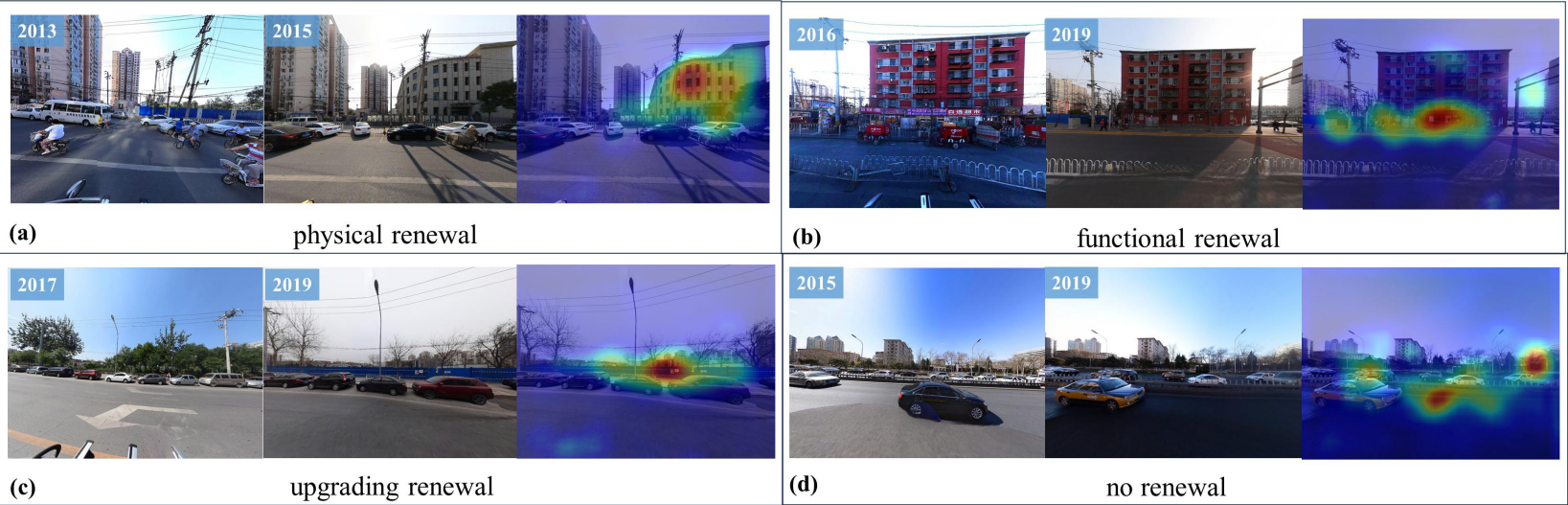
Types	precision	recall	F1-score	Num.
No renewal	0.84	0.91	0.88	701
Physical	0.84	0.72	0.78	259
Upgrading	0.73	0.67	0.70	383
Functional	0.73	0.77	0.75	257

Ablation Experiment

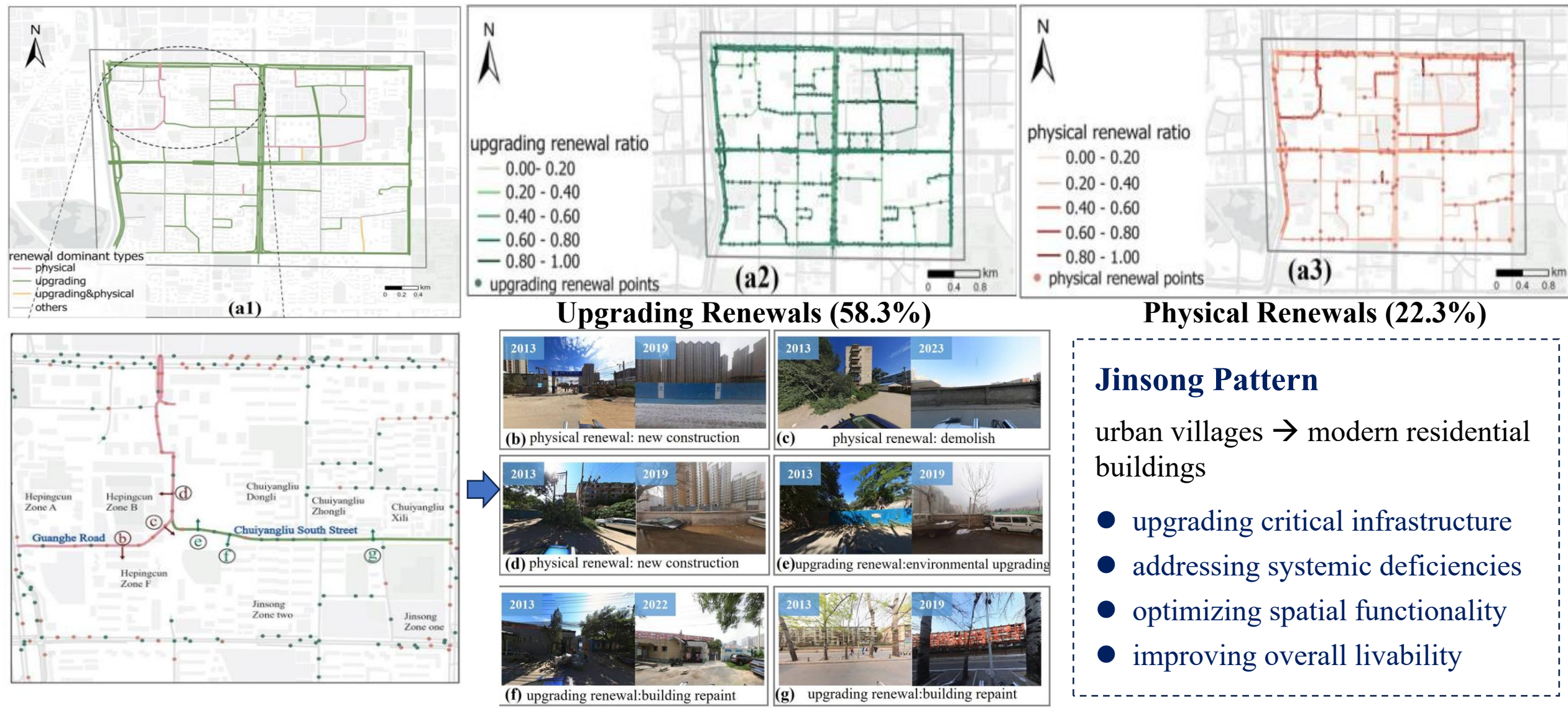
Data	Overall Performance			Renewal Type							
				no renewal		physical renewal		upgrading renewal		functional renewal	
	OA	Macro F1-score	Macro AUC	precision	recall	precision	recall	precision	recall	precision	recall
SVIs (baseline)	0.766	0.747	0.909	0.85	0.82	0.82	0.78	0.64	0.61	0.67	0.80
SVIs + RS	0.796	0.771	0.918	0.87	0.89	0.86	0.69	0.68	0.71	0.72	0.77
FBURI model	0.801	0.776	0.926	0.84	0.91	0.84	0.72	0.73	0.67	0.73	0.77

Street-view attention heatmaps

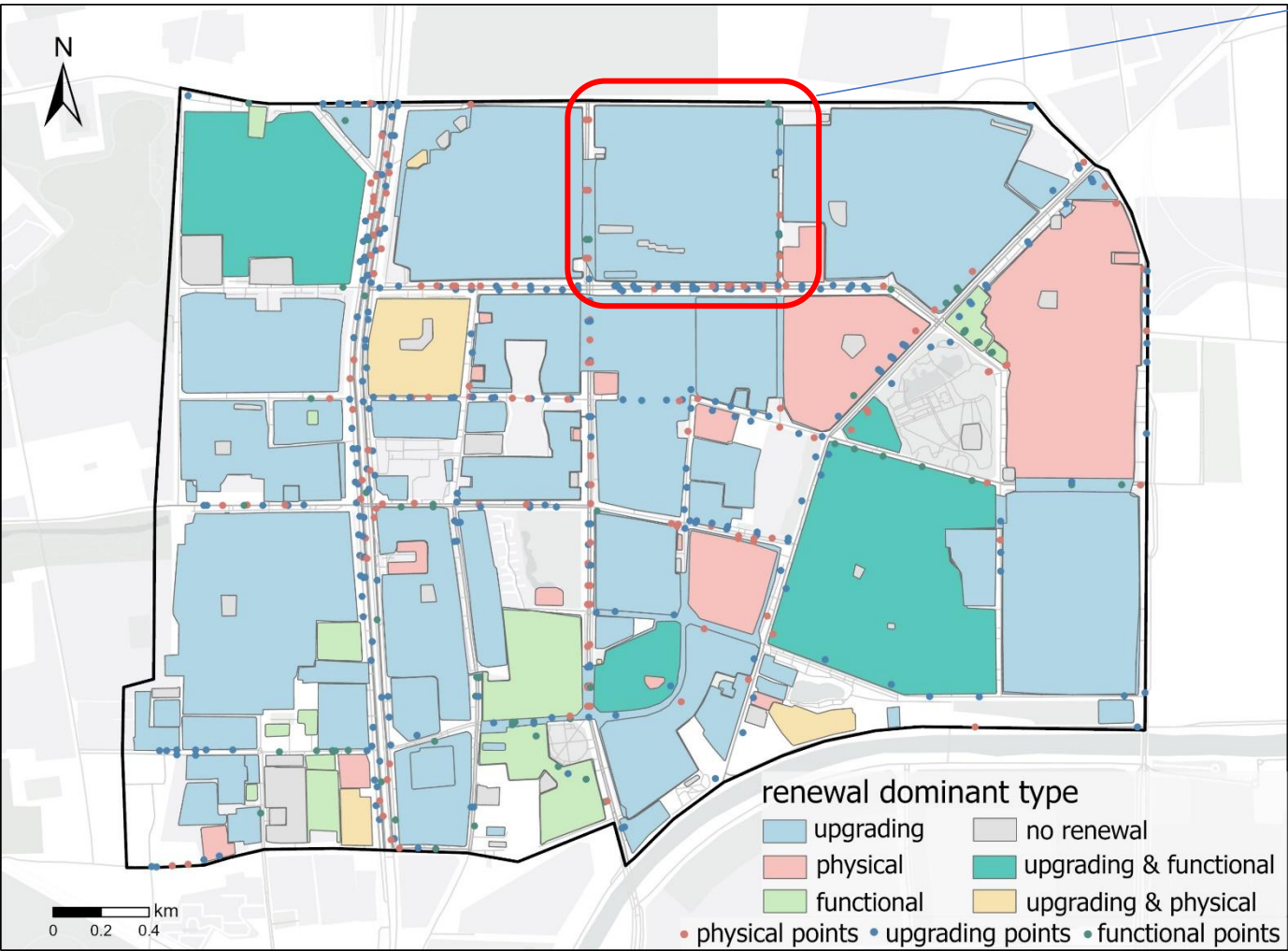
Feature perturbation



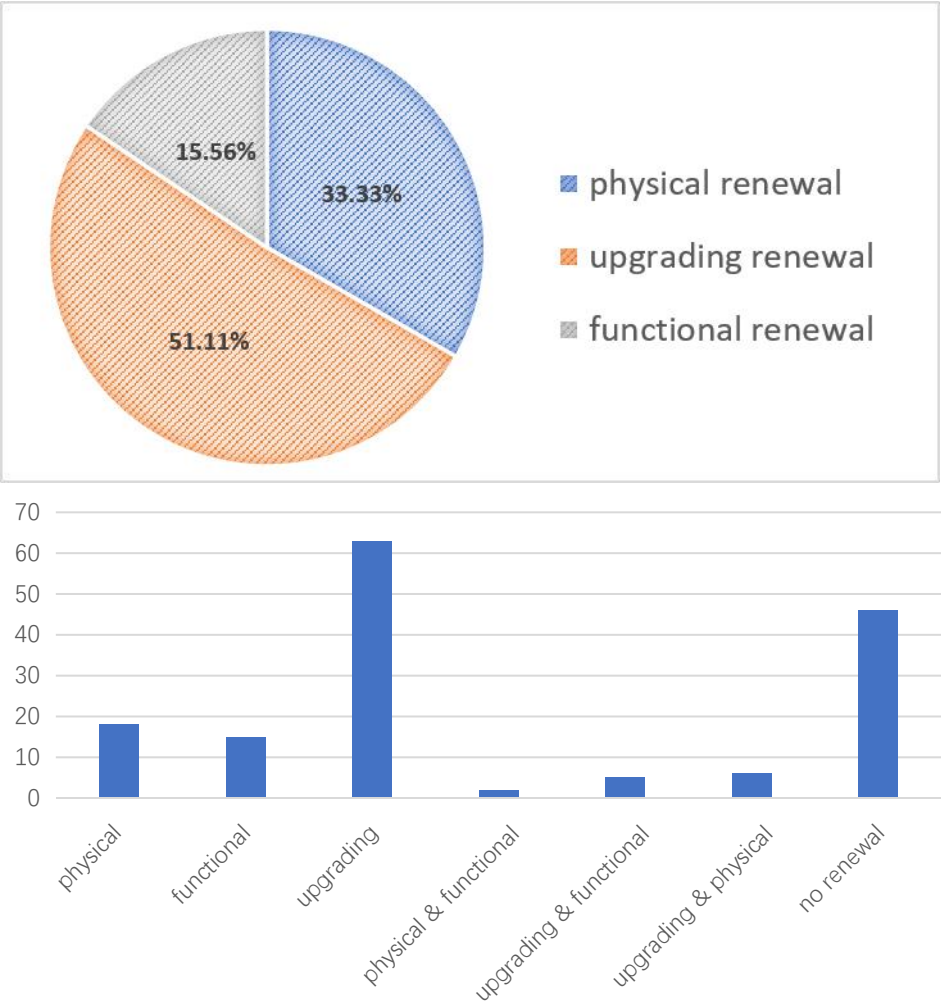
■ Jinsong Area——Old residential community renewal projects



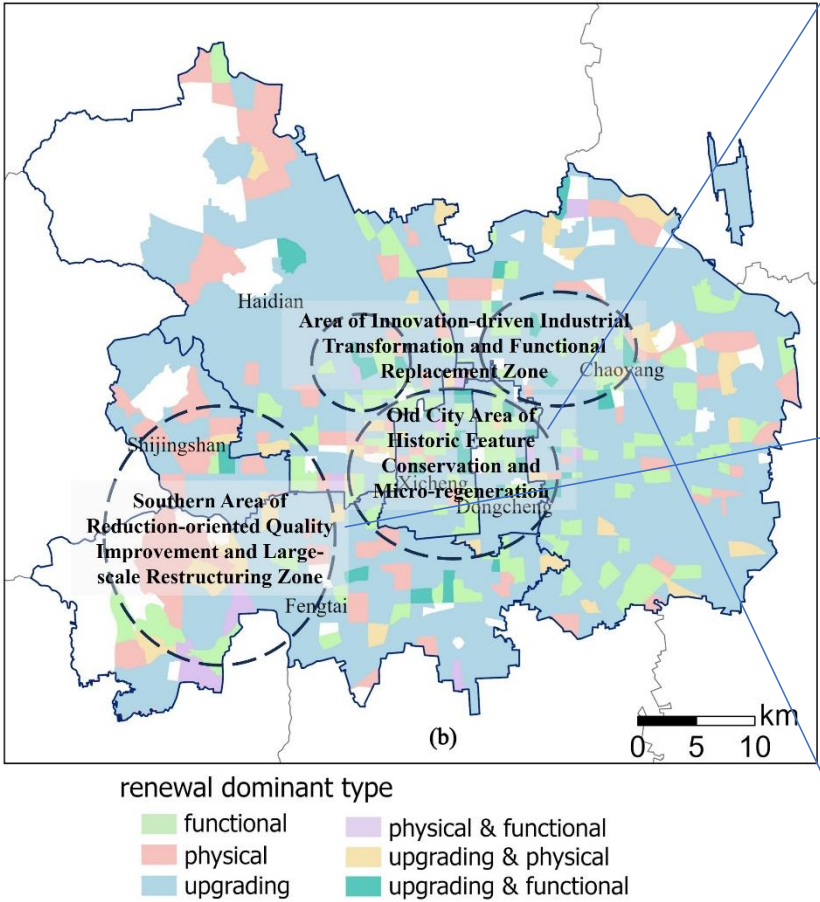
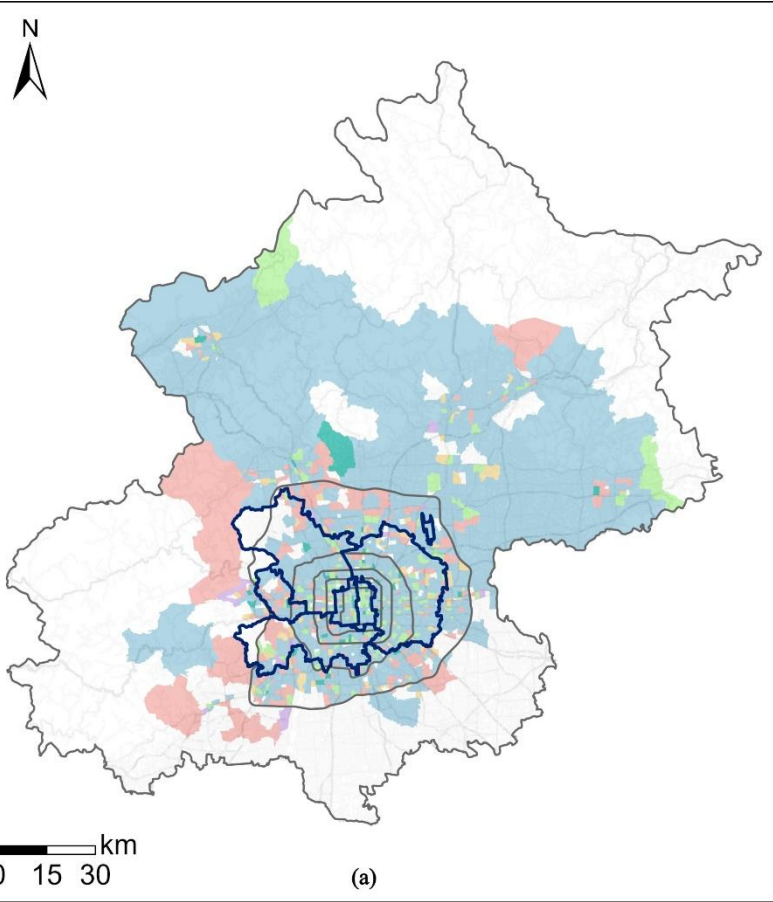
■ Tiantongyuan Community——The Biggest Community



Second District: 45 renewal points, upgrading dominant



■ Six Core Districts of Beijing



Upgrading Renewal

Contiguous built-up areas in core districts

- cultural heritage conservation
- public space improvement
- old residential areas upgrading

Physical Renewal

Urban village in southwest area

- South City Revitalization Initiative
- logistics bases/wholesale markets upgrade
- illegal structure demolition

Functional Renewal

Discrete patches in north and northeast area

- High-tech industries
- Innovation-driven offices
- technological services

- Different data have distinct applicability in urban renewal identification and are subject to scale limitations. Fusion-based model can improve the accuracy and robustness of urban renewal identification.
- The identification results can provide solid empirical evidence of typical renewal modes at different scales and carrying out regionally differentiated governance.
- Future work needs to refine the categorization of urban renewal types and explore the differences in urban renewal modes across cities.



Thank You !



**Big geo-data
mining Group**

Thanks for your attention!