

基于图片数据的 城市空间分析与可视化



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搜索周边



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中国科学院电工研究所



目前是基于图片研究城市的最好时期



对城市品质的追求，
对城市设计的重视，
以及对
美好城市生活
的向往。

目前是基于图片研究城市的最好时期

- 技术上的近期成熟：并行计算、深度学习（如convolutional neural network, CNN）等

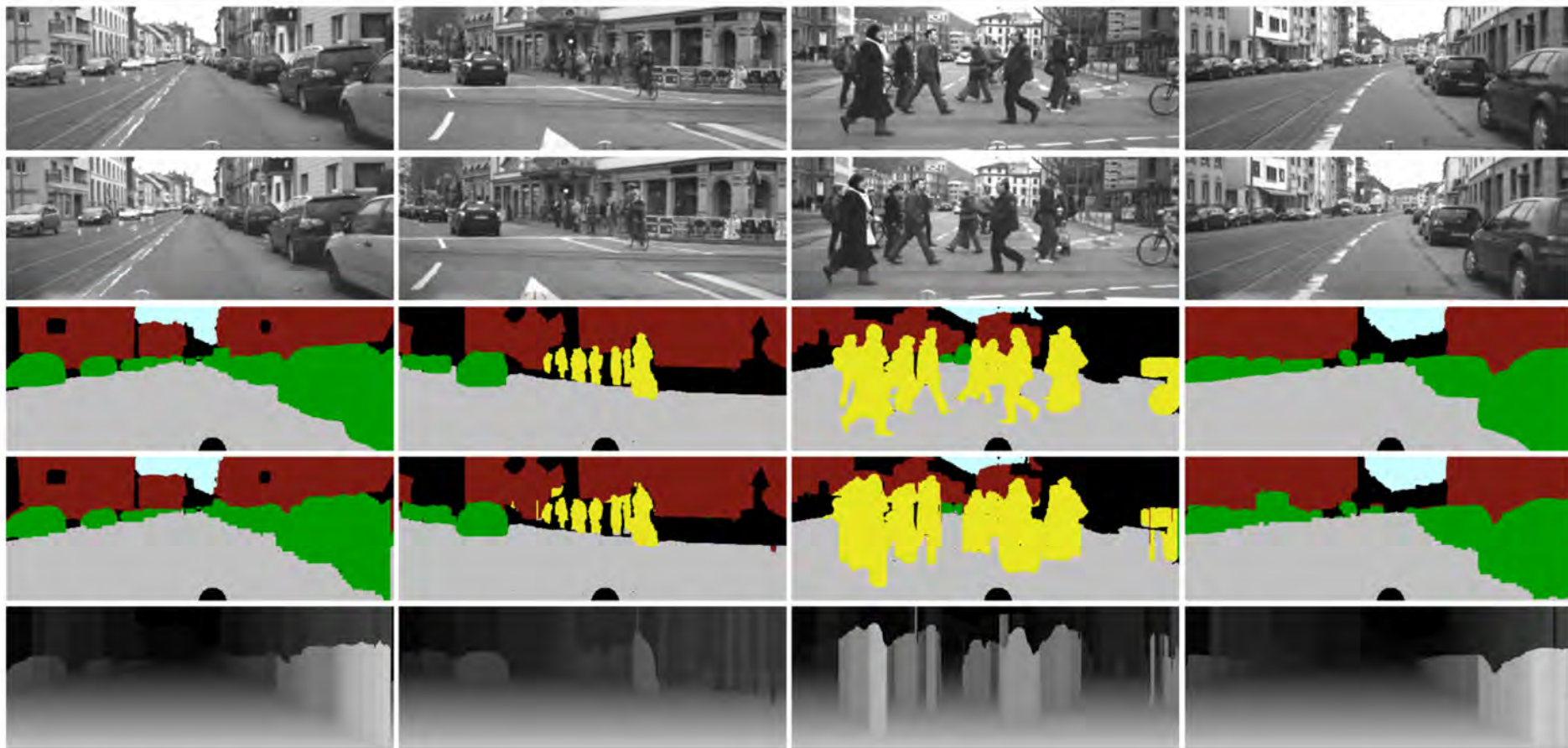



Fig. 5. **Visualization:** The figure visualizes the output computed from the proposed method. From top to bottom, we show the left images, the right images, the ground truth semantic labeling, the semantic labeling, and depth. The black regions are the regions where the ground truths are not available.

- 
- An aerial photograph of a dense, vibrant green forest. The trees are packed closely together, creating a textured canopy. In the upper left, a small portion of a mountainous landscape is visible. A large, dark shadow is cast across the forest floor, suggesting a large object or person is standing nearby. The overall scene is bright and natural.
- 城市空间与生活的重要载体
 - 未来对历史城市考古的重要资料
 - 认识人的尺度城市形态的重要渠道
 - 观察日常生活的重要手段

图片是

图片城市主义

Picture Urbanism



图片城市主义 Picture Urbanism

- 图片城市主义高度认可基于体现客观世界和主观认知的大规模图片进行量化城市研究，认为图片是一种在短期的未来将得到高度重视的城市数据源，是对已有多源城市数据的重要补充
- 有潜力的研究方向：城市意象识别、**空间品质评价**、绅士化过程分析、衰败过程分析、旅游路线推荐、可步行性评价、城市活力评估、城市管理水平评价、城市空间问题诊断、城市中心区判断、绿化水平分析、街道天空开阔度评价、城市色彩分析等
- 规划设计应用场景：远程现状调研、关键城市指标评价、方案辅助生成（步行系统、绿化系统、空间结构）、方案实施效果评价等



- OpenCV, 知名的计算机视觉和机器学习的开源平台 (www.opencv.org)
- Clarifai, Powerful and affordable visual recognition API (<http://www.clarifai.com>)
- CloudCV, 计算机视觉API (<http://www.cloudcv.org>)
- MatLab, 科学计算平台, 也适用于图片分析 (<http://www.mathworks.com/products/matlab/>)
- ESRI ArcGIS, GIS空间分析与统计 (www.esri.com)
- DepthMap, 空间句法常用软件 (<http://varoudis.github.io/depthmapX/>)
- Python, 轻量级脚本语言 (www.python.org)
- Urban Network Analysis Toolbox, 城市网络分析工具箱 (<http://cityform.mit.edu/projects/urban-network-analysis.html>)
- Big Models, 大模型研究范式 (<http://www.beijingcitylab.com/projects-1/9-big-model/>)
- GeoHey, 可视化平台 (<https://geohey.com>)



图片来源

Data sources



Explore



I3 - Yahoo Flickr Creative Commons 100M (14G) (Hosted on AWS)

This dataset contains a list of photos and videos. This list is compiled from data available on Yahoo! Flickr. All the photos and videos provided in the list are licensed under one of the Creative Commons copyright licenses, and as such they can be used for benchmarking purposes as long as the photographer/videographer is credited for the original creation.

If you decide to use the YFCC100M dataset in your work, please cite the following paper: B. Thomee, D.A. Shamma, G. Friedland, B. Elizalde, K. Ni, D. Poland, D. Borth, L. Li, "YFCC100M: The New Data in Multimedia Research", Communications of the ACM, 59(2), pp. 64-73, 2016.

This dataset is hosted on the Amazon Web Services platform, which requires a free Amazon Web Services login for access.

Here are all the papers published on this Webscope Dataset:

- BCL DATA 25 (<http://www.beijingcitylab.com/data-released-1/>)
- <http://webscope.sandbox.yahoo.com/catalog.php?datatype=i&did=67>
- 国内的相册基本不提供API接口



Panoramio

Panoramio | Google Maps

Explore ▾

Sign in ▾

SIGN UP



Share and explore the world in photos

Start exploring

Catedral (2) 05.10.2010
(Ampliar/Enlarge)
FPG24E

Cathedral of León in Spain

- 隶属于Google的免费照片上传网站，主要用于Google Earth上的实景照片，上传照片后可以在卫星地图上进行定位，照片经过审核之后即可出现在Google Earth和Google卫星地图上
- <http://www.panoramio.com/api/widget/api.html>

街景

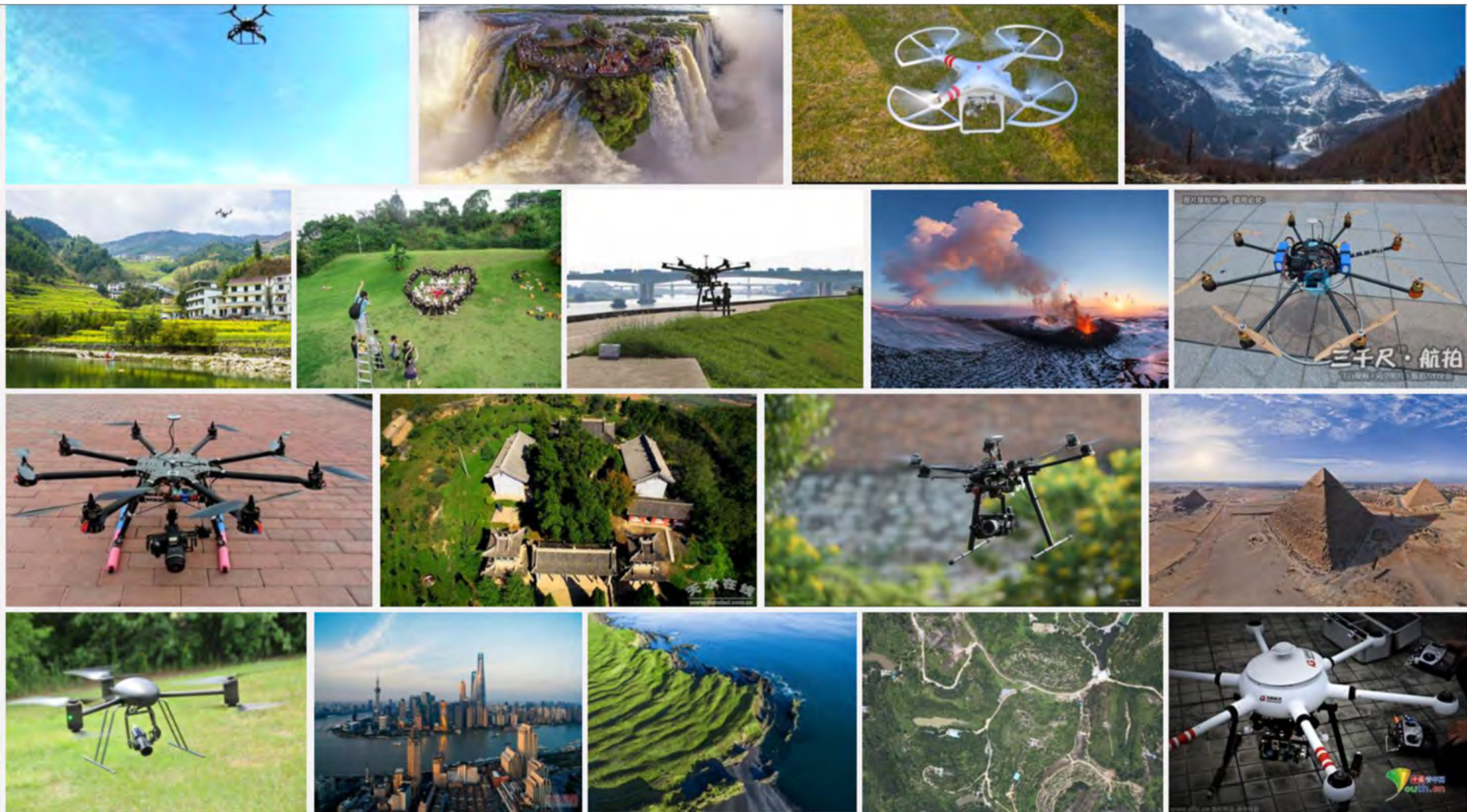


行车记录仪

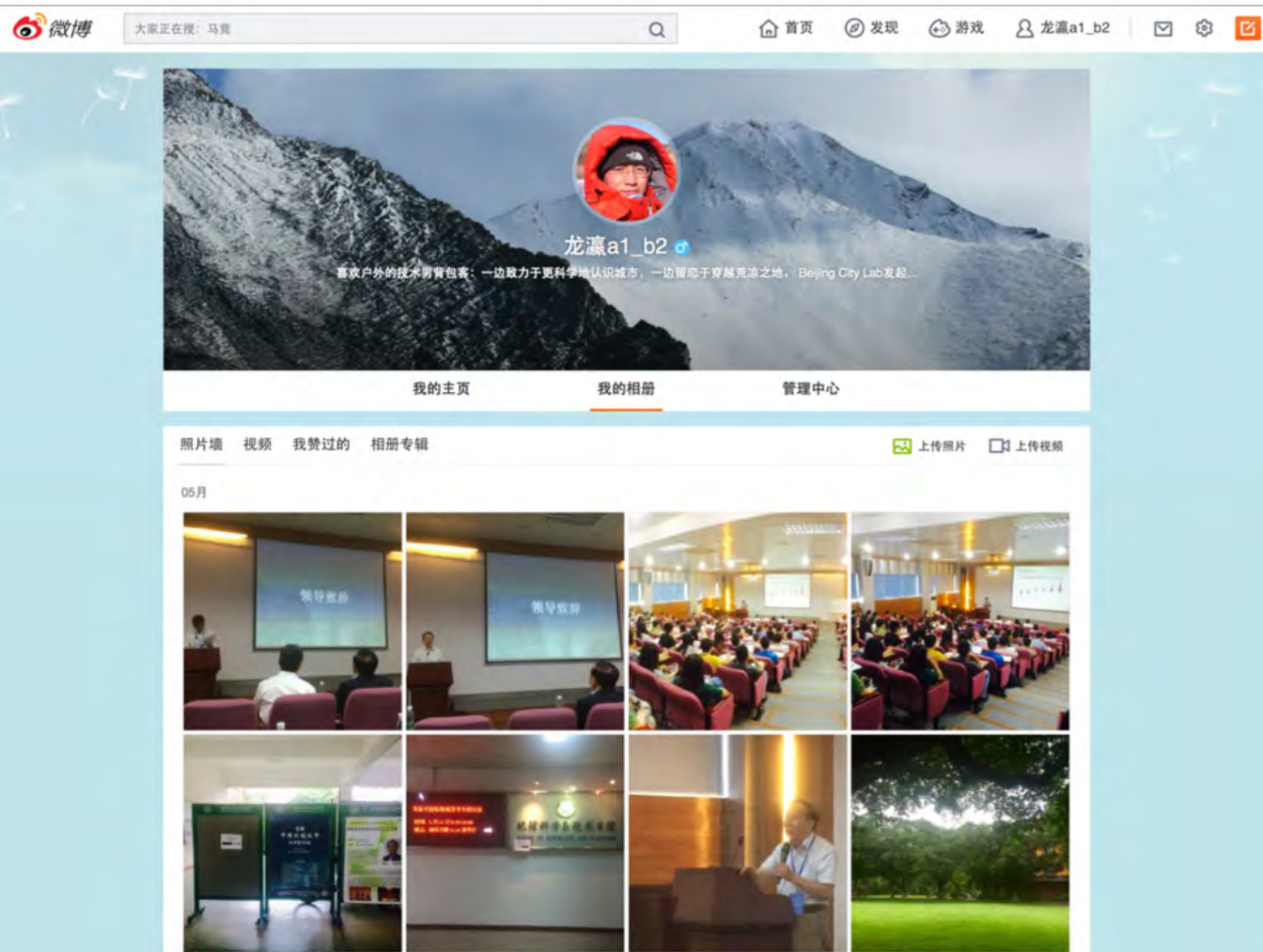


- 百度百科：行车记录仪即记录车辆行驶途中的影像及声音等相关资讯的仪器。安装行车记录仪后，能够记录汽车行驶全过程的视频图像和声音，可为交通事故提供证据。开车时边走边录像，同时把时间、速度、所在位置都记录在录像里，相当“黑匣子”。也可在家用作DV拍摄生活乐趣，或者作为家用监控使用。 **生命记录**

无人机



- 在提供娱乐的同时，还将成为城市研究的数据源，弥补街景图片更新周期慢、地面视角的局限性
- 可以作为公共空间与公共生活调研、城市灾害评价等的工具



- www.weibo.com
- http://open.weibo.com/wiki/2/statuses/public_timeline

互联网搜索

Google

必应

YAHOO!



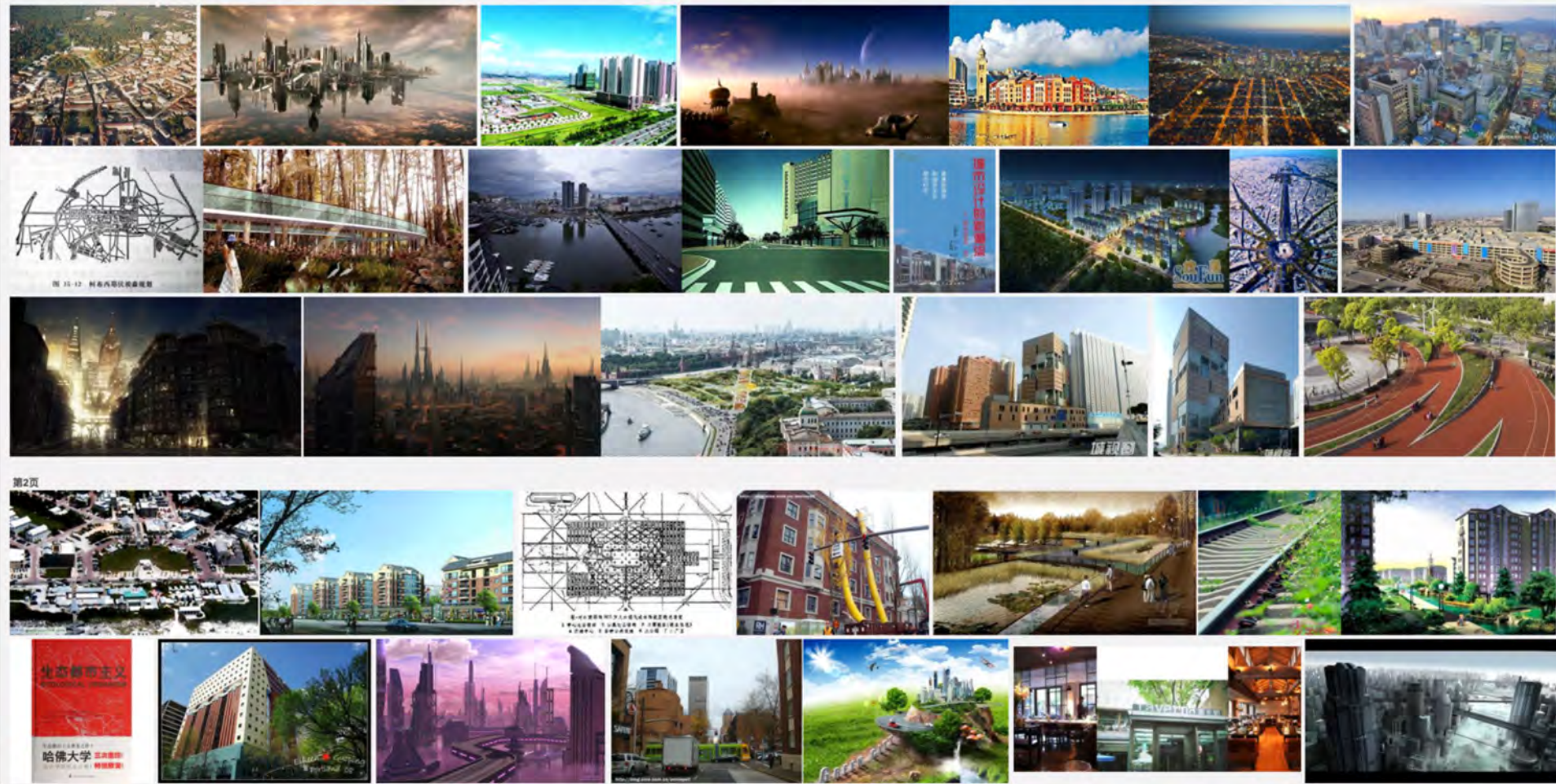
Baidu 图片

城市主义

百度一下

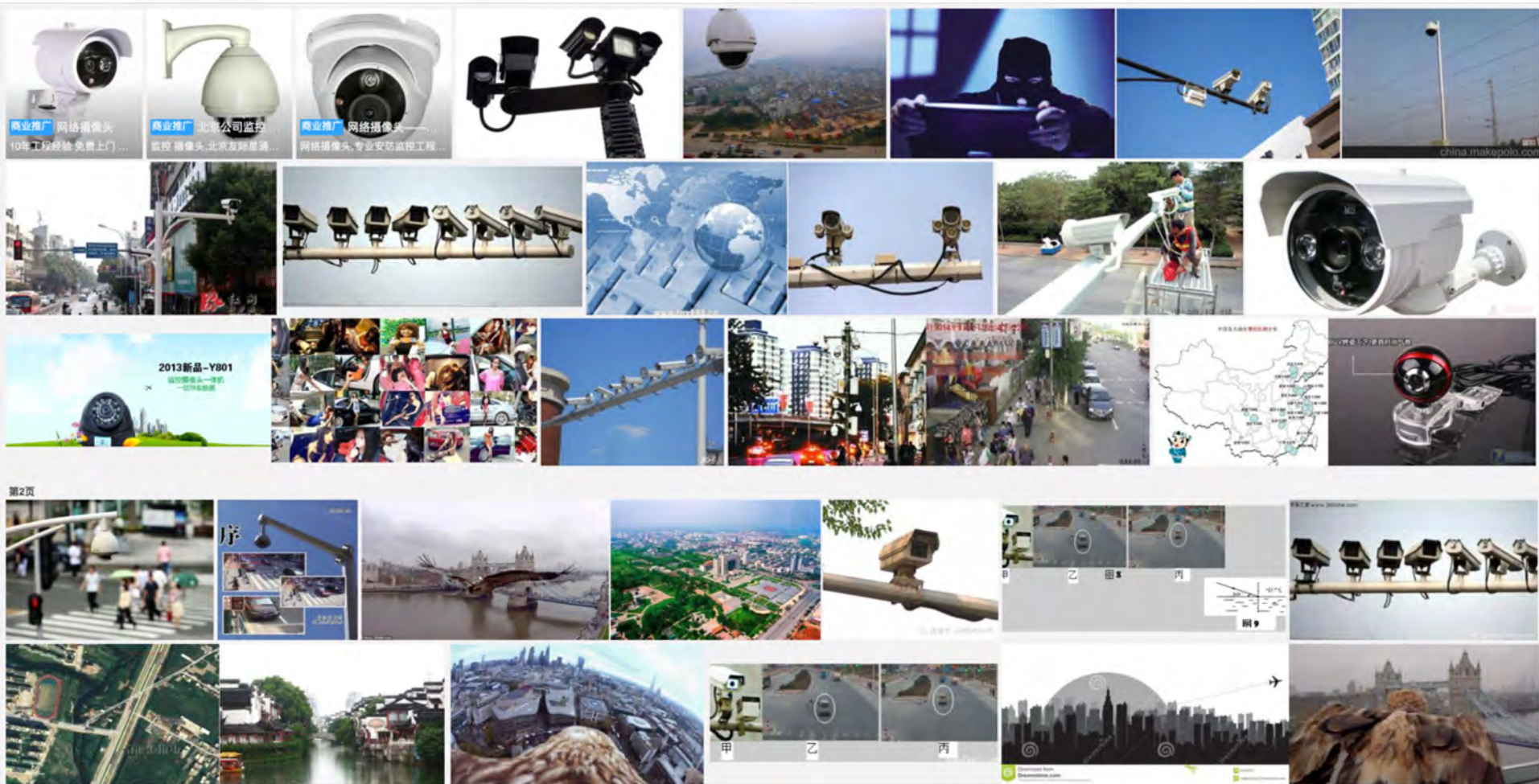
图片筛选

相关搜索: 超现代主义绘画 新现代主义 新现代主义建筑 雅致主义装修风格 归本主义 轻奢新主义 至上主义 新现代主义风格 新装饰主义 英雄主义 现代主义建筑风格 极端主义 男性主义 归本主义风格 超人类主义



[http:// Image.baidu.com](http://Image.baidu.com) <http:// Images.google.com> <http://bing.com/images>

人的尺度城市形态研究的新思路
Picture Urbanism



- 无处不在的摄像头所记录的视频信息，超越了目前所见的大部分的新兴城市数据，除了成为重要的历史遗产，也将成为对历史上的城市进行量化研究的重要数据源

空间视频 (spatial video)

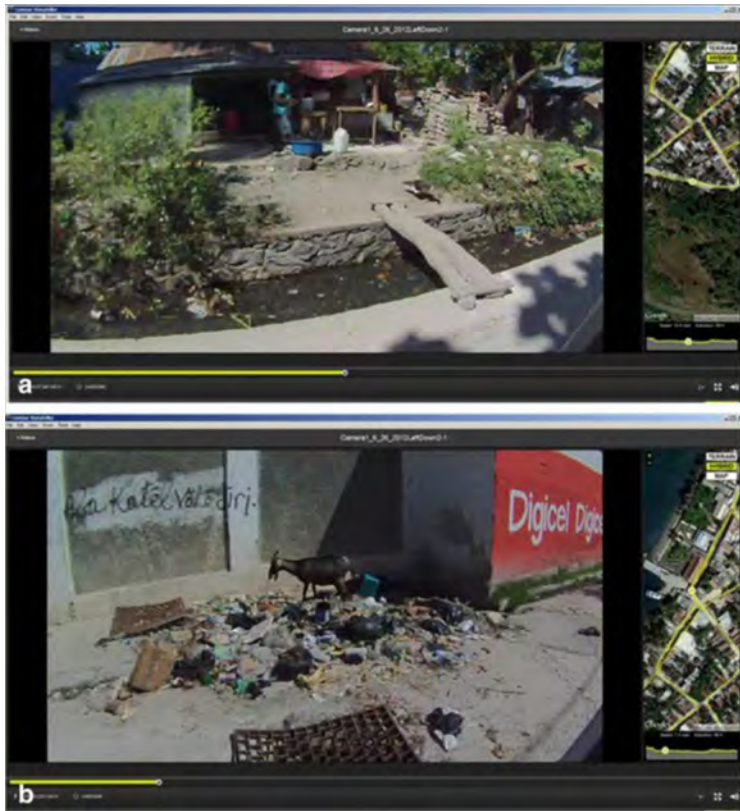


Figure 1 Examples from the spatial video “Storyteller” software showing two of the health risks analyzed in this paper; standing water (a) and trash (b).

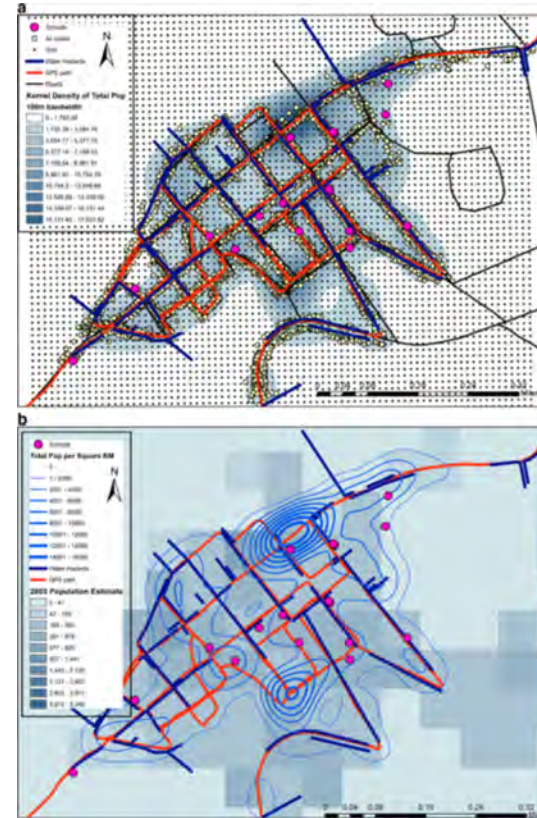


Figure 2 Spatial patterns of coded variables from the video. Kernel density of population, water risks, and school locations (a) and a comparison of spatial video population with alternative pre-earthquake census estimates (b).

- 空间视频是指包括GPS编码的视频，可从多个角度收集高清晰度的动态影像，数据加载进GIS可用于进一步的可视化和分析，已被用于突发的公共卫生事件或灾害后的现场评估，是一种有效的获取精细化尺度数据的手段
- Curtis, A., Blackburn, J. K., Widmer, J. M., & Morris Jr, J. G. (2013). A ubiquitous method for street scale spatial data collection and analysis in challenging urban environments: mapping health risks using spatial video in Haiti. *International journal of Health Geographics*, 12(1), 1-14

图片 vs 其他新数据

- 图片反映物质空间的尺寸、形态、构成、功能、风貌、品质、场所感等，也反映社会空间的密度、活力、精神、阶层、幸福感等
- 相比多对应一个维度的其他新数据，图片体现的维度更为丰富
- 量化城市研究领域，图片相关的研究有限，但有快速上升趋势
- 图片数据量更为巨大，处理难度相应更高（已有研究多针对照片点位的分析，而不是针对具体内容）



社交网络



专业网站





已有相关研究

Literature review

Learning Deep Features for Scene Recognition using Places Database

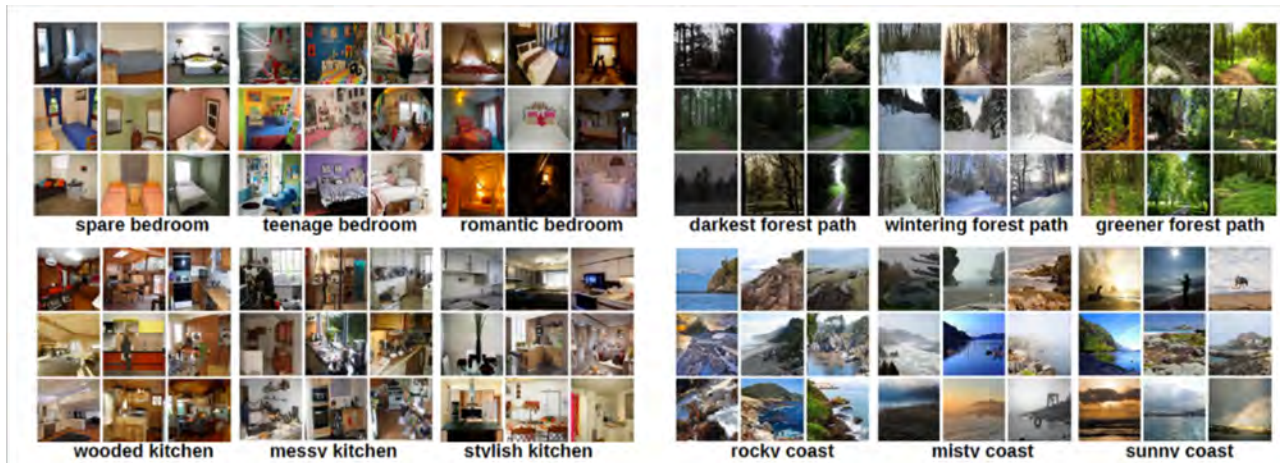


Figure 1: Image samples from the scene categories grouped by their queried adjectives.

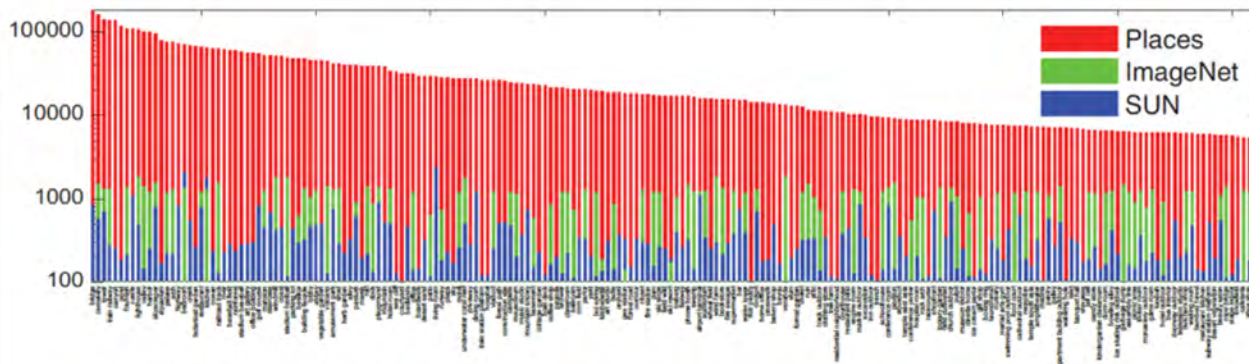


Figure 2: Comparison of the number of images per scene category in three databases.

- Zhou, B., Lapedriza, A., Xiao, J., Torralba, A., & Oliva, A. (2014). Learning deep features for scene recognition using places database. In *Advances in neural information processing systems* (pp. 487-495).

C-IMAGE: City Cognitive Mapping Through Geo-Tagged Photos



- Liu L. 2014. C-IMAGE: city cognitive mapping through geotagged photos. Massachusetts Institute of Technology, Department of Urban Studies and Planning. <http://hdl.handle.net/1721.1/90205>

Google Street View and Gentrification

Google Street View shows that gentrification in Chicago has largely bypassed poor minority neighborhoods, reinforcing urban inequality.

Share this:



*Gentrification has become a catchphrase in recent decades, signaling a reversal of fortunes for declining neighborhoods and cities. Yet **Jackelyn Hwang** and **Robert Sampson** show that race plays a significant role in the degree to which neighborhoods undergo renewal in Chicago, reinforcing durable patterns of urban inequality and revealing the limits of stated preferences for racial diversity. Using Google Street View to collect data on visible indicators of gentrification, they find that neighborhoods suffering from a lack of investment with high concentrations of blacks and Latinos in the mid-1990s had lower levels of reinvestment over the next 14 years. While gentrification does favor a degree of racial diversity, most poor minority neighborhoods have not witnessed widespread reinvestment.*

- <http://blogs.lse.ac.uk/usappblog/2014/07/09/google-street-view-shows-that-gentrification-in-chicago-has-largely-bypassed-poor-minority-neighborhoods-reinforcing-urban-inequality/>, 2014
- <http://www.press.uchicago.edu/ucp/books/book/chicago/G/bo5514383.html>

互联网媒介中的城市意象图景：以广东21个城市为例



- 赵渺希, 徐高峰, & 李榕榕. (2015). 互联网媒介中的城市意象图景——以广东 21 个城市为例. *建筑学报*, (2), 44-49.

Layered Interpretation of Street View Images

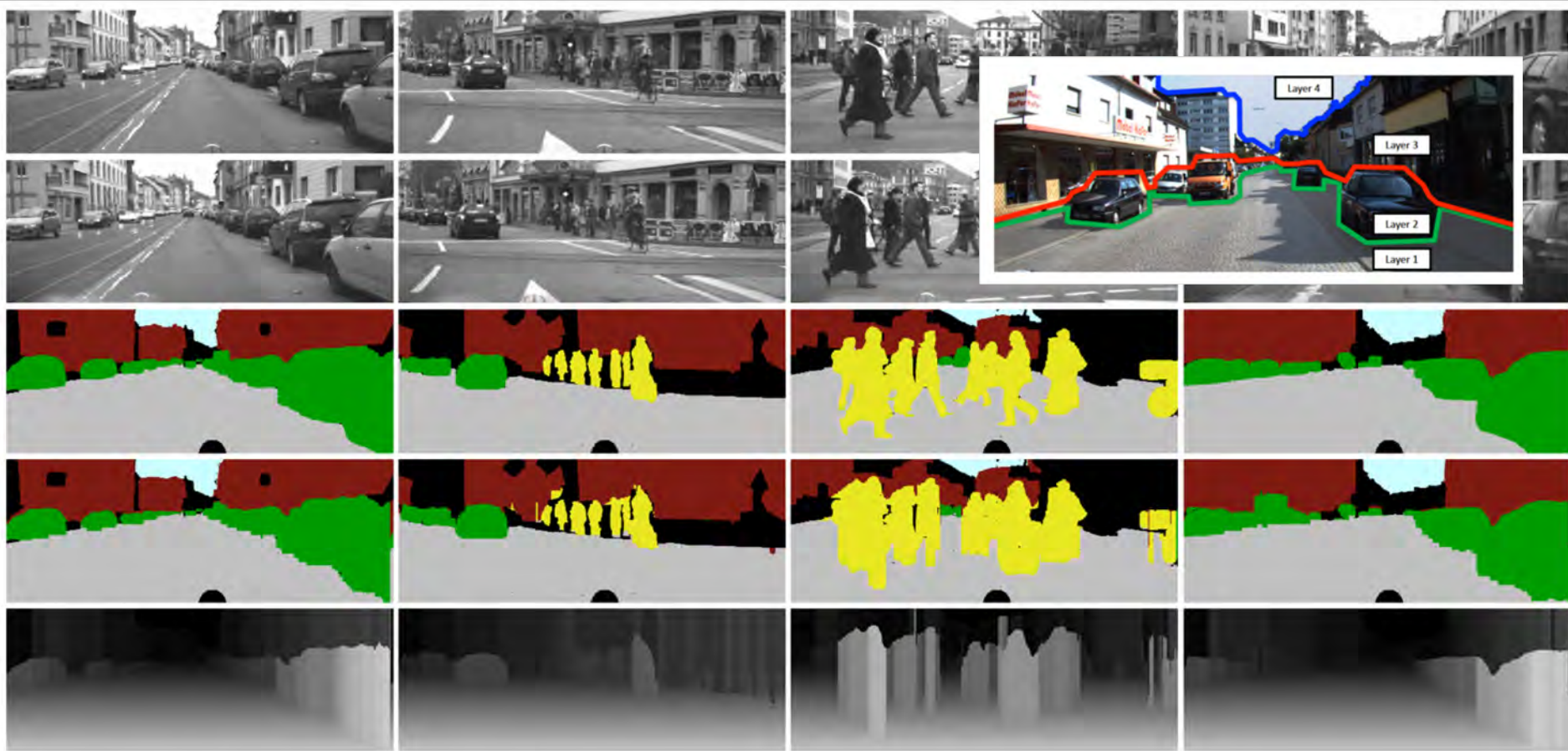
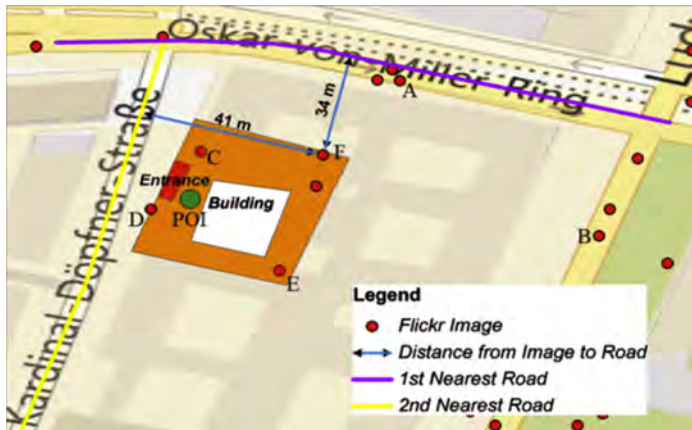
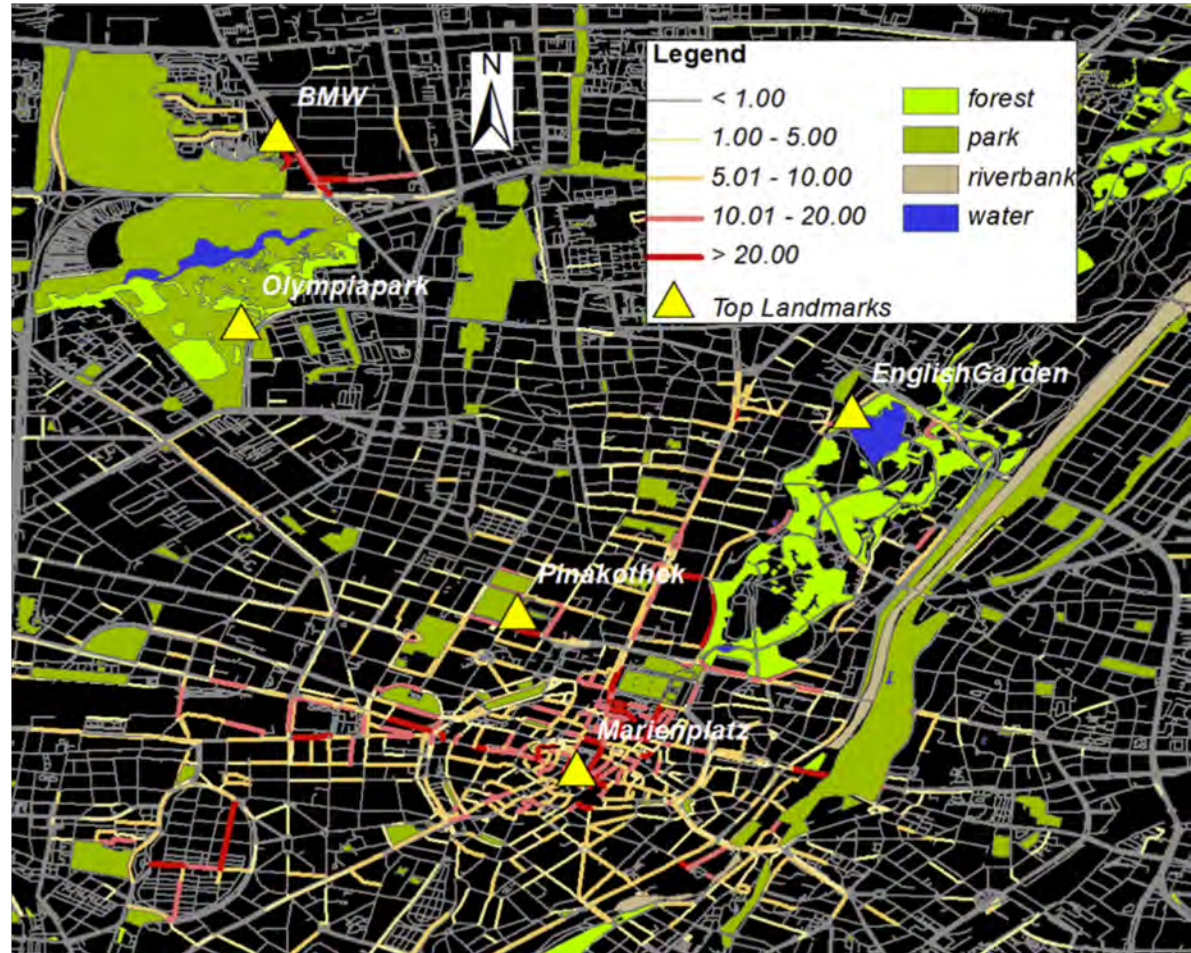
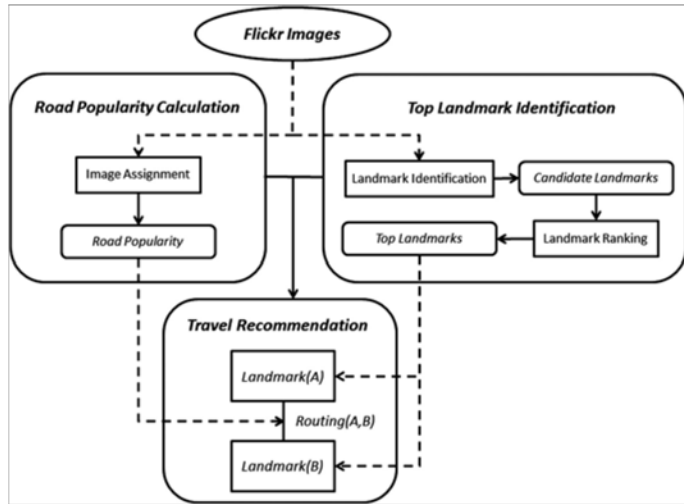


Fig. 5. **Visualization:** The figure visualizes the output computed from the proposed method. From top to bottom, we show the left images, the right images, the ground truth semantic labeling, the semantic labeling, and depth. The black regions are the regions where the ground truths are not available.

- Liu, M. Y., Lin, S., Ramalingam, S., & Tuzel, O. (2015). Layered Interpretation of Street View Images. *arXiv preprint arXiv:1506.04723*.

Road-based travel recommendation using geo-tagged images



- Sun, Y., Fan, H., Bakillah, M., & Zipf, A. (2015). Road-based travel recommendation using geo-tagged images. *Computers, Environment and Urban Systems*, 53, 110-122.

Modelling human mobility patterns using photographic data shared online

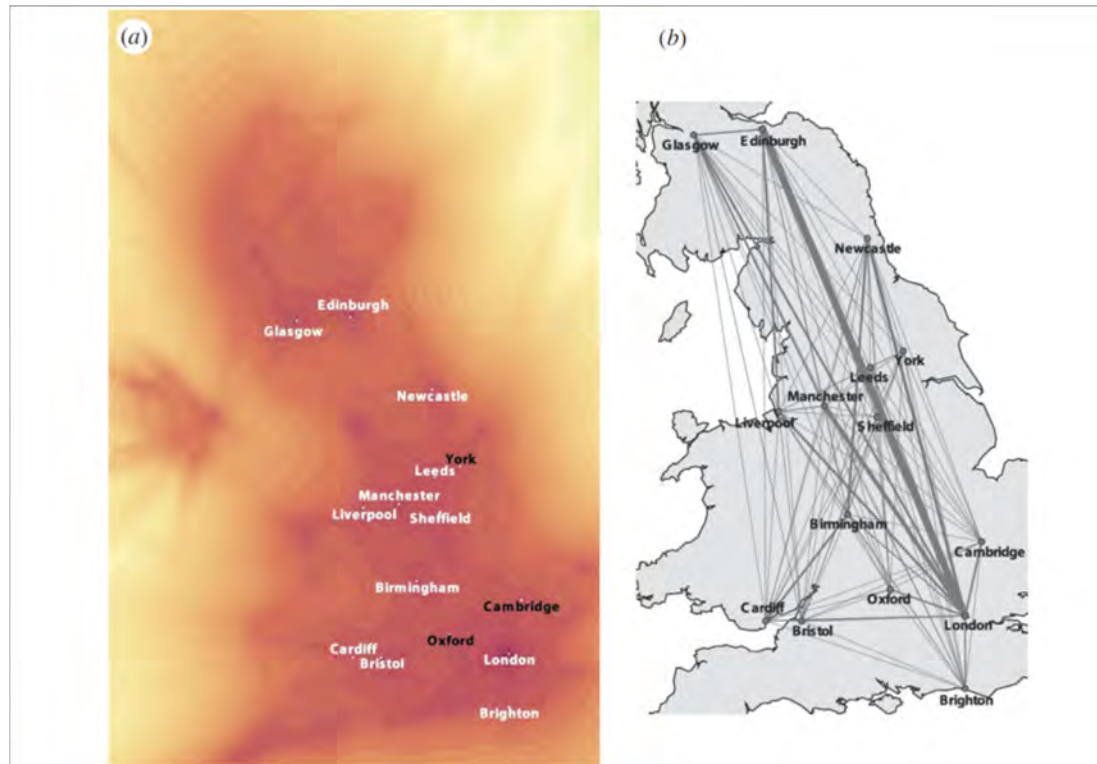


Figure 2. Aggregate model of mobility. (a) Probability of an individual's location derived from data uploaded by all the users in the *Flickr* dataset. The plot depicts the natural logarithm of $p(\mathbf{x})$ as defined in equation (4.1). This describes the likelihood of finding a *Flickr* user in each geographical location and, since the dataset contains photos uploaded in the UK, it resembles the shape of the UK. The points in the map are local maxima identified with a maximum filter and thresholding, and correspond to the location of main UK cities. The names indicated in black indicate cities that do not appear in the list of the 20 most populous UK cities. (b) Aggregate transition probability between pairs of main UK cities. The line widths are proportional to $p(\mathbf{x}_d, \mathbf{x}_o) + p(\mathbf{x}_o, \mathbf{x}_d)$ as defined in equation (4.2) and represent the probability of observing a transition between any two pairs of cities, aggregated over all the users in the dataset.

- Barchiesi, D., Preis, T., Bishop, S., & Moat, H. S. (2015). Modelling human mobility patterns using photographic data shared online. *Royal Society open science*, 2(8), 150046.

A multi-scale approach to exploring urban places in geotagged photographs

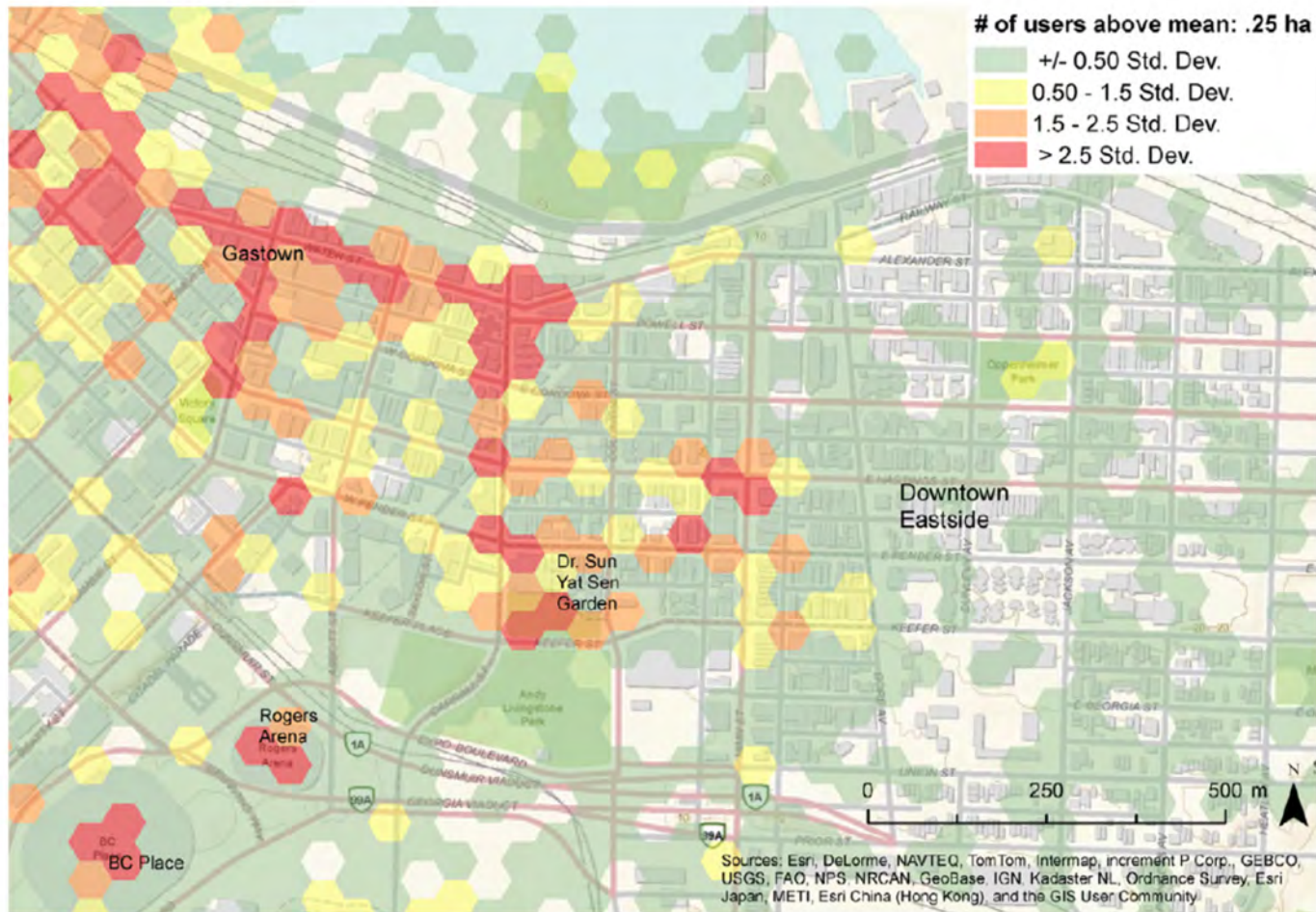
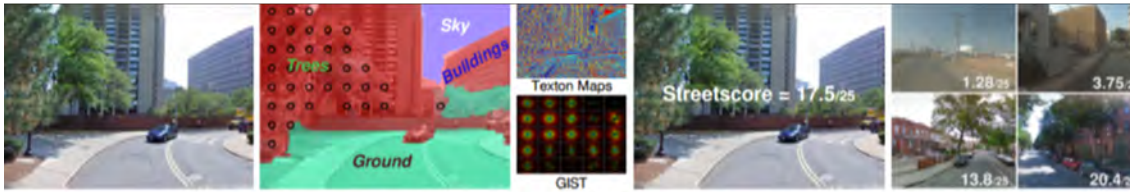


Fig. 6. Vancouver's Downtown Eastside – number of Flickr users with photographs in 1 ha sampling areas.

- Feick, R., & Robertson, C. (2015). A multi-scale approach to exploring urban places in geotagged photographs. *Computers, Environment and Urban Systems*, 53, 96-109.

Do people shape cities, or do cities shape people?



(a) Streetscore Prediction from Image Features



(b) Street Blocks with No Significant Change in Streetscore



(c) Street Blocks with Significant Improvement in Streetscore



利用多点动态街景对社区空间变化进行量化，探寻美国五个大城市物质空间与人口、经济变化之间的交互作用机制

FINDING:

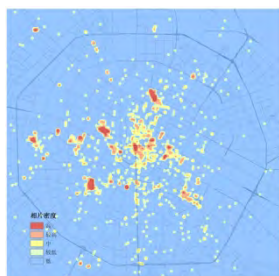
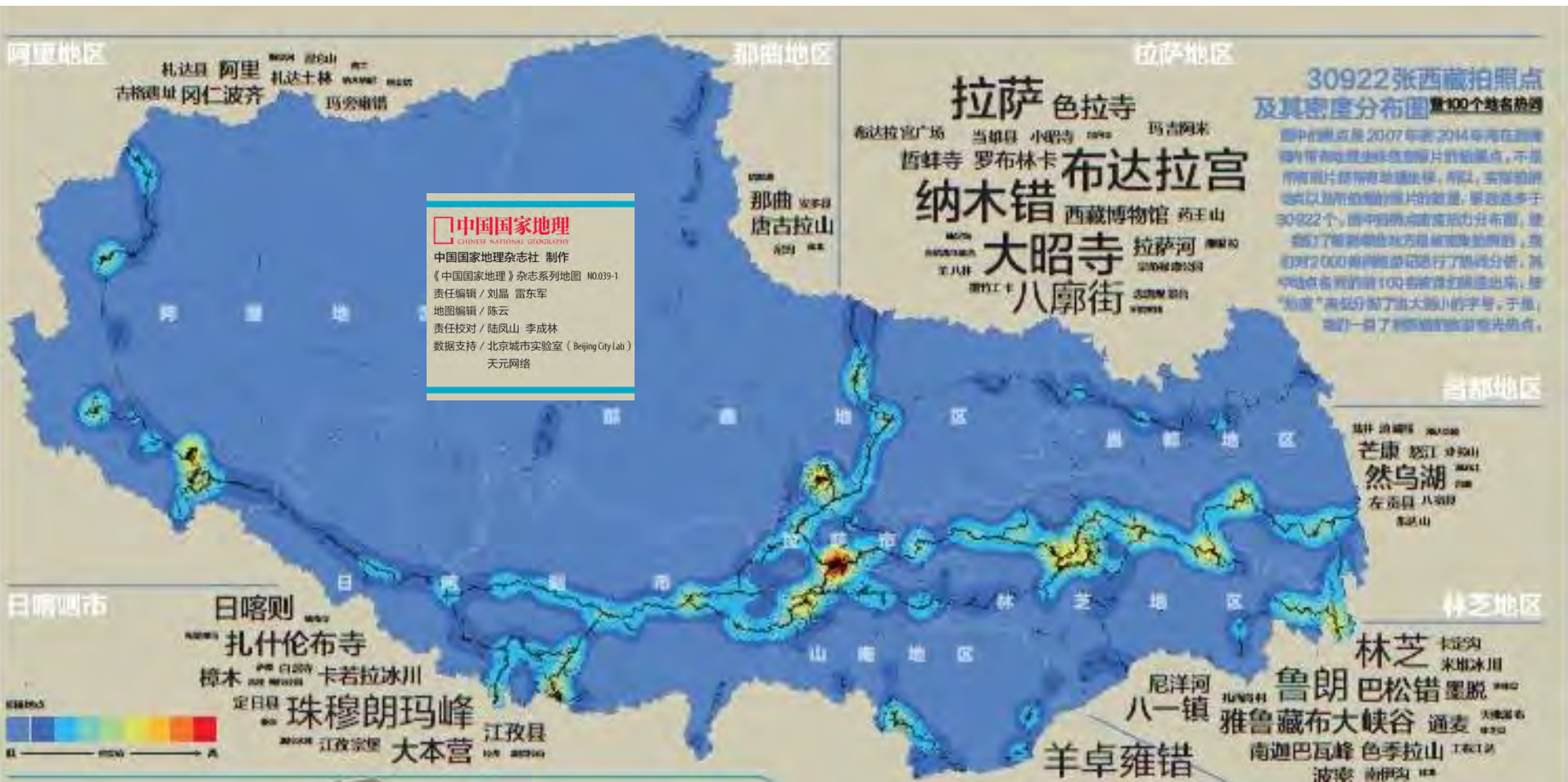
人口密度、教育水平的提升将促进社会环境品质的改善，收入、空置率、月租与空间形态并没有太大关系，空间品质的影响符合“同心圆”理论“临界”和“过滤”理论的部分正确性。

来源：Do People Shape Cities, or Do Cities Shape People? The Co-evolution of Physical, Social, and Economic Change in Five Major U.S. Cities

Existing case studies

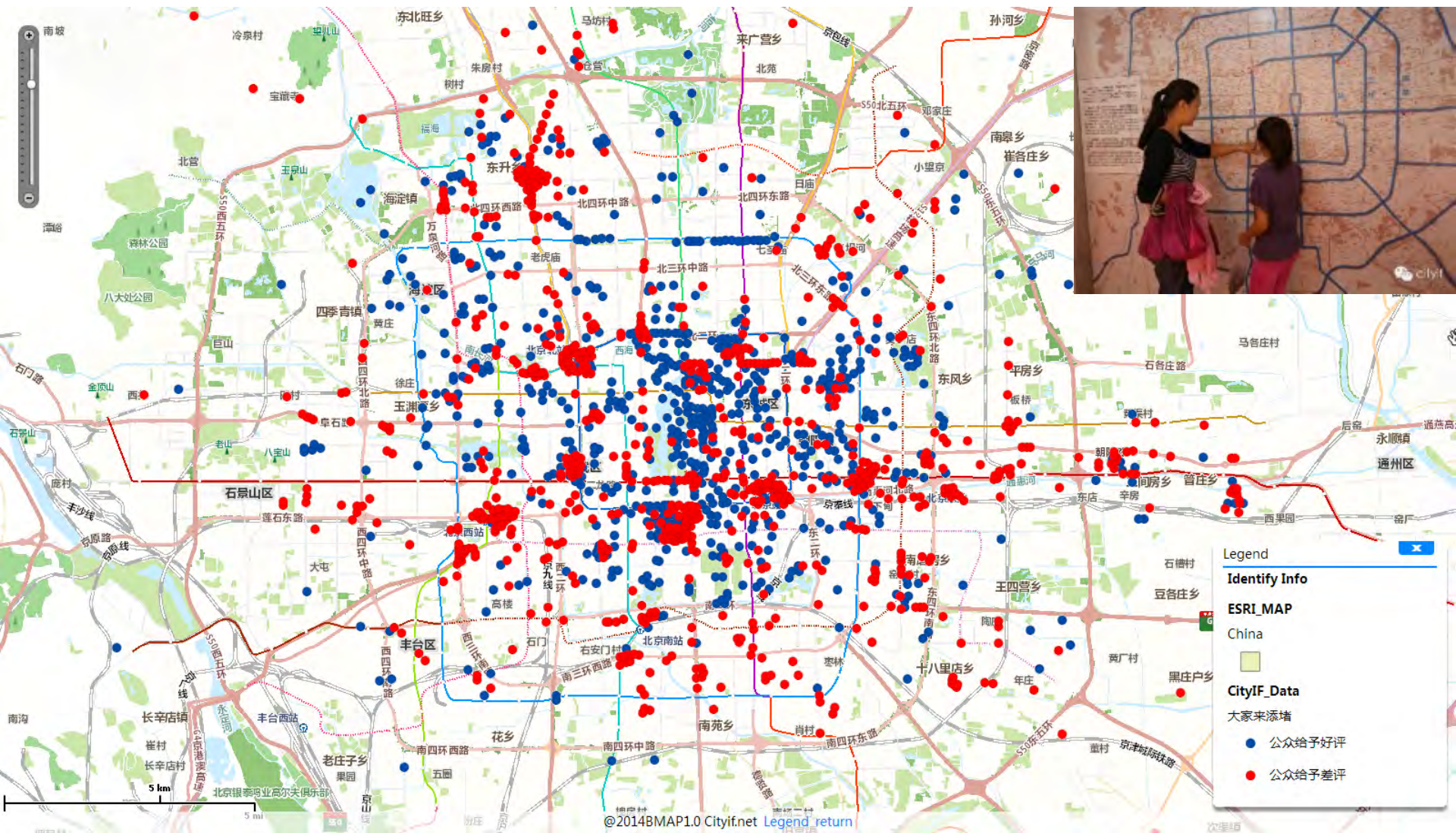
已有研究 (龙瀛与其合作者)

《中国国家地理》西藏专辑



- 基于Flickr照片的点位信息，识别主要旅游关注点，展示了西藏以点和线为主要形态的空间意象
- 2015年10月刊

北京街道可步行性评价



- 利用参与式规划的方法，由公众对北京不同街道的可步行性进行评价，给予好评与差评
- 合作者：茅明睿、储妍、崔鹤等

北京街道可步行性评价

大类	细分类	精细评分标准		
		-1	0	1
减分项	路面铺装	N/A	铺装平整	铺装残缺或杂草丛生
	无障碍性	N/A	有必备盲道和缓坡	无盲道或缓坡
	违章停车	N/A	无停车占道	存在停车占道
	设施占道	N/A	无设施占道	存在市政设施占道
	视线遮挡	N/A	无侧边停车	侧边停车遮挡视线
加分项	步行尺度	容许 2 人或以上 并行通过	容许 1 人轻松通过	无路可走
	可达性	方便安全的人行 横道或十字路口	道路较宽但可视范 围内设有天桥或地 下通道	可视范围内无路口或行 人路线过于复杂
	魅力空间	能聚集人气的积 极空间	正常路边空间	混乱无序的消极空间
	绿化景观	能遮蔽大部分步 行道空间的绿荫	正常的绿化空间	无遮蔽

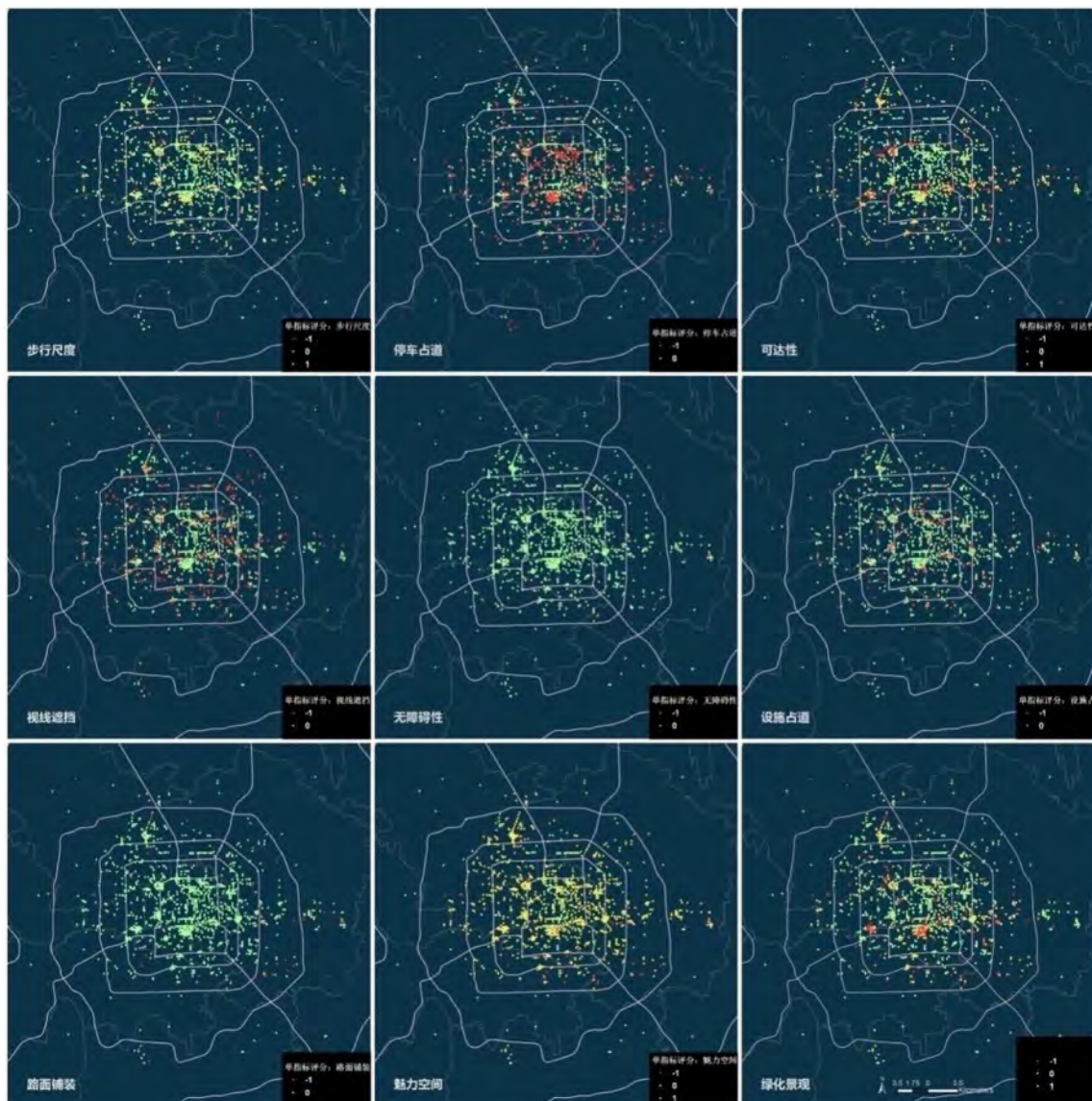
- 针对被综合评价的街道，利用街景照片，对单项指标进行打分，进而识别北京街道可步行性的影响因素，进而产生政策建议

北京街道可步行性评价

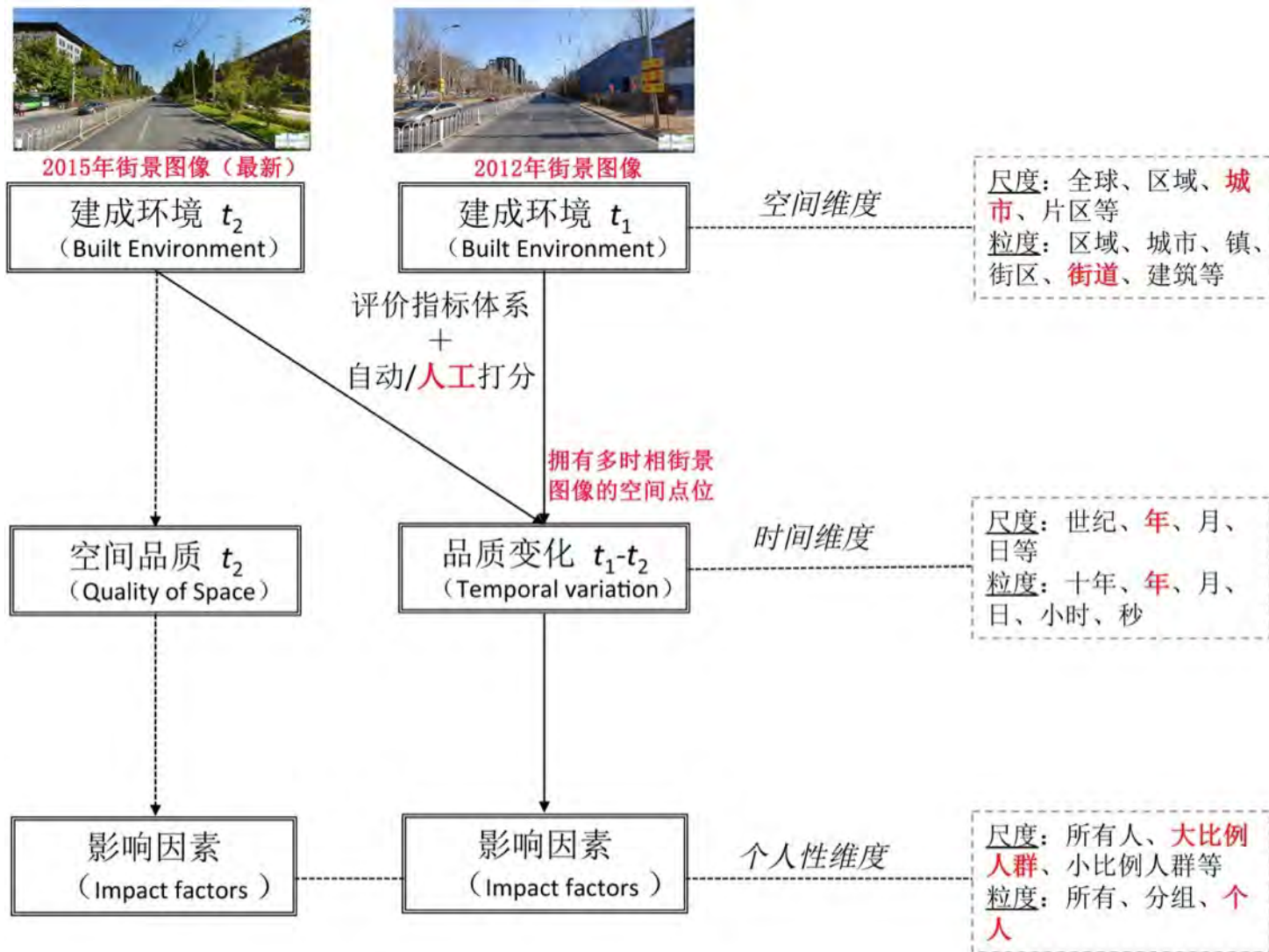


- 针对每个扎针点，获取360度街道全景图，对加分项和减分项的所有指标进行量化评价

北京街道可步行性评价



城市空间品质的测度、变化评价与影响因素识别



- 合作者：清华大学建筑学院 唐婧娴、翟炜、马尧天、杨东

城市空间品质的测度、变化评价与影响因素识别

- 围墙周边绿化和设施建设 (0)



- 围墙周边绿化和设施建设 (1)



- 说明：围墙通透性发生变化为1，无变化为0

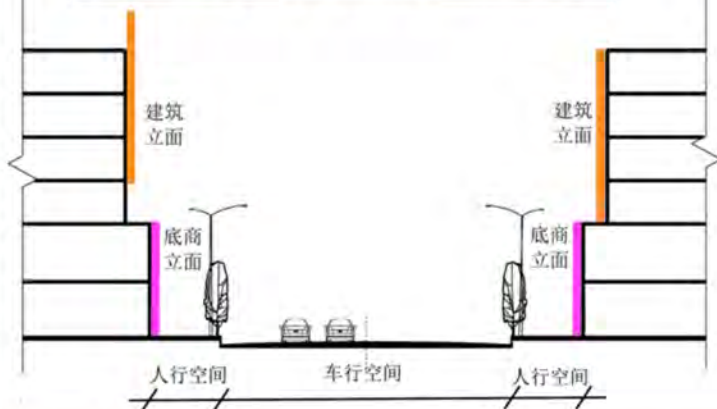
城市空间品质的测度、变化评价与影响因素识别

2

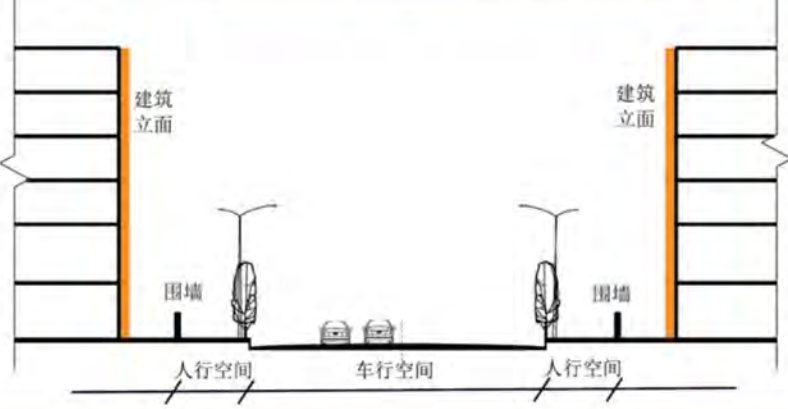
空间品质 变化评分

根据从建筑界面到道路中线的空间位置的不同，结合北京居住项目周边空间环境变化的实际情况，将居住项目周边空间品质的评价指标划分为4个大类，11个子类。

街道空间评价要素（底商）



街道空间评价要素（围墙）



大类	建筑部分	人行道部分	车行道部分	底商或围墙部分	
				底商部分	围墙部分
子类	<ul style="list-style-type: none"> 立面色彩变化 (0或1) 立面清理、材质更改及其他 (0或1) 建筑部分改善是否有效 (0或1或2) 	<ul style="list-style-type: none"> 停车空间整治 (0或1) 绿化改善 (0或1) 街道家具增设或优化 (0或1) 人行道部分改善是否有效 (0或1或2) 	<ul style="list-style-type: none"> 车道细化 (0或1) 绿化改善 (0或1) 道路部分改善是否有效 (0或1或2) 	<ul style="list-style-type: none"> 店面招牌变化 (0或1) 店面立面通透性、装饰变化 (0或1) 底商部分改善是否有效 (0或1或2) 	<ul style="list-style-type: none"> 通透性变化 (0或1) 周边绿化与设施建设 (0或1) 围墙部分改善是否有效 (0或1或2)

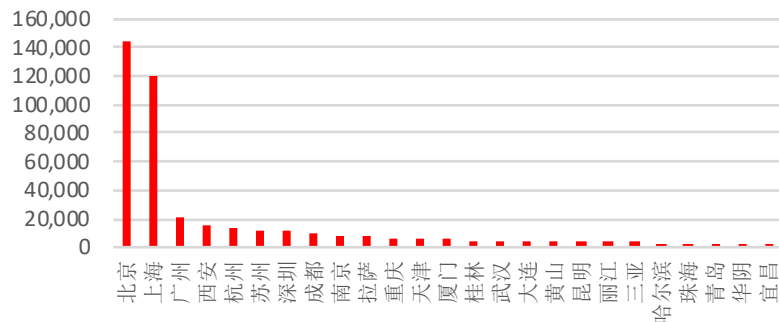
中国城市意象识别



照片数量前30位的城市

城市名称	照片数量	城市名称	照片数量	城市名称	照片数量
北京	144,832	重庆	6,255	哈尔滨	2,932
上海	120,601	天津	6,027	珠海	2,759
广州	21,212	厦门	5,365	青岛	2,212
西安	16,160	桂林	4,787	华阴	1,990
杭州	12,818	武汉	4,593	宜昌	1,944
苏州	11,720	大连	4,554	济南	1,875
深圳	11,060	黄山	4,231	贵阳	1,819
成都	9,195	昆明	4,064	张家界	1,778
南京	7,440	丽江	3,713	东莞	1,727
拉萨	7,316	三亚	3,433	大同	1,574

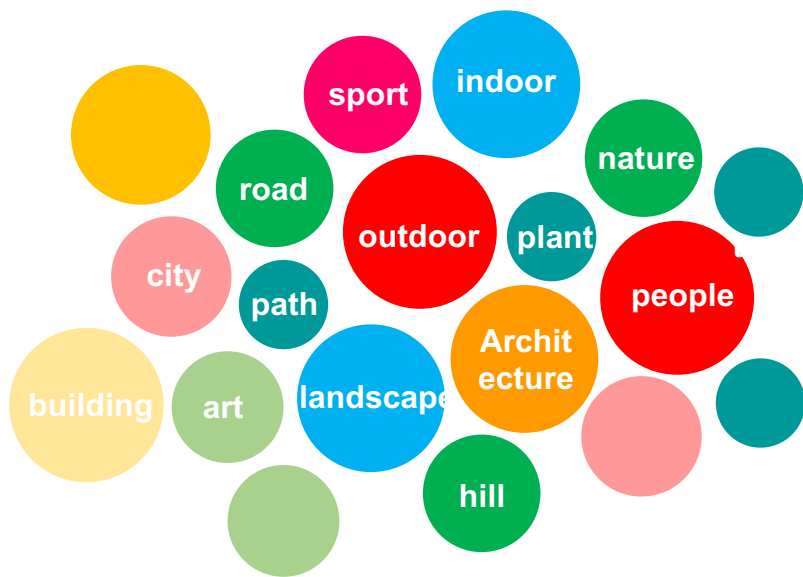
Flickr照片数量



- YFCC100M：中国境内1,907,176张Flickr照片，中国大陆659个城市范围内共有479,471张Flickr照片。
- 合作者：重庆大学 曹越皓

中国城市意象识别

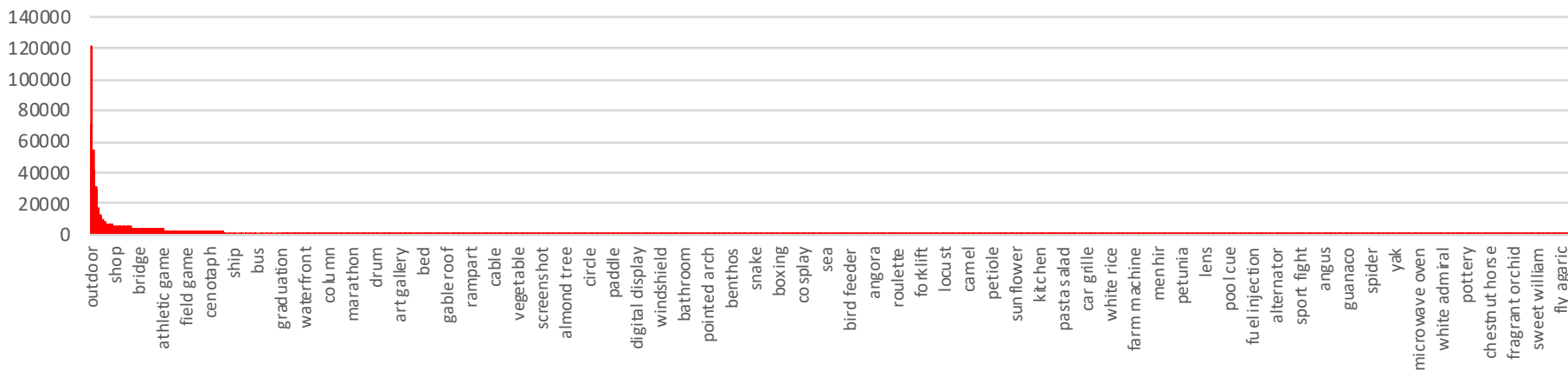
数量前50类标签



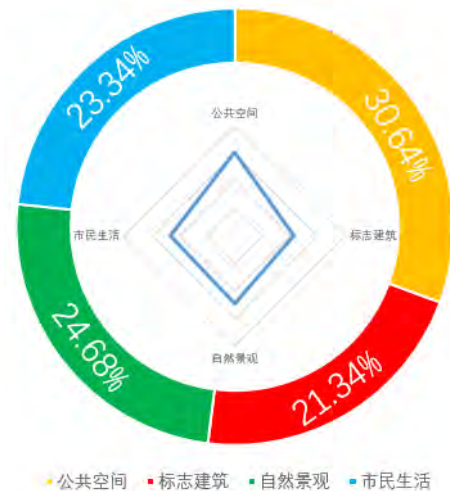
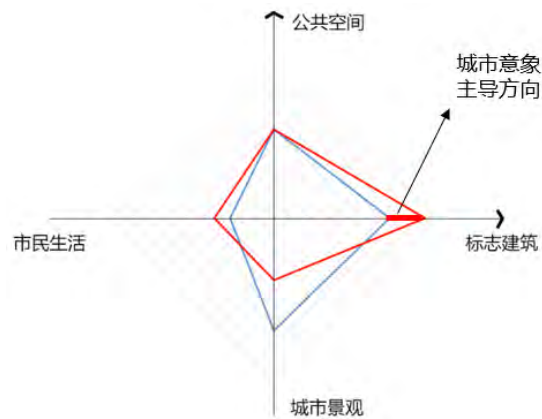
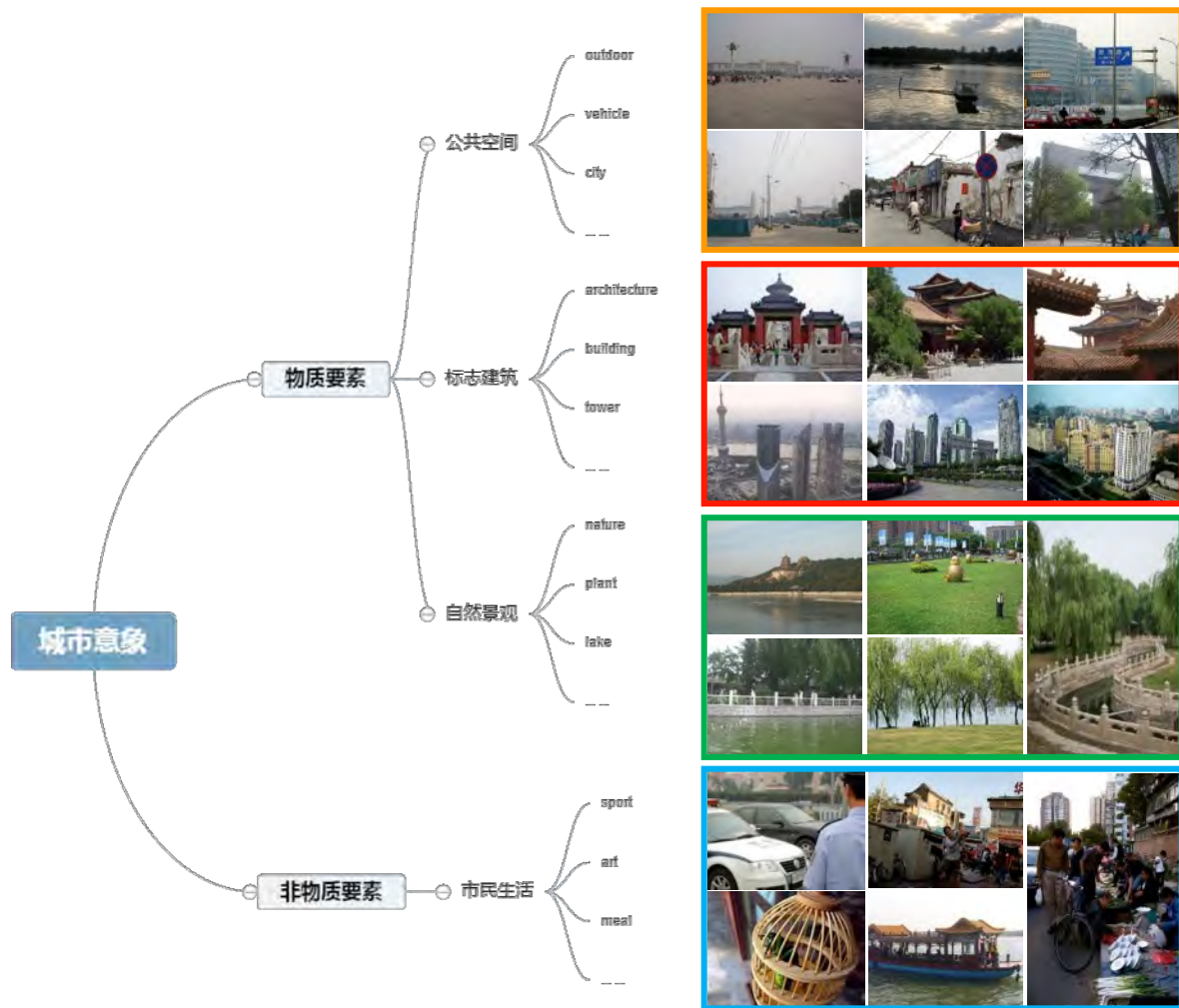
平均每张照片拥有**5.75个深度学习标签**。数量前300类标签数据，即**19.12%**的标签占标签总数的**82.62%**。

TAGS	SUM	PCT	TAGS	SUM	PCT
outdoor	121689	8.36%	shop	6330	0.44%
indoor	70530	4.85%	music	6195	0.43%
architecture	55397	3.81%	mountainside	6137	0.42%
nature	41080	2.82%	lake	5988	0.41%
landscape	31792	2.19%	tree	5738	0.39%
building	31663	2.18%	road	5732	0.39%
people	30091	2.07%	hall	5687	0.39%
sport	17510	1.20%	bike	5680	0.39%
animal	13935	0.96%	harbor	5606	0.39%
plant	13823	0.95%	bluff	5520	0.38%
vehicle	11109	0.76%	electronics	5501	0.38%
city	9597	0.66%	foliage	5396	0.37%
food	9164	0.63%	cloud	5246	0.36%
hill	9102	0.63%	alp	5246	0.36%
art	8538	0.59%	friends	5216	0.36%
building complex	8080	0.56%	sign	5208	0.36%
boat	7973	0.55%	flower	5188	0.36%
furniture	7667	0.53%	court game	5171	0.36%
room	7606	0.52%	classroom	5090	0.35%
house	7586	0.52%	cliff	5044	0.35%
building structure	7530	0.52%	field	5038	0.35%
mountain	7195	0.49%	dusk	4919	0.34%
text	7159	0.49%	water	4841	0.33%
coast	6809	0.47%	condominium	4826	0.33%
foothill	6421	0.44%	path	4705	0.32%

照片标签数量表



中国城市意象识别



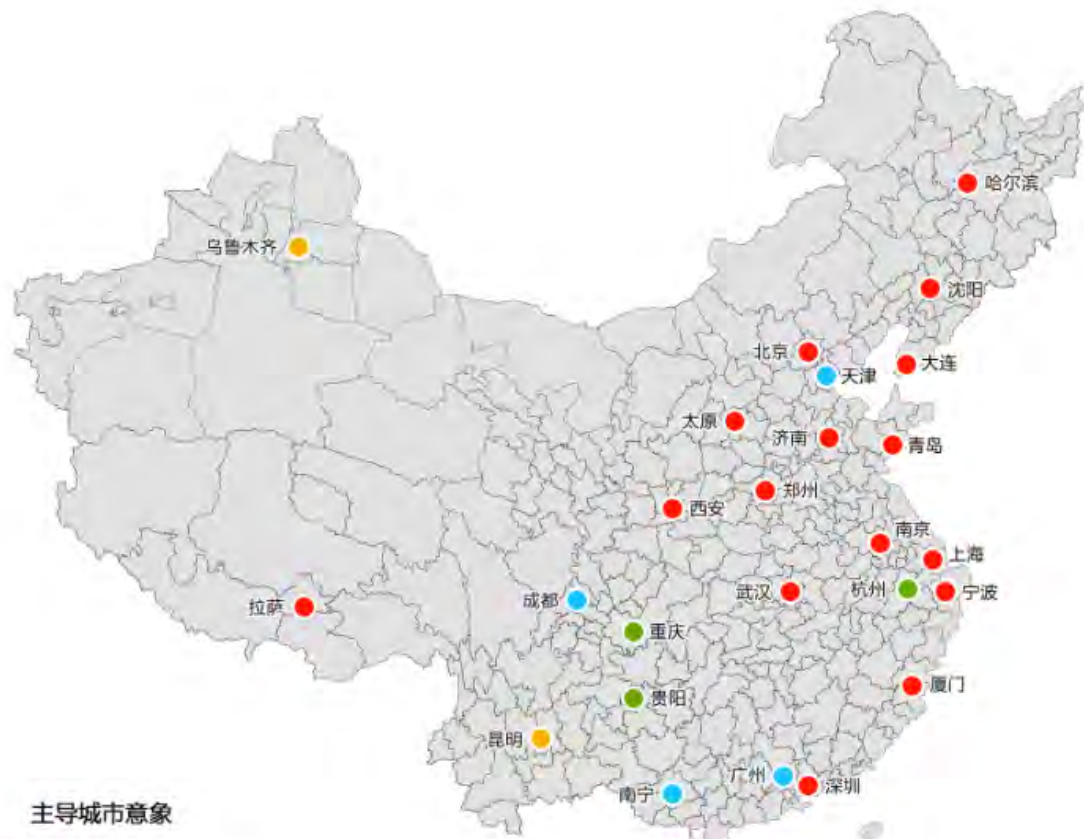
- 根据城市意象的研究与标签内容，将城市意象按照物质要素与非物质要素分为公共空间、标志建筑、自然景观和市民生活四种类型。以各类别标签数量比例表达各要素在城市意象中的构成关系。

中国城市意象识别



• 全国24个主要城市的城市意象识别

中国城市意象识别



• 全国24个主要城市的城市意象识别

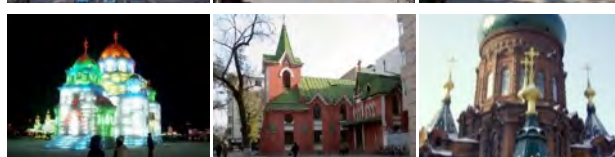
乌鲁木齐



昆明



哈尔滨



西安



重庆



杭州



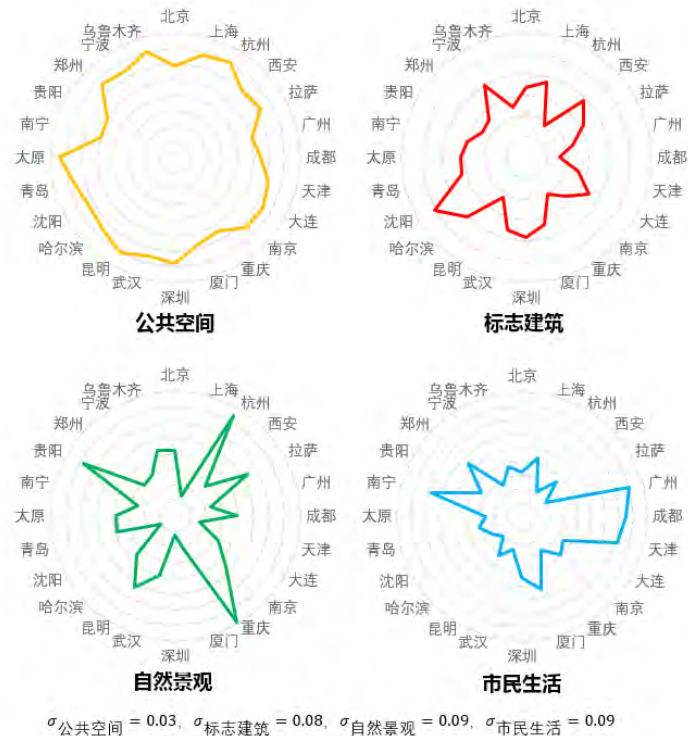
广州



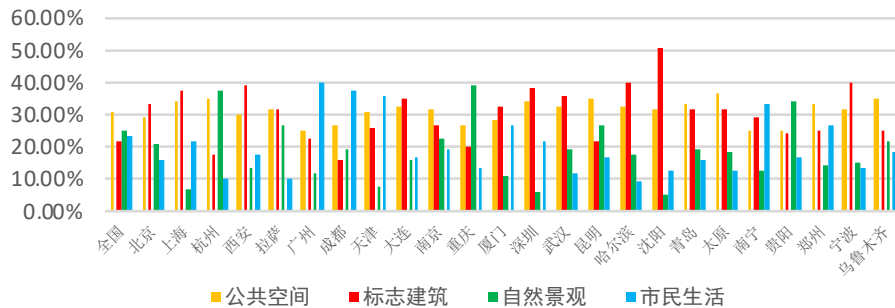
成都



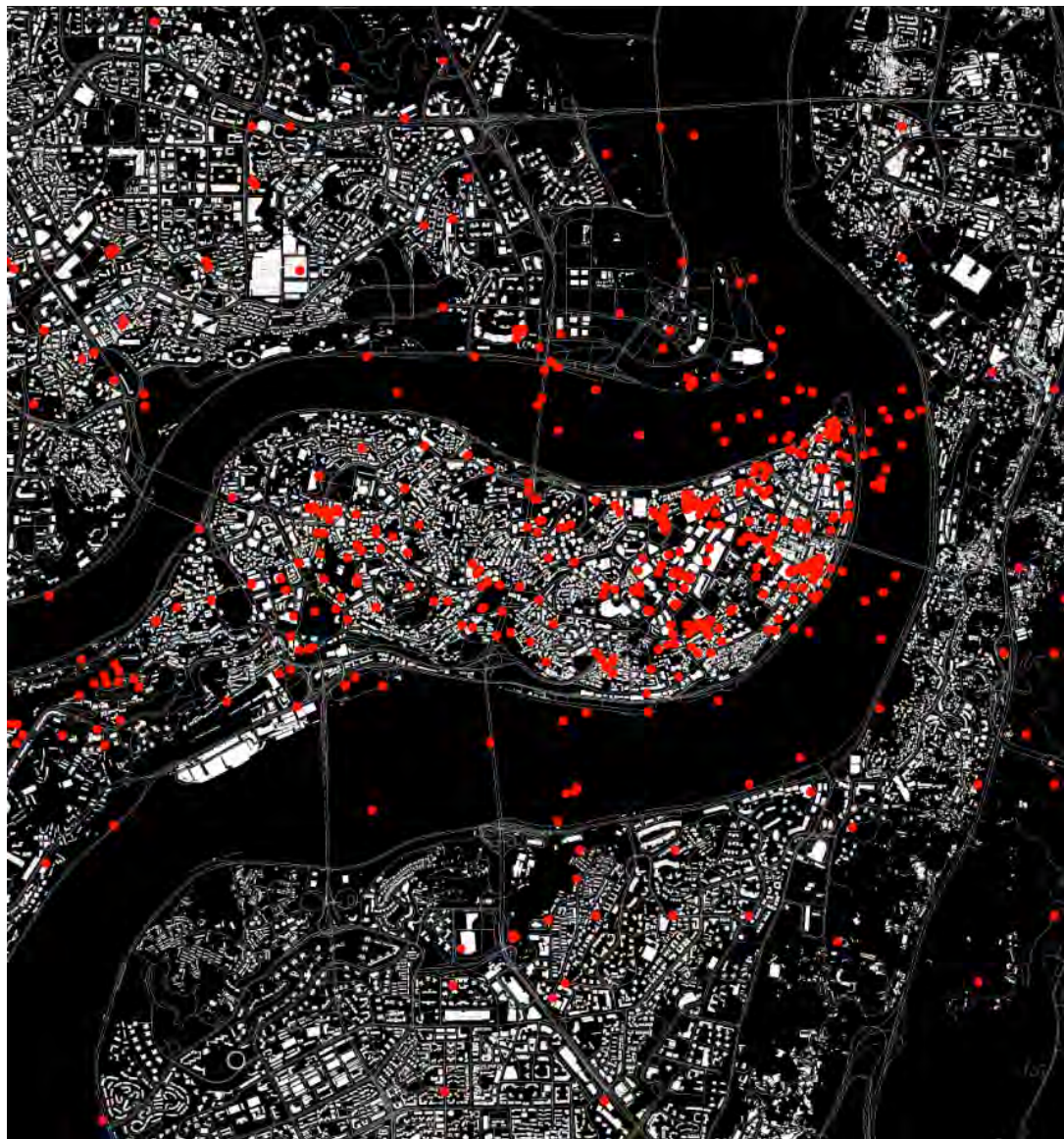
中国城市意象识别



城市意象要素构成



What is the city image of Chongqing?

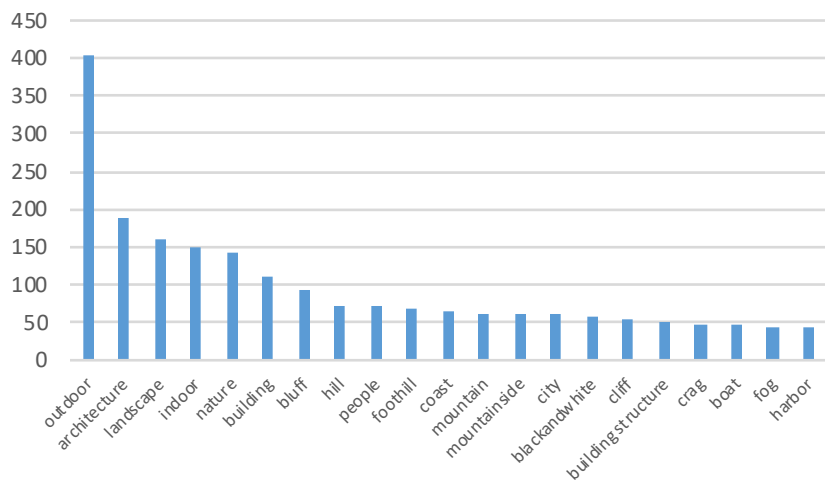


6255 Tagged-Photos
in Chongqing
from Flickr



中国城市意象识别

TOP20 Tags in Chongqing



Architecture + Mountain + Cliff

Tagged-Photos > 45%

Architecture



Architecture

Building

Building Structure

Mountain



Hill

Foothill

Mountain

Mountainside

Cliff



Bluff

Coast

Cliff

Crag

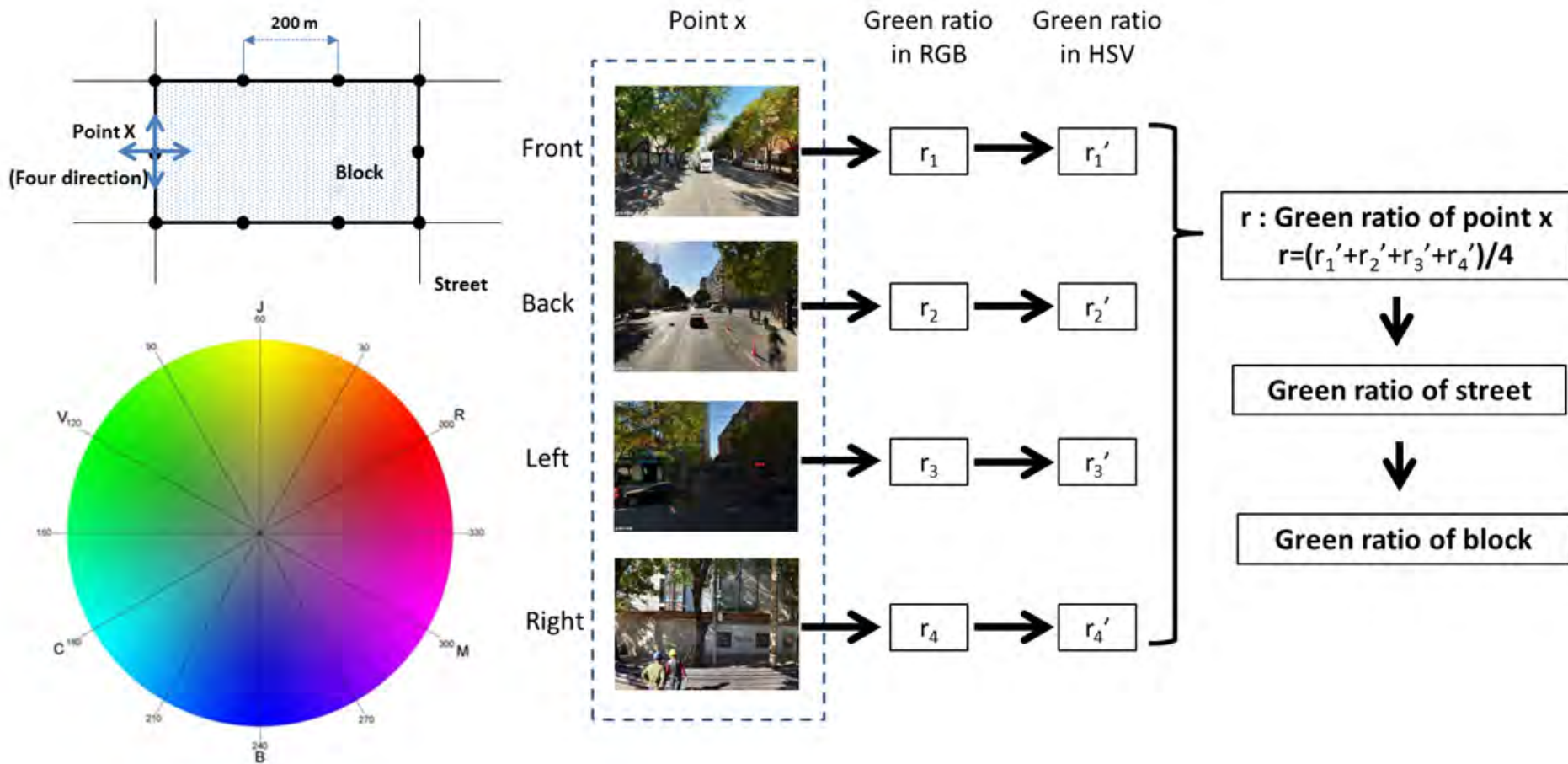
Harbor

我们的街道有多绿？



- 绿化是建成环境的重要要素，具有净化空气、缓解紧张情绪等作用，是空间规划关注的重要对象（如长久以来对田园城市的追求）
- 国家住房与城乡建设部的国家园林城市多批名单
- 平面的绿化（绿地率）与立体的绿化（绿视率）
- 合作者：刘浏

我们的街道有多绿？

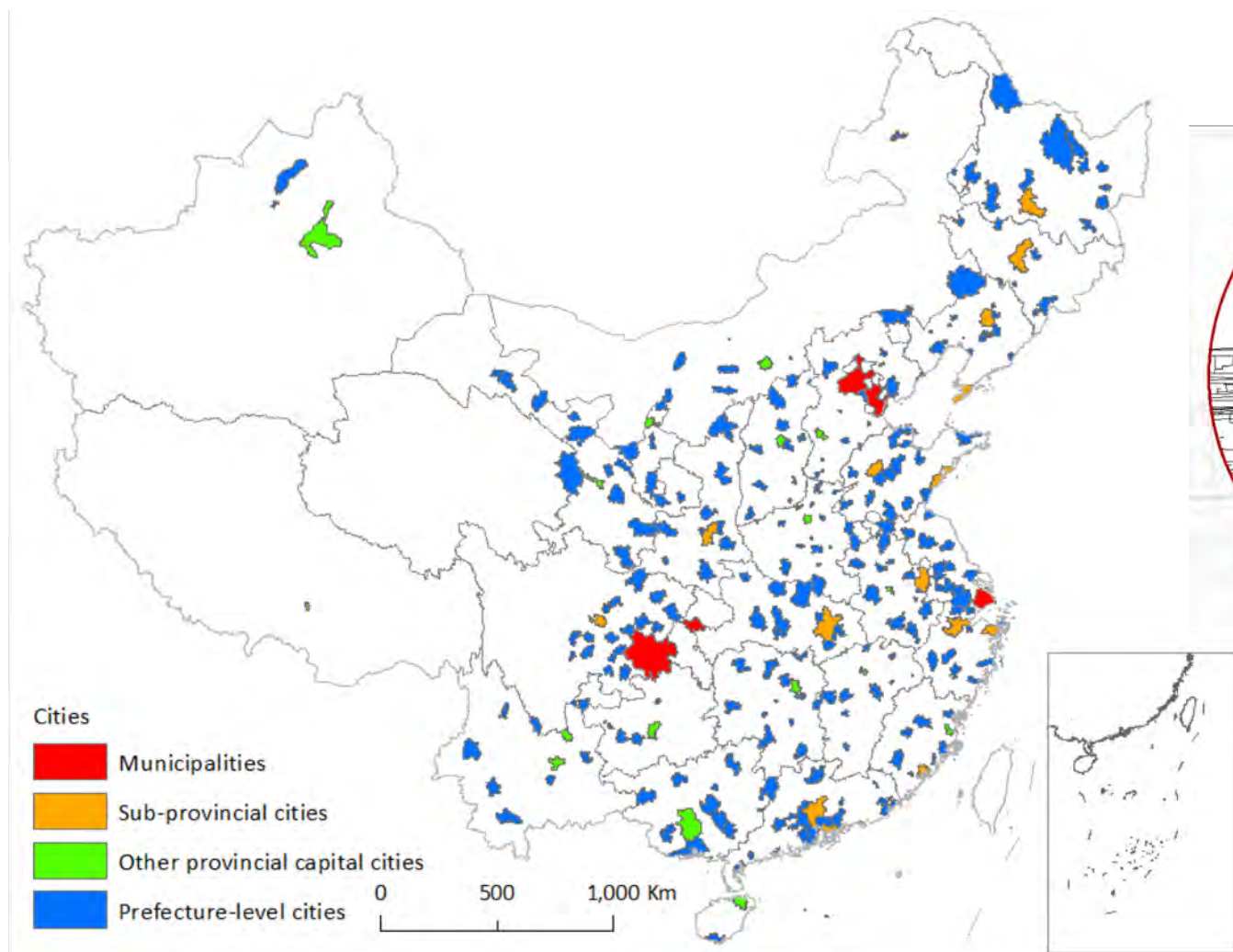


- 基于街景图片对街道绿视率进行评价，主要包括街景点提取（街道50m间隔）、街景图片抓取、街景图片识别以及绿视率统计分析四个环节

我们的街道有多绿？

Parameter	Mandatory item or not	Description	Examples
size	Yes	Picture size in pixel, maximum width 960 px and height 640 px	size=138x187
location	One in location or pano	Coordinates or place name for confirming the street view location	location=Tsinghua University or location=39.12,116.83
pano		Street view ID for confirming the street view location	pano=10011022120723095812200
heading	No	The value of heading represents the angle the forward direction making with the north, which is measured in clockwise with a range from 0 to 360 degree (0 as the default value)	North: heading=0 East: heading=90 South: heading=180 West: heading=270
pitch	No	The vertical angle of the camera covers -20 to 90 degree, in which a positive number stands for the level of looking up and vice versa (0 as the default value)	pitch=0
key	Yes	Developer's key (can be retrieved by online application)	key=OB4BZ-D4W3U-7BVVO-4PJWW-6TKDJ-WPB77

我们的街道有多绿？



- 4个直辖市，15个副省级城市，17个一般省会城市，252个地级市
- 考虑到有限的抓取时间和计算能力，选取每个城市中心的3km半径范围作为每个城市的研究范围（对应74.8万条街道）

我们的街道有多绿？



Figure 6 Street view pictures with various green percentages (only 127 locations/sites with the green ratio greater than 0.8)

not green ≤ 0.2
 somehow green (0.2-0.4]
 green (0.4-0.5]
 very green > 0.5

我们的街道有多绿？



- 基于各个点的街道绿视率计算结果，对街道层次的绿视率进行评价，较高的街道可以作为步行系统规划的参考

我们的街道有多绿？

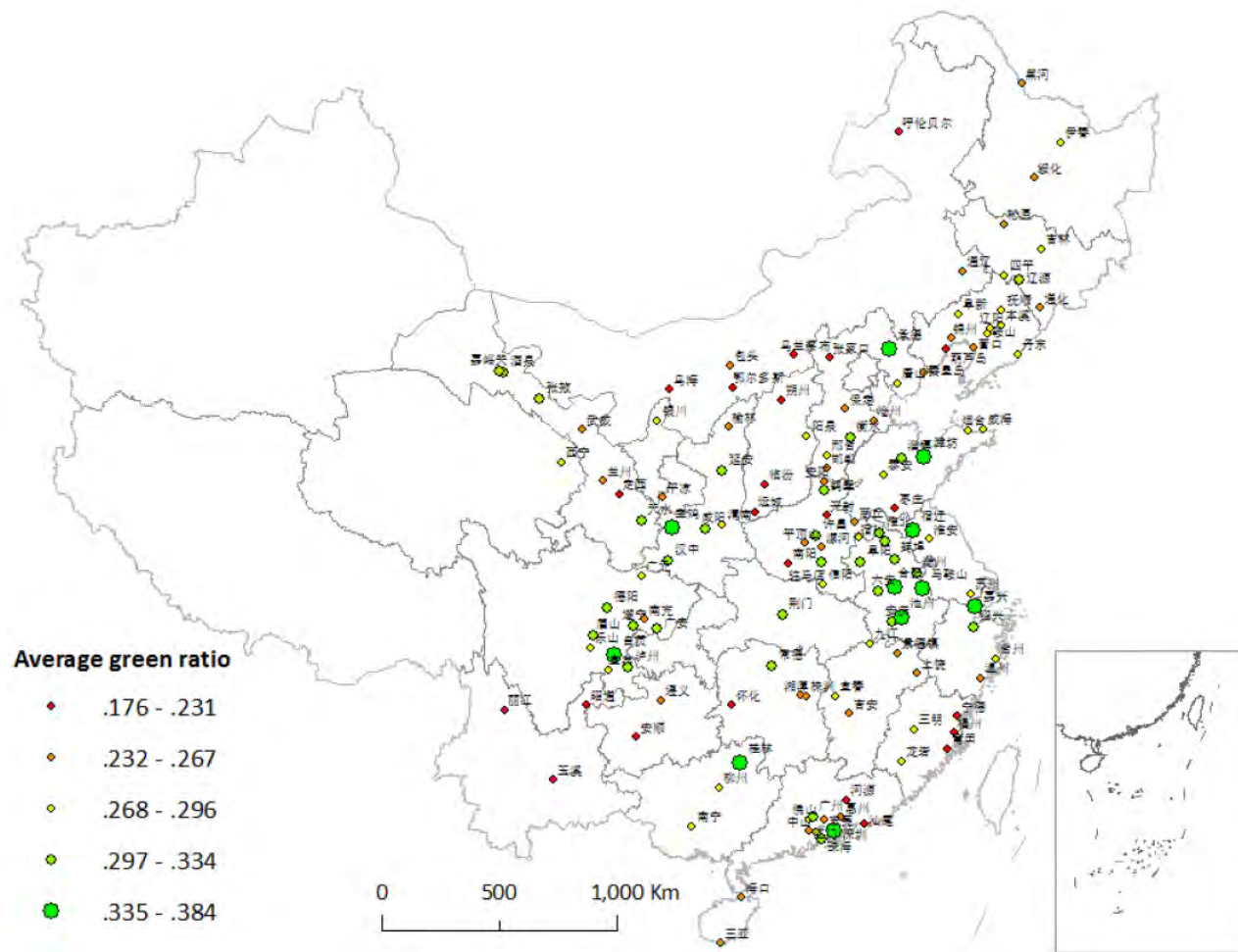
Type	# features	Min	Max	Mean	Green ratio			
					<0.2	0.2-0.4	0.4-0.5	>0.5
Locations	173,425	0.000	0.913	0.277	55,962 (32.3%)	85,702 (49.4%)	21,224 (12.2%)	10,537 (6.1%)
Street segments with over 13 locations per km)*	23,917	0.002	0.840	0.261	8,188 (34.2%)	12,619 (52.8%)	2,258 (9.4%)	852 (3.6%)
Blocks greater than 1 ha and with over 1 location per ha**	9,424	0.002	0.737	0.265	2,583 (27.5%)	5,931 (62.9%)	718 (7.6%)	192 (2.0%)

* “13” is the average value of location density for all street segments.

** “1” is the average value of location density for all blocks greater than 1 ha

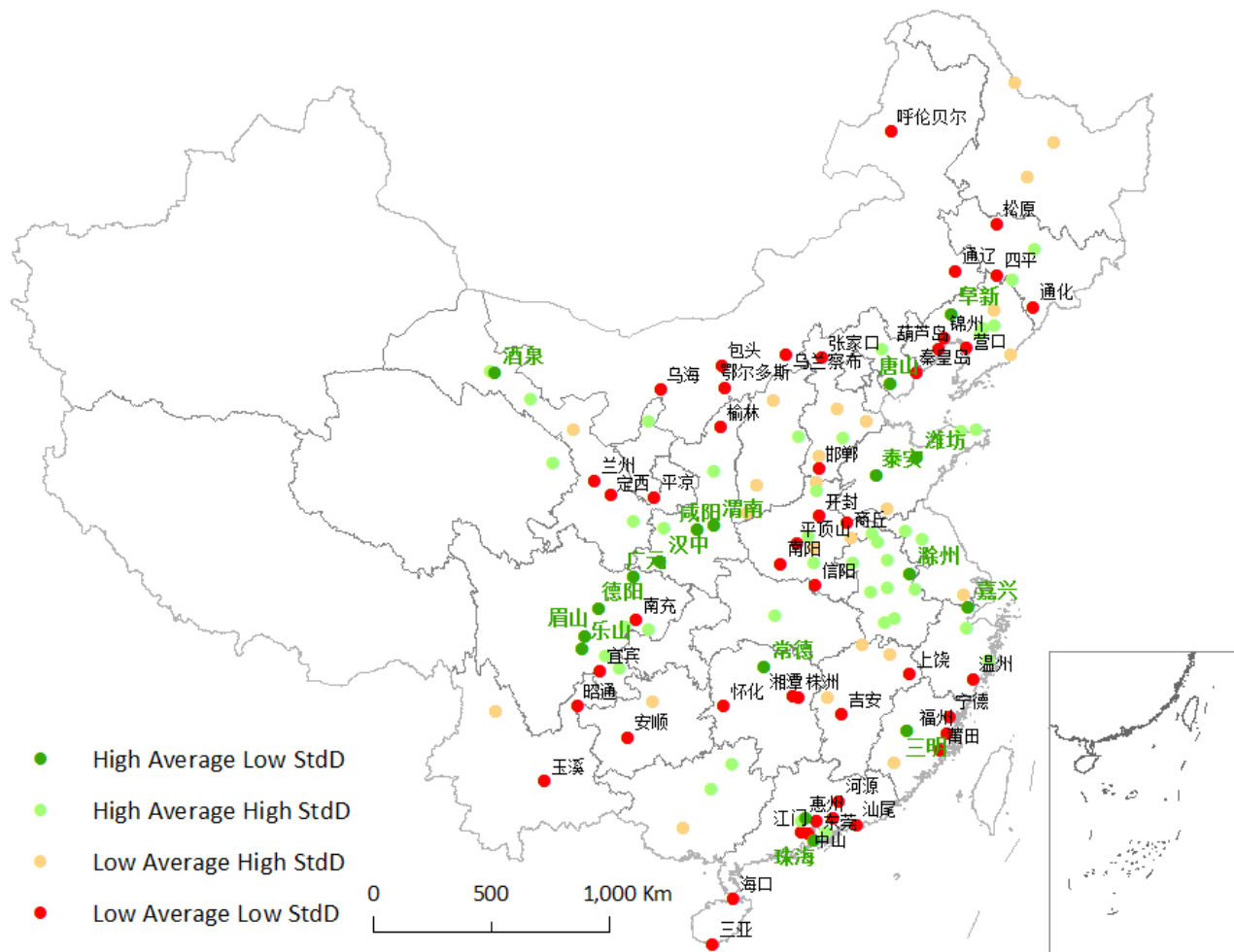
- 部分城市的街景拍摄日期不适合评价街道绿视率（如秋冬季节）
- 131个有效城市的平均街道绿视率范围为 0.132-0.384

我们的街道有多绿？



- 前五城市均为国家园林城市（潍坊、自贡、宝鸡、马鞍山和承德）

我们的街道有多绿？

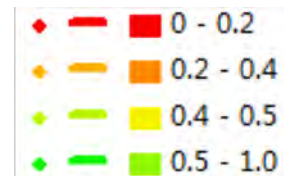


- 将131个有效城市根据街道绿视率的平均值与标准差，以中位数作为界线，分为四类
- 高均值低标准差（整体绿化好）、高均值高标准差（整体好但个别街道低）、低均值低标准差（整体绿化差）和低均值高标准差（整体差但个别街道高）。

我们的街道有多绿？

Table 3 Street greenness for typical cities

City	Locations	Street segments	Blocks
Weifang			
Hefei			
Yanan			



图片城市主义 Picture Urbanism



新浪微博：龙瀛a1_b2 北京城市实验室BCL
微信公众号：beijingcitylab



北京城市实验室
Beijing City Lab

<http://www.beijingcitylab.com>