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# 规划设计智能化调研工具 ——“猫眼象限”调研分析系统的 特点与应用

## CAT'S EYE — AN INTELLIGENT INVESTIGATION TOOL FOR URBAN PLANNING AND DESIGN

### 1 项目研发背景

获取第一手的调研数据是开展规划设计工作必不可少的环节。随着中国城市逐渐转向存量规划阶段，规划设计更强调对微观个体的观测，这一转变对调研手段和方法也提出了更高要求。然而，传统调研方式通常“见物不见人”，照片等素材难以被有效量化，对于空间中发生的活动缺少有效的测度方法；调研过程中需对调研对象进行拍照和记录，但信息的记录整理和空间地图的转化过程需要耗费大量精力。与此同时，物联网、互联网、云计算和大数据等信息与通讯技术的不断发展为规划设计调研，尤其是更加贴近微观个体的调研提供了技术支撑。在此背景下，逐渐涌现出的在线表格、在线问卷和轨迹记录等智能化工具在为调研带来便捷的同时，也存在与应用需求结合不够紧密、应用散点化等问题。城市象限研发团队针对规划设计调研的科学性和效率问题，借助深度学习等技术手段，于2018年5月研发了“猫眼象限”调研分析系统（以下简称“猫眼象限”），希望为规划

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#### 摘要

在城市精细化治理的发展趋势和信息技术应用日益广泛的背景下，提升规划设计调研的智能化水平是规划设计行业的迫切诉求。基于此，城市象限团队研发了“猫眼象限”调研分析系统，其主要应用于中微观尺度的规划设计调研，以照片位置信息为应用出发点、计算机视觉技术为支撑，实现了规划设计调研过程的空间化记录和图像资料的有序管理。“猫眼象限”移动端通过标签和照片命名等方式，可以便捷采集空间环境、设施情况、行为活动等信息；桌面端则可以进行调研结果的可视化、视频分析和数据管理等高级功能操作。本文首先介绍了“猫眼象限”的设计构思、技术运用、功能构成，以及使用方法，随后结合具体案例，从空间环境、设施情况和行为活动三个方面展示了基于“猫眼象限”的调研操作方法。最后，结合产品的使用情况和城市智能化发展现状，研发团队展望了“猫眼象限”产品的改进方向及未来智能化调研工具的发展趋势。

#### 关键词

规划设计调研；智能化调研；图像识别技术；深度学习；猫眼象限

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#### ABSTRACT

Under the backdrop of refinement of urban governance and the increasingly broad application of information technology, an urgent demand for intelligent investigation has emerged among urban planning and design professions. Cat's Eye, an intelligent investigation tool developed by UrbanXYZ, operates with position information of survey photos and computational vision technology, realizing spatial mapping and photo management in investigations of medium- and small-scale planning and design projects. The Cat's Eye applet is designed to collect information of spatial setting, facility / amenity conditions, and human behaviors and activities; and its PC terminal is developed for higher investigation needs such as result visualization, video analysis, and data management. This article introduces the product architecture, technical innovation, interface and operation, and investigation methods of Cat's Eye. Furthermore, by combining authentic cases, the article illustrates how Cat's Eye investigates the spatial setting, facility / amenity, and human behaviors in survey areas. Finally, the article prospects the future of intelligent investigation tools.

#### KEY WORDS

Planning and Design Investigation; Intelligent Investigation; Image Recognition Technology; Deep Learning; Cat's Eye

① “云雀象限”是针对公众参与定制研发的调研应用程序。公众可以在程序内上传某一空间的照片，并对该场所中的安全、交通、环境和公共服务问题等进行评论。

师和设计师提供一套智能调研工具，以提高调研效率和设计方案的合理性与准确性。

## 2 设计构思

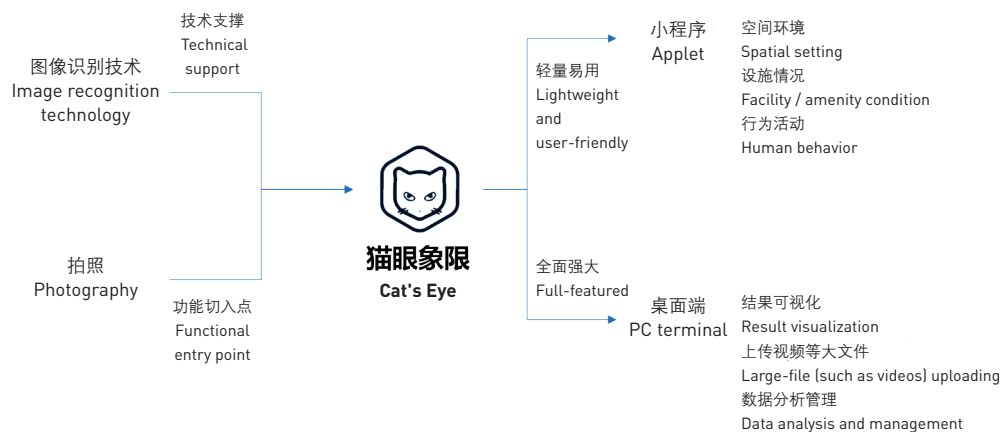
调研的根本目的在于项目信息的收集；广义的调研还包括部分研究分析工作。“猫眼象限”即是包含了分析功能的广义调研系统。在应用场景上，“猫眼象限”服务于中微观尺度（如社区、街道尺度）的规划设计及规划研究项目。此类项目的调研内容主要包括空间环境、设施情况、行为活动和公众意见等方面，“猫眼象限”尝试将空间环境、设施情况和行为活动整合在一起，构成具有综合功能的智能化调研系统。由于公众意见的收集在很大程度上依赖于公众参与，研发团队为此单独研发了另一个系统——“云雀象限”<sup>①</sup>。

“猫眼象限”的产品架构和开发设计兼顾多功能性与使用便捷性，并推出了移动端和桌面端两款产品（图1）。移动端采用了使用门槛较低的微信小程序形式，支持空间环境、设施情况、行为活动等基本信息的现场采集；桌面端则支持视频等大文件的上传、数据分析管理，以及分析结果可视化等功能。

鉴于拍照是现场调研的主要信息采集手段，“猫眼象限”以照片的位置信息为出发点，力求实现空间化记录和图像资料的有序管理。

“猫眼象限”是中国首个引入人工智能技术的调研工具。目前已有的图像识别技术已较为成熟，通过微信小程序友好的操作界面，调用已有开源数据集并运用图像分割和目标检测识别技术，可以直接从调研人员拍摄的照片中获取所需信息，例如可以对照片图像中的行人及车辆进行快速识别与统计（图2）。

1. “猫眼象限”产品架构设计
  2. 利用深度学习技术进行物体探测示例：“猫眼象限”能够对照片中的行人和车辆进行智能识别。
1. Architecture of Cat's Eye
  2. Object detection by applying deep learning techniques: Cat's Eye realizes an intelligent recognition on pedestrians and vehicles in given pictures.



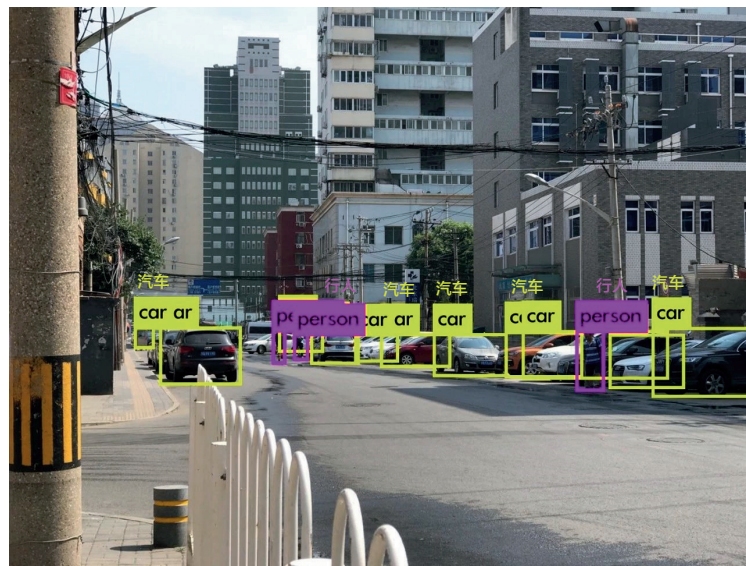
## 3 操作方法

“猫眼象限”移动端依托微信小程序进行操作。进入界面后，使用者可以创建新项目或导入已有项目，创建任务后即可开始调研。调研人员在拍摄并上传照片时，可选择并修改照片名称、位置、时间和照片类型标签等信息。照片类型标签包括行为活动、空间环境、街道家具、景观小品和停车场等常见类型，每个类型又包括若干子标签，而照片名称则可对类型标签无法涵盖的信息进行补充，以提升信息采集的准确性并实现结构化分类。每个任务结束后，可以查看和导出数据，目前支持人流、车流、绿视率、建筑物面积率、道路面积率和天空面积率6个常用指标的数据导出（图3）。

除照片外，“猫眼象限”桌面端还支持视频等大文件的上传、图像识别与数据分析（图4）。当调研人员选择某一项目后，系统将自动读取该项目的所有分析结果，同时可按照指标、照片拍摄时间和类型、任务等进行结果的可视化汇总展示（如点状图、热力图等形式）。此外，桌面端还支持照片和视频的数据导出，方便调研人员进行项目管理。

## 4 基于“猫眼象限”的调研方法

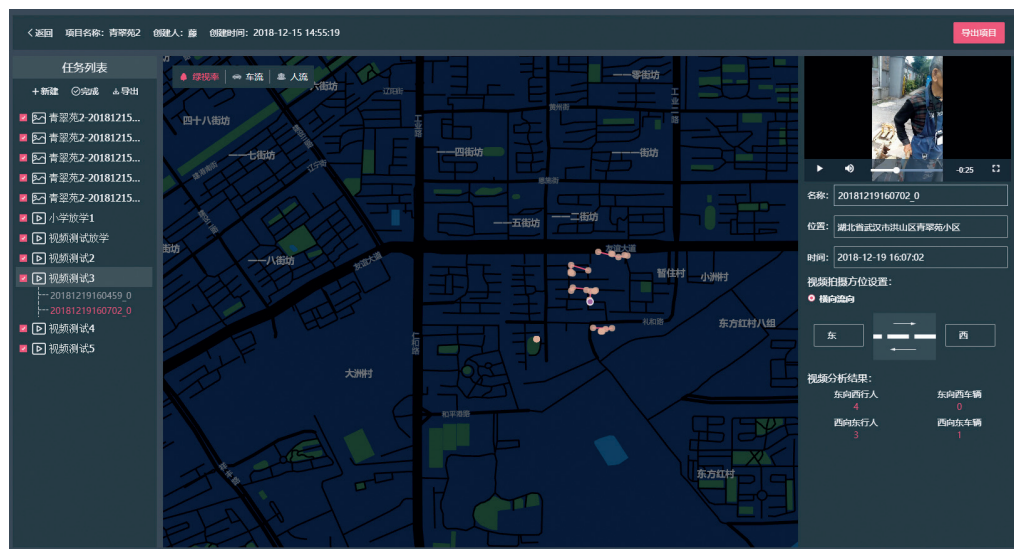
“猫眼象限”最早主要用于社区调研，随着使用人数的不断增加，目前逐渐扩展到其他调研领域。根据不同的项目类型，“猫眼象限”的应用方式和分析视角各有侧重。研发团队总结了一套基于“猫眼象限”的通用调研方法，包含空间环境、设施情况和行为活动情况三部分，每部分又包括若干调研内容。下文将结合两个具体案例——





- “猫眼象限”移动端界面：从左至右依次为开始任务、标签编辑和结果展示。
- “猫眼象限”桌面界面：图中展示了对上传视频进行行人/车流量自动识别。

- Interface of Cat's Eye applet. From left to right, selecting photo types, and result review.
- Interface of Cat's Eye PC terminal: Cat's Eye is recognizing the numbers of pedestrians and vehicles in the uploaded video file.



北京市法源寺地区和前门东地区，对这套调研方法的应用进行阐释。其中，法源寺地区面积为1.2km<sup>2</sup>，调研时间为2018年8月；前门东地区面积为0.5km<sup>2</sup>，调研时间为2018年11月。

#### 4.1 空间环境

空间环境调研着眼于公共空间的环境品质，我们将调研内容总结为安全性、环境卫生、美观舒适、空间秩序和停车分布5个方面（表1）。其中，无序停车是当前城市治理中最为突出的问题之一。由于违章停放的车辆通常会占用公共空间，严重影响人们对于公共空间的使用、感知和体验，因此停车状况也是空间环境的调研内容之一。

#### 4.2 设施情况

“猫眼象限”支持对调研区域内各类设施，尤其是街道设施（以

表1: 利用“猫眼象限”对公共空间环境品质进行调研的内容  
Table 1: Spatial quality investigation with Cat's Eye

空间环境 Aspects of spatial quality	调研内容 Investigation issues
安全性 Safety	1) 步行舒适度, 主要记录路面起伏不平整、破损和步道不连续的情况; 2) 夜间灯光照明, 主要记录照明设施不工作和缺乏照明设施的情况。 1) Walkability, including unevenness and damages of road surface, and discontinuous sidewalks; 2) Night lighting, including the out-of-order street lights and places where street lighting is lacked.
环境卫生 Sanitary	区域卫生 (如垃圾、污渍等)、噪音和异味等情况。 Sanitary conditions (such as garbage and stains), noise, and unpleasant odor.
美观舒适 Visual impact	1) 绿视率, 包括定点准确绿视率和所有调研照片的平均绿视率 (图5); 2) 乱涂乱画、小广告、不协调的广告牌等; 3) 建筑或景观小品损坏的破坏空间; 植被破坏情况。 1) Visible vegetation ratio, including visible vegetation ratio of specific places and the average visible vegetation ratio of all the photos [Fig. 5]; 2) Graffiti, post adlets or fliers, unpleasant signboards, and other incongruities; 3) Dilapidated built-up or landscape space; ill or dying plants.
空间秩序 Tidiness	1) 违章搭建和线路乱搭; 2) 车辆无序停放 (只记录较为严重的违章停放, 如占用消防通道和公共绿地等)。 1) Illegal construction and wiring chaos; 2) Illegal parking (that occupies fire passages, green space, or other public areas).
停车分布 Parking	公共空间和街道分时分区停车情况 (图6)。 Parking distribution in public spaces and streets during different time periods [Fig. 6].

表2: 利用“猫眼象限”对设施情况进行调研的内容  
Table 2: Facility / amenity investigation with Cat's Eye

设施情况 Facility / amenity condition	调研内容 Investigation issues
分布与数量 Distribution and quantity	垃圾箱、路灯、景观小品、健身器材、电线杆、座椅和其他设施 (消防栓、晾衣绳、报箱/牛奶箱、变电设施、衣物回收箱等最为常见) 的分布情况。 Distribution and quantity of trash bins, street lights, landscape features, fitness equipments, telegraph poles, seatings, and other objects [fire hydrants, clothes drying racks, newspaper boxes, milk boxes, electricity substations, and clothes recycle boxes are commonly observed].
破损情况 Extent of damage	设施的老旧程度及破损情况。 Dilapidated or damaged facilities.
使用情况 Usage	健身器材、座椅等设施的使用时间和使用人数。 Usage duration and the number of users of fitness equipments, street seatings, and other facilities.

表3: 利用“猫眼象限”对行为活动进行调研的内容  
Table 3: Behavior / activity investigation with Cat's Eye

行为活动 Behavior / activity	调研内容 Investigation issues
人流量/车流量 Pedestrian and vehicle volumes	通过拍照或拍摄视频, 统计调研区域中某一节点的人/车流量 (图7-9), 以项目中其他任务照片中的人/车流数据作为补充。 Quantifying pedestrian / vehicle volume at certain places in the survey area by taking photos or videos [Fig. 7 - 9].
居民行为 Human behavior	通过拍照或拍摄视频, 对调研区域内居民的工作 (安保执勤、清洁打扫、送快递、售卖等)、休憩 (锻炼、遛狗、玩耍等)、生活 (如做饭、洗衣、倒垃圾等)、社交 (如聊天、打牌等)、行走等行为活动进行记录 (图10)。 People's working (e.g. security guarding, cleaning, delivering, and vending), rest (e.g. physical exercise, walking the dog, and playing games), living (e.g. cooking, doing laundry, and trash dumping), social activities (e.g. chatting and playing cards), walking, and other behaviors are recorded with photographs or videos [Fig. 10].

健身器材和座椅最为常见) 的分布、数量、破损情况和使用情况进行调查 (表2)。

### 4.3 行为活动

行为活动调研主要对与人相关的活动进行记录。首先是记录人流量和车流量, 这是反映区域活力和交通情况的重要指标。其次要对不同时刻、不同区域内发生的工作、通勤、休憩、行走、生活、社交等各类行为进行断面标记, 并选取典型行为进行跟踪记录 (表3)。

## 5 结语

截至2019年3月底, “猫眼象限”已经积累了上万名用户, 服务了数千个规划设计调研项目, 遍布中国各个省市, 以及亚洲、欧洲和北美地区的十多个城市, 涵盖社区更新改造、城市设计、乡村规划、景观规划、历史文化遗产保护、规划实施评估和房地产开发等多个领域。“猫眼象限”能够在调研中得到广泛应用得益于其响应了规划设计从业人员对于智能化调研的诉求, 在提高调研效率的同时, 还从功能上涵盖了空间环境、设施情况和行为活动三大类常见调研需求, 并分别针对每个大类提出了具体的调研内容要求, 使之能够为调研提供方法参考。

今后, “猫眼象限”会在提升调研效率和科学性的基础上不断迭代更新。在技术层面上, 研发团队将持续更新图像识别数据集, 以进一步提高识别结果的准确度; 同时, 更多智能化技术将被运用于调研之中。例如, 通过使用无人机将航拍照片和视频与“猫眼象限”处理技术相结合, 将更加有助于制定更科学的人流、车流和停车方案。在功能层面上, 研发团队考虑对标签进行调整, 包括增加定制标签, 并在现有6个计算指标的基础上增加更多指标。

技术变革正深刻影响着社会经济的发展形态和轨迹, 借助智能化工具, 规划设计领域从业人员可以突破传统研究和实践中存在的局限。未来, 各种新技术的传播和应用将愈加迅速。特别值得一提的是, 深度学习技术将使高度精细化的图像分析成为可能, 这将为提升规划设计调研质量提供有力支撑, 从而使得规划设计方案能够与时俱进, 并更加符合使用者的真实需求。LAF

### 项目信息

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设计时间: 2018年5月

## 1 Introduction

Urban planning and design relies on field investigation to collect first-hand data. Traditional investigation focuses more on physical setting survey rather than considering social factors, partially because it lacks efficient methods to measure human behaviors or to quantify information from survey photos and other recorded materials. In addition, traditional investigation, as well as material sorting and mapping, requires a considerable labor work. With a transition from incremental planning towards inventory planning, planning and design practitioners begin to seek refined investigation approaches and take more consideration on the individuality of research objects. Meanwhile, continuous advance and innovation of information and communications technologies, such as Internet of Things, Internet, cloud computing, and big data, offer new technical supports to planning and design research and investigation, especially to micro-scale practice. Intelligent investigation tools, including online forms, online

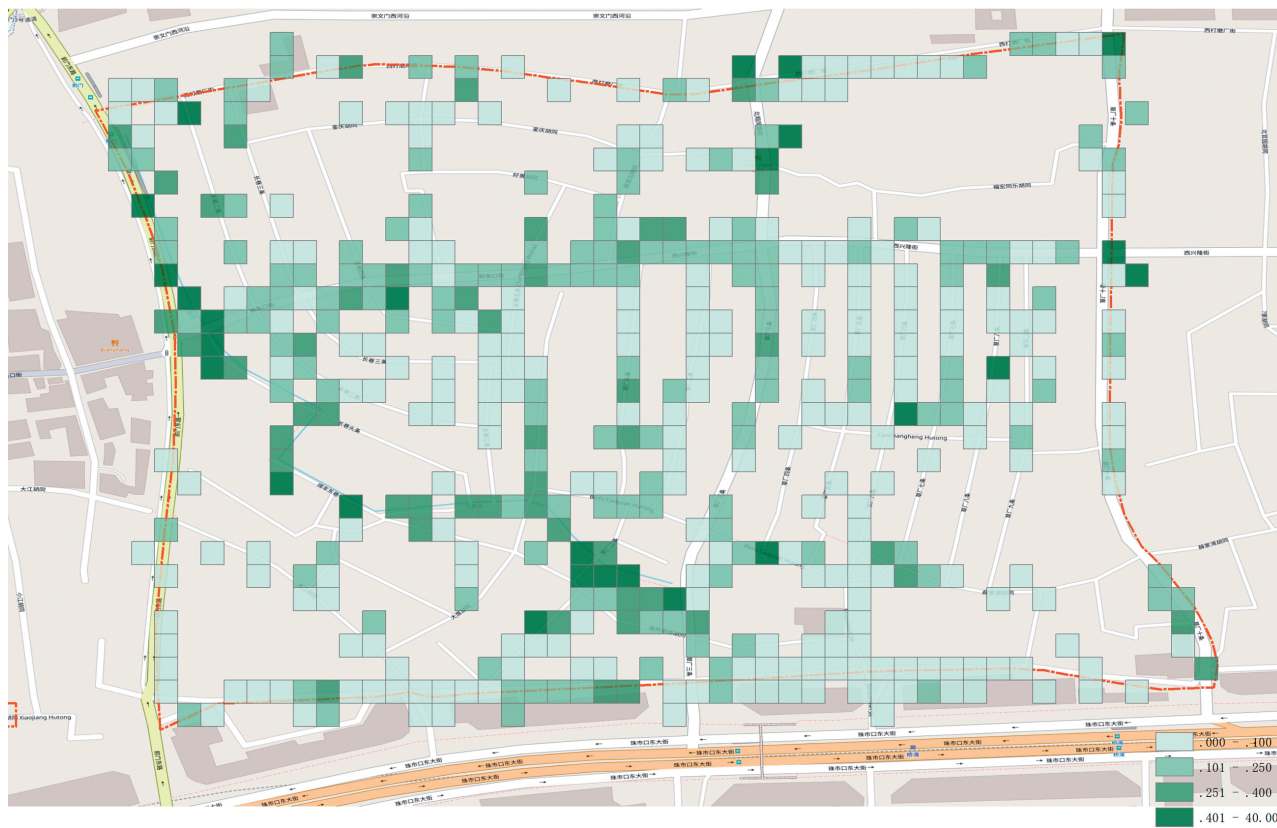
questionnaires, and survey-route recorders, have improved investigation efficiency greatly. Nevertheless, such tools are mostly developed for single use, which fail to meet multiple needs during investigation processes of urban planning and design practice. Cat's Eye, an intelligent investigation tool developed by UrbanXYZ in May 2018, was designed as an integrated system which can improve investigation efficiency and enhance the rationality and accuracy of schemes with advanced technical means of deep learning and so on.

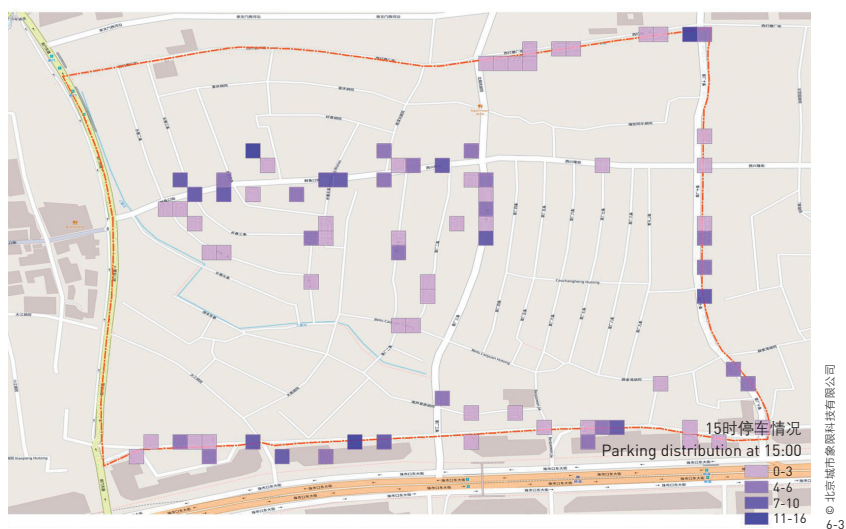
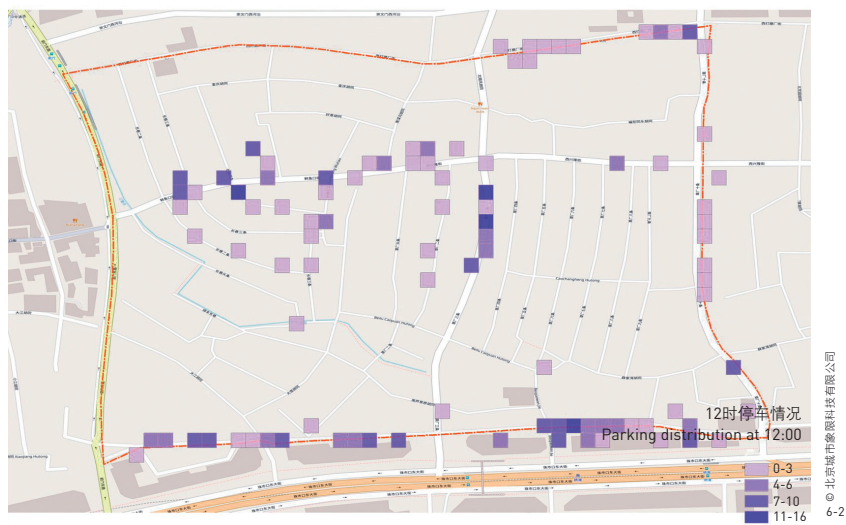
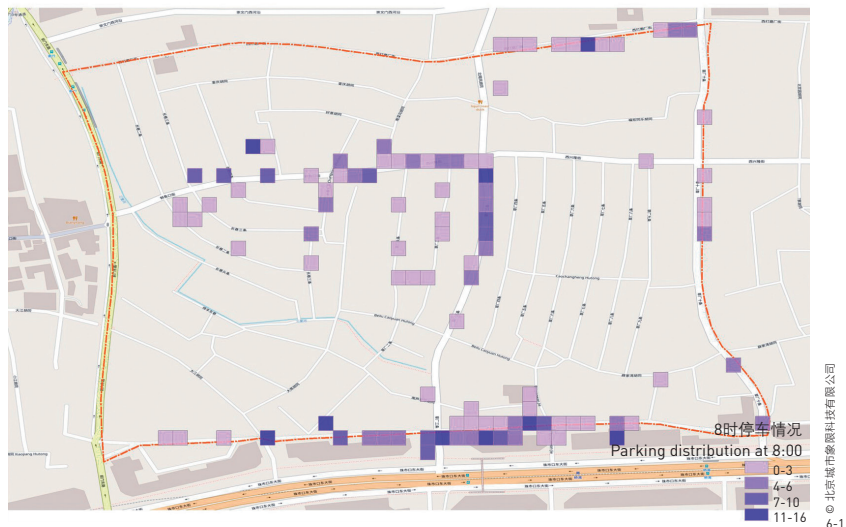
## 2 Design Concept

Investigation is about collecting information, which, in a broader sense, entails research and analysis work. In application scenarios, Cat's Eye is defined as an investigation tool for medium- and small-scale (e.g. communities or neighborhoods) urban planning and design practice and research. Such investigations are conducted to collect information of spatial settings, facility / amenity conditions,

① Skylark is an investigation tool to collect public comments. Users can upload pictures of a certain place and make comments on safety, traffic, environment, or public service problems.

5. 北京市前门东地区平均绿化率情况
6. 北京市前门东地区8时、12时和15时的停车情况。
5. The average visible vegetation ratio of the Qianmen East area of Beijing
6. Parking distribution of the Qianmen East area at 8:00, 12:00, and 15:00.





human behaviors and activities, and users' comments. Since comment collection largely relies on public participating, UrbanXYZ developed another intelligent tool, Skylark<sup>①</sup>, to investigate users' comments specifically.

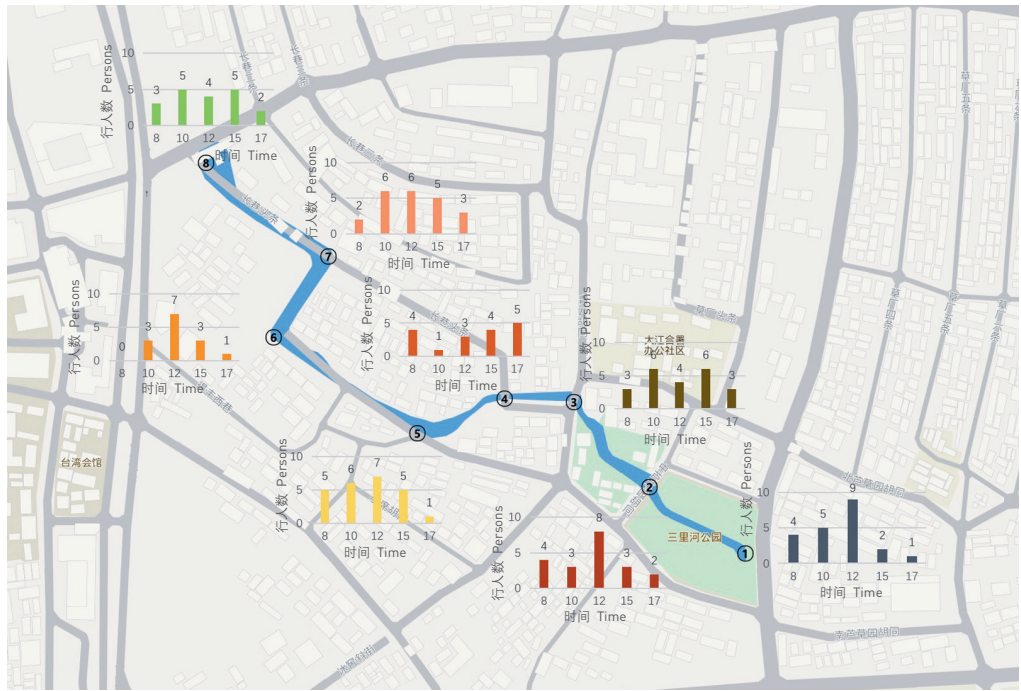
The product architecture and design of Cat's Eye reconciles multi-functionality and user-friendliness, in forms of applet and PC terminal (Fig. 1). The Cat's Eye applet runs within WeChat program, which is low-tech and free to all users. It provides basic investigation services, covering spatial setting, facility / amenity condition, and human behavior and activity. The PC terminal is designed for higher project management and analysis needs, supporting large-file (such as videos) uploading, data analysis and management, as well as visualization of results.

Photography is the most commonly used data-collecting means in investigations. Cat's Eye operates with the information of photo-taken locations to realize spatial recording and mapping and smart management of survey photos — Cat's Eye is China's first application that combines intelligent technologies with investigation devices. By using a user-friendly WeChat interface and adopting open source datasets and algorithms of image segmentation and target detection, such applets can recognize required information from site photos taken by investigators. For example, pedestrians and vehicles in given pictures or videos can be detected and counted in seconds (Fig. 2).

### 3 Operation Methods

In the interface of Cat's Eye applet, users can set up a new project or import an on-going project and start an investigation by creating certain tasks. When users take and upload a photo, they can select or edit its basic information, including location, time, and type. Specifically, photo types range from human behavior, spatial setting, street furniture / amenity to landscape, parking, and others; each type also has detailed divisions. When a photo cannot be categorized into any of these types, investigators are allowed to rename the file for a more precise description and classification. When investigators finish a task, they can review and export data of six indicators: number of pedestrian, number of vehicle, visible vegetation ratio, built-up area ratio, road area ratio, and sky area ratio (Fig. 3).

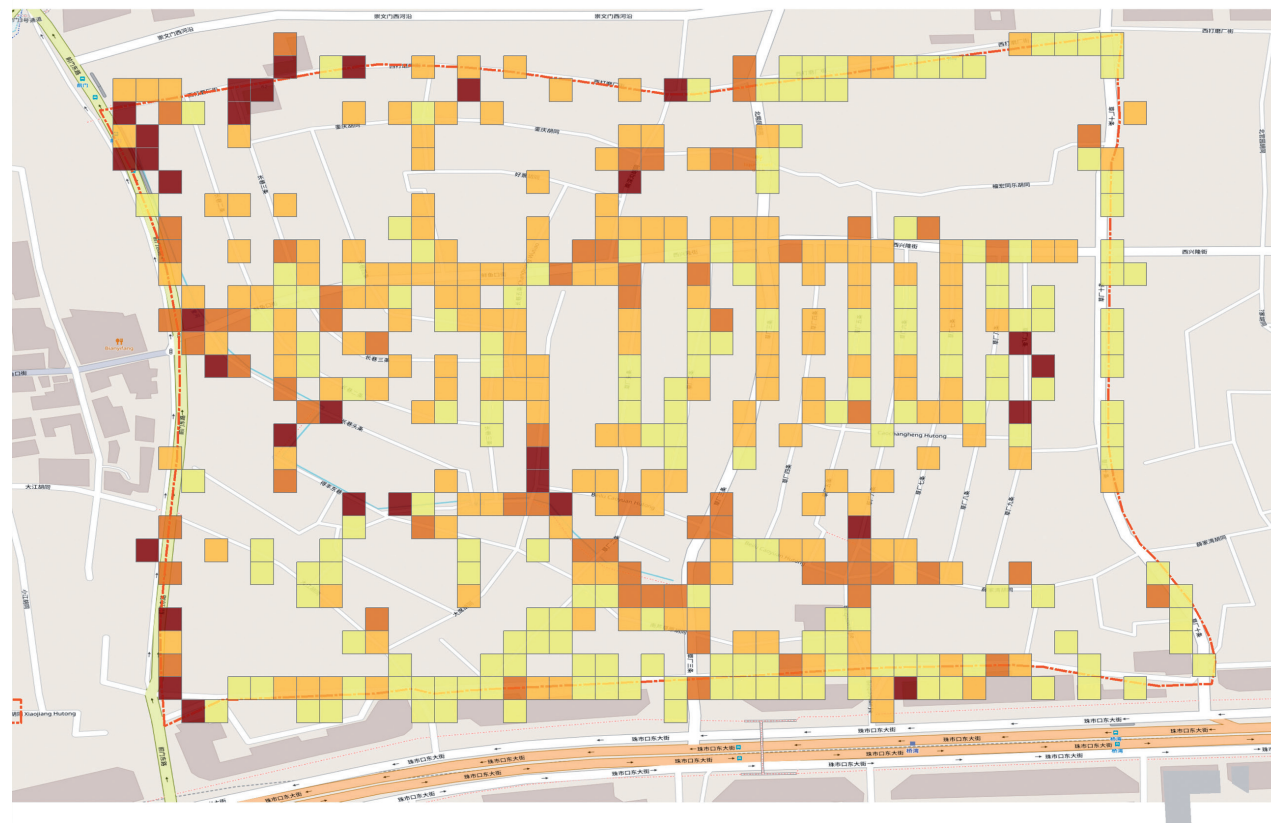
In addition to the functions above, Cat's Eye PC terminal supports upload, image recognition, and data analysis of video files (Fig. 4). Investigators can review all the analyses of a certain project and visualize the results in indicators, time and



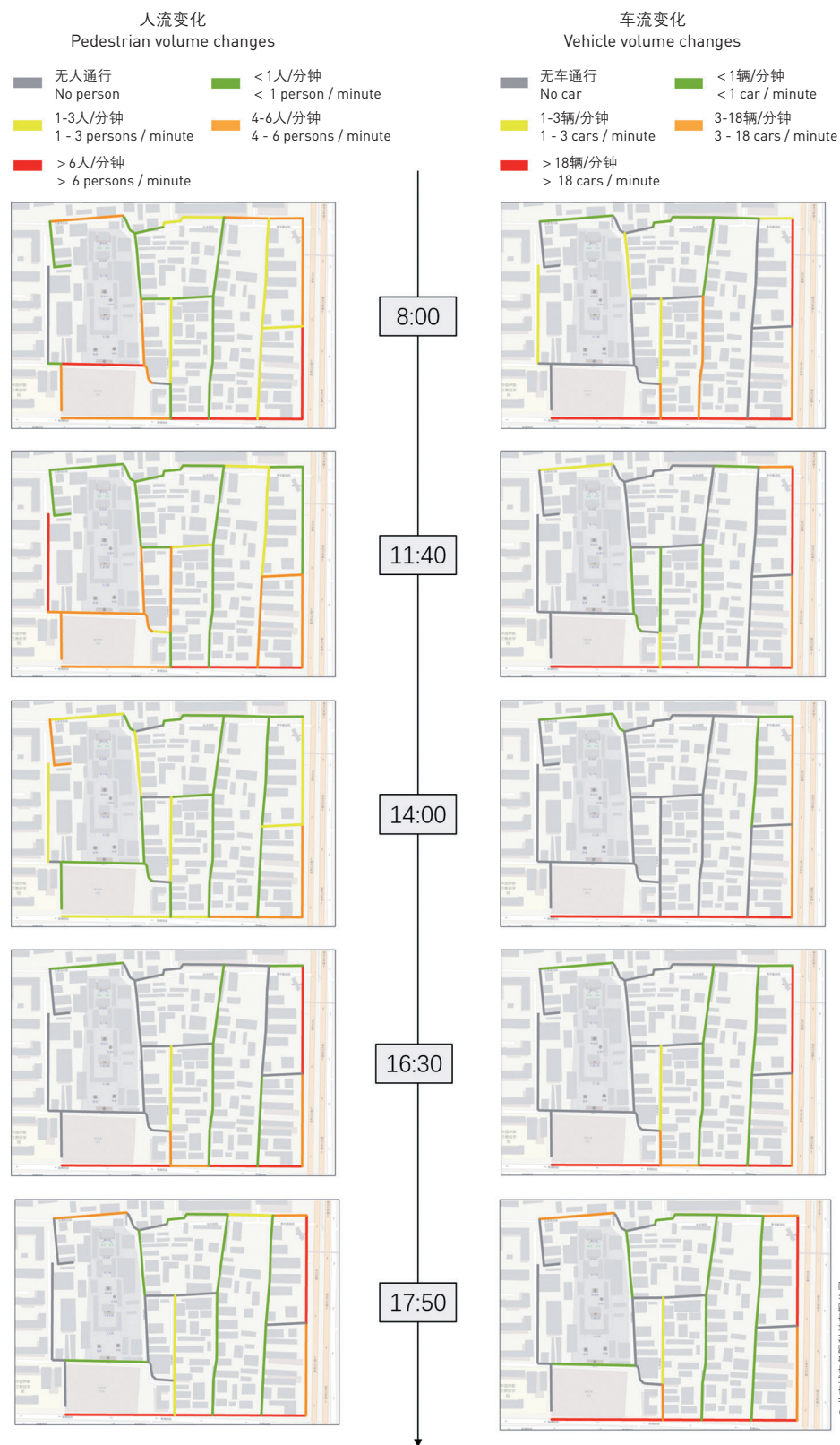
types of the taken photos, and tasks in forms of dot-chart, heat map, etc. The PC terminal also supports photo and video exporting, which facilitates project management.

#### 4 Investigation Methods

Cat's Eye was initially conceived for community-scale investigations. Now, as the number of its users grows, it has been employed in boarder survey fields, and the priorities of application and data analysis might vary according to different project types or demands. UrbanXYZ summarized a set of methods for general investigations, covering analyses of spatial quality, facility / amenity, and human behaviors / activities, which is demonstrated here with two authentic investigation cases in Beijing: the Fayuan Temple case conducted in August 2018 and the Qianmen East area case conducted in November 2018. The survey areas of them are around 1.2 km<sup>2</sup> and 0.5km<sup>2</sup>, respectively.



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- 北京市前门东地区三里河公园8时、10时、12时、15时和17时的人流量分布情况。
- 北京市前门东地区全天平均人流量
- 基于视频数据的北京市法源寺地区人流、车流自动识别结果。
- Pedestrian volume patterns of different spots at 8:00, 10:00, 12:00, 15:00, and 17:00 in the Sanlihe Park of the Qianmen East area.
- Average daily pedestrian volume of the Qianmen East area
- Pedestrian and vehicle volume patterns of the Fayuan Temple area by Cat's Eye intelligent recognition on video files.

#### 4.1 Spatial Quality

Investigations on spatial setting evaluate environmental quality of public space by focusing on safety, sanitary, visual impact, tidiness, and parking (Table 1). Specifically, parking is one of the most lasting problems in urban governance nowadays: quite a few public spaces are occupied by illegal parking, impacting people's use, perception, and experience of public spaces.

#### 4.2 Facility / Amenity

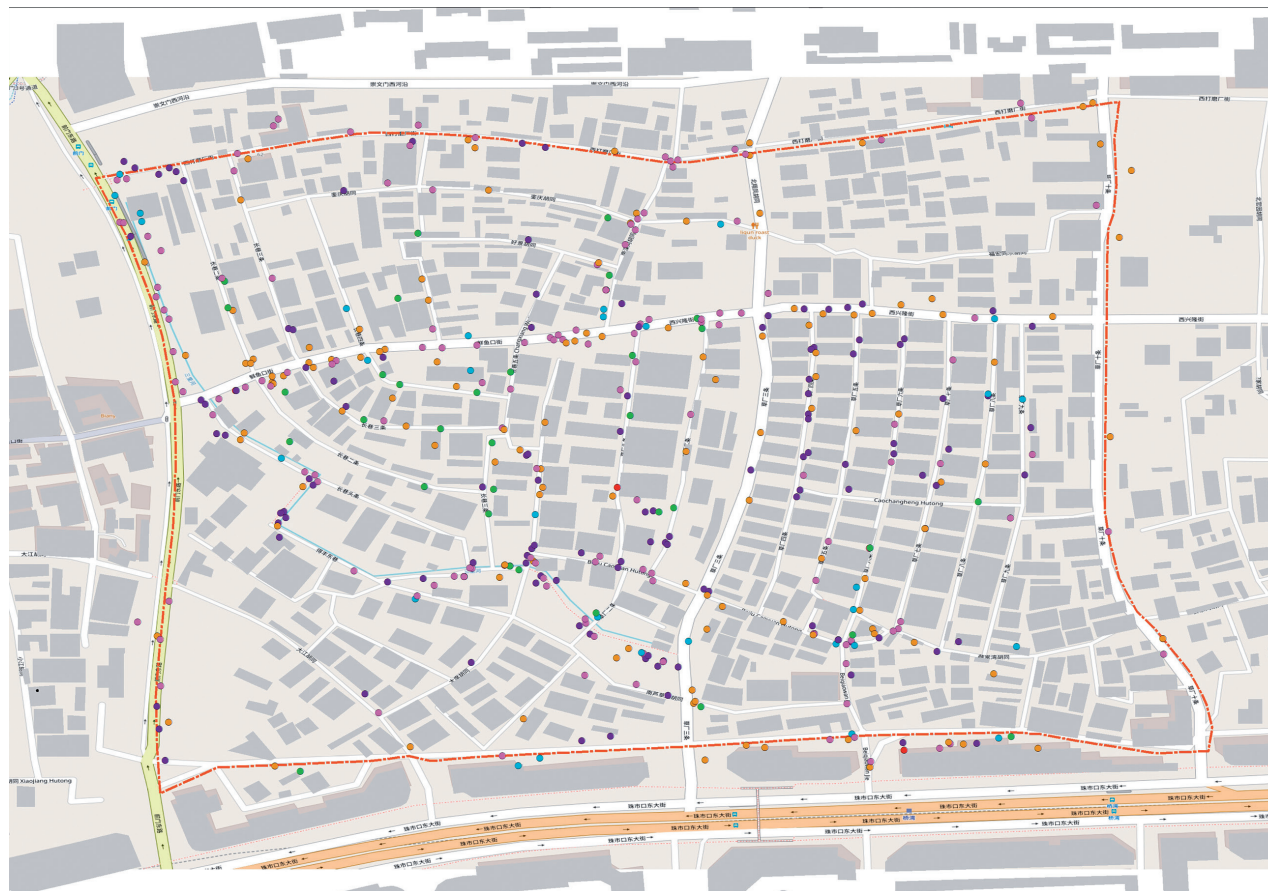
This investigation targets at the distribution, quantity, extent of damage, and usage of different kinds of facilities and amenities in the survey area (Table 2). Fitness equipments and seatings are most commonly observed.

#### 4.3 Behavior / Activity

This investigation records the patterns of people's behaviors and activities observed in the survey area. As important indicators describing the vitality and traffic situation of the survey area, numbers of pedestrians and vehicles are recorded. The investigation also aims at collecting information of people's working, commute, rest, walking, living, and social activities at particular places and time segments, and then selecting typical behaviors for a further tracking observation (Table 3).

### 5 Conclusion

By the end of March 2019, Cat's Eye has served thousands of users from all Chinese regions, as well as more than ten oversea cities in Asia, Europe, and North America. It has been



行为类型  
Behavior types

- 工作 Working
- 游憩 Resting
- 生活 Living
- 社交 Social activities
- 行走 Walking
- 其他 Others

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employed in a great number of planning and design investigation projects, ranging from community renewal, urban design, rural planning, landscape planning, historical and cultural heritage protection, planning implementation evaluation to real estate developments. By offering scientific methods that combine intelligent means with investigation approaches, Cat's Eye meets various investigation needs and increases investigation efficiency.

In the future, Cat's Eye is expected to keep improving its efficiency and scientific reliability. On the technical level, image recognition datasets will be updated to improve the accuracy of intelligent recognition. Moreover, UrbanXYZ is going to integrate more intelligent technologies into investigation approaches. For example, drones are expected to be combined with Cat's Eye to take aerial photos or videos, offering an alternative examining perspective that helps investigators understand the survey site and inform the development of pedestrian and vehicle circulation and parking planning schemes. In terms of the interface, the team is considering introducing

custom photo types and adding more indicators for result analysis and review.

Technological advance has profoundly influenced the form and trajectory of socio-economic development. With the aid of intelligent tools, planning and design professionals could overcome the limitations of traditional research and practice modes. The future will see a faster and wider spread and application of new technologies. In particular, the advance of deep learning technology might allow for a highly refined intelligent processing and analysis of image and video materials, meeting higher demands of planning and design investigations and the real needs of related practice in this age. **LAF**

#### PROJECT INFORMATION

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Design Period: May 2018

10. 北京市前门东地区各类行为活动分布情况
10. Patterns of various human behaviors and activities in the Qianmen East area