

# 古村落宅间元素的分类 及其平面特征解读 ——以安徽省黄山市关麓村为例

## CATEGORIZATION OF THE SPATIAL ELEMENTS BETWEEN COURTYARDS IN HISTORICAL VILLAGES AND INTERPRETATION OF THEIR MORPHOLOGICAL CHARACTERISTICS —A CASE STUDY ON GUANLU VILLAGE IN HUANGSHAN CITY, ANHUI PROVINCE

### 1 研究背景

随着城镇化的不断推进，城乡二元体制下的中国乡村和城市之间的差距日益扩大，并引发了一系列社会矛盾<sup>[1]</sup>。村落城镇化的模式主要有“拆村并点”<sup>[2]</sup>和“村落拟城市化”<sup>[3]</sup>。部分破坏性建设致使村落的景观多样性和传统生产生活方式等发生剧烈变化<sup>[4]</sup>，村落和谐的人居环境

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### 摘要

宅间元素是古村落景观的重要组成部分。在乡村景观同质化的当下，现有地方元素的研究倾向于传统符号或建筑细部等，而较少关注构成古村落宅间平面形态的核心元素。本文以安徽省黄山市关麓村为例，梳理了28种古村落宅间元素的分类，绘制了相应的元素图式，并从面积、圆形度、矩形度、紧凑度和宽长比5个方面量化分析了元素的平面特征。本研究不仅有益于细化古村落平面形态的理论研究，还有助于促进地方元素的挖掘及应用。这一基于元素分类、图式及其平面特征量化分析的方法模型为以延续地域特征为目的的村落景观平面设计提供了客观依据，同时丰富了村落景观设计语汇，避免设计元素模块化和千村一面等现象。

### 关键词

古村落；宅间元素；设计元素；景观；平面特征；设计语汇；关麓村

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### ABSTRACT

Spatial elements between courtyards are an important component of the landscape of historical villages. With an increasingly homogenous rural landscape in China, most existing studies focus on traditional symbols and architectural details, while little research is conducted to explore the core elements that shape the spaces between village courtyards. Taking Guanlu Village in Huangshan City, Anhui Province as an example, the research team identified 28 sorts of spatial elements, developed the corresponding diagrams, and quantified their morphological characteristics in area, circularity, rectangularity, compactness, and width-length ratio. This research not only contributes to the theoretical development on the morphology of ancient villages, but also helps promote the exploration and application of local elements. This village landscape design model constituted with element categorization, diagram drawing, and morphological quantitative analysis would provide scientific evidences that help inform the practices to revitalize village localities, showing its practical significance of enriching the design vocabulary of village landscapes and avoiding the prevailing, generic usage of modular designs with urban landscape elements.

### KEYWORDS

Historical Village; Spatial Element between Courtyards; Design Elements; Landscape; Morphological Characteristics; Design Vocabulary; Guanlu Village

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及地域景观特色面临被破坏和异化的窘境<sup>[5]</sup>。其中,过度使用城市设计元素以及设计语汇的模块化是村落景观设计中存在的主要问题,趋同的城市设计元素(如广场、草坪、树池)不可避免地导致地域特征弱化和千村一面的现象<sup>[6]</sup>,使乡村景观缺乏场所精神和乡土气息<sup>[7]</sup>。村落地域特征的弱化引发了相关专家学者的广泛讨论,他们呼吁村落建设应注重地方村落景观特质的延续,不应盲目效仿城市景观<sup>[8][9]</sup>。村落景观应使当地居民拥有地方文化认同感<sup>[10]</sup>,但目前很多乡村的规划和设计并没有实现这一目标。

村落景观本身具有地域性、文化性、多样性、复合性、延续性和稳定性等特征<sup>[11]</sup>,相关空间元素具有特定的形状、功能和含义,是村落设计语汇的重要组成,但却没有得到足够的重视,也缺乏相应的研究。2011年,联合国教科文组织大会通过了《关于城市历史景观的建议书》,其中提到挖掘和沿用地方元素对村落景观可持续发展的重要性<sup>[12]</sup>。然而,目前对村落地方元素的挖掘主要集中在古村落建筑细部、建筑材料等宅院部分的研究<sup>[13]</sup>,以及古村落耕读文化、宗教文化、名人轶事等文化层面的研究<sup>[14]</sup>。为了提升乡村居民的文化认同感,本文认为,在村落景观设计过程中可以将具有村落地域特征的元素作为景观设计语汇。

村落所处的自然环境、村民的生产生活方式,以及当地的文化习俗等共同塑造了其景观特色,其中,古村落宅间元素便是村民日常生活与村落环境长期相互适应发展的结果<sup>[15]</sup>。村落宅间元素是针对村落景观平面形态构成的细化研究提出的概念,这些元素是中国乡村在长期的农耕社会发展中积累的优秀人居文化遗存,是践行可持续性村落景观设计的重要资源。本文认为,延续村落地域特征、营造和谐人居环境

## 1 Background

The urban-rural dualism long-time existing in China's rapid urbanization process results in development disparities and social conflicts between the urban and rural areas<sup>[1]</sup>. Urbanization in rural China is mostly realized by merging a number of small villages into a larger one<sup>[2]</sup> or adopting urban / town development patterns<sup>[3]</sup>. In some cases, the aggressive construction has dramatically changed the local landscape diversity and the traditional production patterns and lifestyles<sup>[4]</sup>, eliminating or dissimilating the harmony of human settlements and regional landscape features<sup>[5]</sup>. Particularly, the prevailing use of urban elements and vocabulary (e.g. squares, lawns, tree pools) has caused stereotyped rural designs that neglect the place spirit and country identities<sup>[6][7]</sup>. Scholars and experts' criticisms on the disappearing localities in China's urbanization call for a halt to the generic rural development and an emphasis on protecting and celebrating the uniqueness of vernacular landscapes<sup>[8][9]</sup> which ensure people having a sense of local cultural identity<sup>[10]</sup>. However, such concepts have still not been practiced in the current planning and design of rural construction.

Village landscapes are, and should be regional, cultural, diverse, compound, sustaining, and persisting<sup>[11]</sup>, and the associated spatial elements have particular shapes, functions or services, and cultural implications, which, however, have not been studied as key components of the village design vocabulary. In 2011, the UNESCO approved the Recommendation on the Historic Urban Landscape, which highlights the importance of exploring and integrating local spatial elements into the sustainable development of village landscapes<sup>[12]</sup>. However, most existing studies on local elements focus on architectural details, building materials<sup>[13]</sup>, and rural culture such as farming-reading traditions, religions, and ancient anecdotes<sup>[14]</sup>. To strengthen locals' cultural identity, indigenous elements can be used in village landscape design to enrich the design vocabulary.

Village landscape is defined by the natural environment and people's production patterns and lifestyles, as well as cultural traditions. Being part of the village landscape, the spatial elements between the courtyards of a historical village are shaped by the generations' interaction between the locals' daily activities and the nature<sup>[15]</sup>. The research on the existing spatial elements between village courtyards is considered a subfield of the study on the morphological and typological constitution of village landscapes. It examines such elements as cultural legacies of rural settlements of China's agricultural society, and provides a source for enhancing the rural sustainability through landscape

境需要保护、传承和善用这些村落宅间元素，通过创造性转化来实现这些元素的活态再生<sup>[16]</sup>。

在将这些村落宅间元素作为景观设计语汇之前，设计师面临的一个问题是，这些元素的平面特征大多并非几何形。那么，这些地方性的、在人与环境的长期相互适应中发展而来的元素平面特征是什么？如何用其指导设计？惯常的图式方法是设计过程中的常见工具，也是设计表达和交流的语言<sup>[17]</sup>，其优点是可以概括和总结村落宅间元素非几何形态的综合特征<sup>[18]</sup>，但不能准确、严谨地表述元素具体的平面特征，如面积、圆形度、矩形度、紧凑度和宽长比等。然而，对非几何形的村落宅间元素平面特征的准确描述至关重要，因为这决定了研究成果能否准确地用于指导设计实践，以有效地延续地域特征。因此，本研究提出了图式与图形特征量化分析相结合的研究方法，基于实例分析对村落宅间元素进行了分类，并借由量化工具对这些元素的平面特征进行了解读。

## 2 概念界定与文献综述

### 2.1 古村落宅间元素释义

古村落宅间元素是指村落宅院之间平面形态的各个组成部分，包含了实体聚落边界范围内非建筑部分的诸要素，研究对象是属于公共活动区范畴的平坦、晒场、巷道等空间，以及棚架、圈舍、添灯等构筑物。

### 2.2 图式释义

图式的形式可以为概念模型或抽象简图，也可以理解为一种设计工具或示意符号<sup>[19]</sup>。影响宅间元素形式的因素包括比例、结构及其他不可见的参数，这些因素具有模糊性，但这种模糊性不是随意的、无边际的，而是有着严格的范畴。较文字而言，图式可以更为准确地捕捉这种模糊性，可以对平面特征进行更为直观的概括和提炼。

### 2.3 文献综述

在元素形态特征研究方面，设计学领域现有研究以文本描述和图式为主。例如，以图式语言对古村落公共开放空间类别和形态特征进行梳理<sup>[20]</sup>；通过图式语言对徽州传统村落宗族图谱中的宅院图进行研究<sup>[21]</sup>；以图式与文本分析相结合的方法对古村落中的集中型、组团型、带状、放射型、象征型、灵活型等平面形态进行定性分析<sup>[22]</sup>等。

村落平面形态量化研究大多集中在整体空间形态方面，缺少对单个元素形态的量化分析。例如，基于三种数学原型——“群”“序”“拓扑”——对太湖流域古镇进行的空间结构解析<sup>[23]</sup>；运用空间句法对古村落空间形态进行的定量分析<sup>[24]</sup>；运用计算机编程

design means. The authors believe that, to preserve localities of historical villages and to rebuild harmonious human-land relationships, landscape designers are encouraged to preserve, adopt, and regenerate such elements in village landscape design for rural revitalization<sup>[16]</sup>.

Before extracting the existing spatial elements between village courtyards as design vocabulary, landscape design needs to understand that most of these elements in historical villages are often in irregular shapes. What are the morphological characteristics of such elements? How can they inform the design practice? Diagram is a conventional design tool that expresses and communicates design ideas<sup>[17]</sup>. It can map and extract the overall typological characteristics of the non-geometric spatial elements<sup>[18]</sup>, but fails to accurately describe detailed morphologies, such as area, circularity, rectangularity, compactness, and width-length ratio. However, such an accuracy is necessary, because it determines the application of the research findings in guiding design practices to honor the localities. Illustrating with a case study, this paper proposes to combine diagrams with a quantitative method of graphic characteristics, in order to describe and interpret the morphology of the spatial elements between village courtyards.

## 2 Concept Definitions and Literature Review

### 2.1 The Spatial Elements between Village Courtyards

The spatial elements between village courtyards refer to the morphological components defined by the non-architectural elements within a village settlement, such as the flat ground in front of gate, sunning ground, alleys, and structures (e.g., canopy frames, colony houses, and ever-burning lamps).

### 2.2 Diagrams

Diagrams can be conceptual models or sketches; they are also a design tool and a graphic symbol<sup>[19]</sup>. The forms of the spatial elements are defined by proportion, structure, and other invisible factors, which are of ambiguity, but not randomly. Compared with texts, diagrams can more accurately describe and represent such an ambiguity through a direct extraction of the morphological characteristics.

### 2.3 Literature Review

Texts and diagrams are mostly employed in morphological studies. Diagrams' effectiveness has been proven in categorizing the public space in historical villages and sorting out their morphological characteristics<sup>[20]</sup>; in studying the courtyard maps of the genealogies of Huizhou historical villages<sup>[21]</sup>; and

1. 关麓村航拍平面图  
1. The aerial image of Guanlu Village

软件绘制建筑节点网络图，对聚落平面形态的方向性秩序特征进行科学而精准的量化描述<sup>[25]</sup>；运用数理分析方法，从住居面积、住居间距离、住居中心性和方向性等方面对传统村落空间形态的结构和秩序进行分析<sup>[26]</sup>；通过多智能体技术平台对村落形式结构自组织动态演变进行模拟等<sup>[27]</sup>。

另外，既有村落整体形态方面的研究多以建筑及其围合的巷道为对象讨论村落平面形态特征<sup>[28]</sup>，较少涉及古村落平面形态构成元素的详细类别。从语言学的角度来看，对单体元素（语汇）进行分析是研究村落整体形态（语法）的必要步骤。本文的创新性在于从语言学视角探讨了村落平面形态的构成内容及图式分类，并援引信息工程学图形特征量化分析方法计算了古村落宅间元素的平面特征数值。

### 3 研究方法

#### 3.1 案例选取

关麓村位于安徽省黄山市黟县，是“中国历史文化名村”<sup>[29]</sup>及“中国传统村落”<sup>[30]</sup>（图1）。村内目前有150余位常住居民，他们传承了当地的生产及生活方式。鉴于村落的整体空间结构和宅间元素得到了较好的保护，故本文选取关麓村作为研究案例。

#### 3.2 宅间元素分类

研究团队主要采用实地走访及文献检索的方法确认关麓村宅间元素的分类，这一过程分为三个步骤：1）通过走访当地年长村民（包括前任村长、书记和当地学校的退休教师），初步收集宅间元素的名称

in supporting qualitative analysis of the centralized, clustering, belt-like, radial, symbolic, and flexible morphologies in historical villages<sup>[22]</sup>, etc.

Most quantitative research on the morphologies of villages studies the overall spatial forms, rather than individual spatial elements. For instance, three mathematical prototypes, i.e. group, order, topology, were employed to interpret spatial structures of historical towns in Taihu Lake Basin<sup>[23]</sup>; the space syntax methodology was applied in quantitative analyses of the spatial forms of historical villages<sup>[24]</sup>; computing-mapped architectural node network was used for accurate quantitative description of the directional order of settlement morphologies<sup>[25]</sup>; mathematical analysis methods were introduced to analyze the area, spacing distance, centrality, and directionality of settlements in traditional villages<sup>[26]</sup>; and multi-agent technology platform was developed to simulate the spontaneous dynamism of village structures<sup>[27]</sup>.

The existing studies on the overall forms of villages mainly focus on the morphologies of architectures and alleys<sup>[28]</sup>, paying insufficient attention to detailed spatial element categorization. In a linguistic analogy, understanding grammars (the overall form of villages) necessitates the study on vocabulary (individual spatial elements). This paper innovatively explores the components and diagram categories of village morphologies from the linguistic perspective and quantifies the morphological characteristics of the spatial elements between village courtyards with the graphic method adopted from Information Engineering.

### 3 Research Methods

#### 3.1 Case Selection

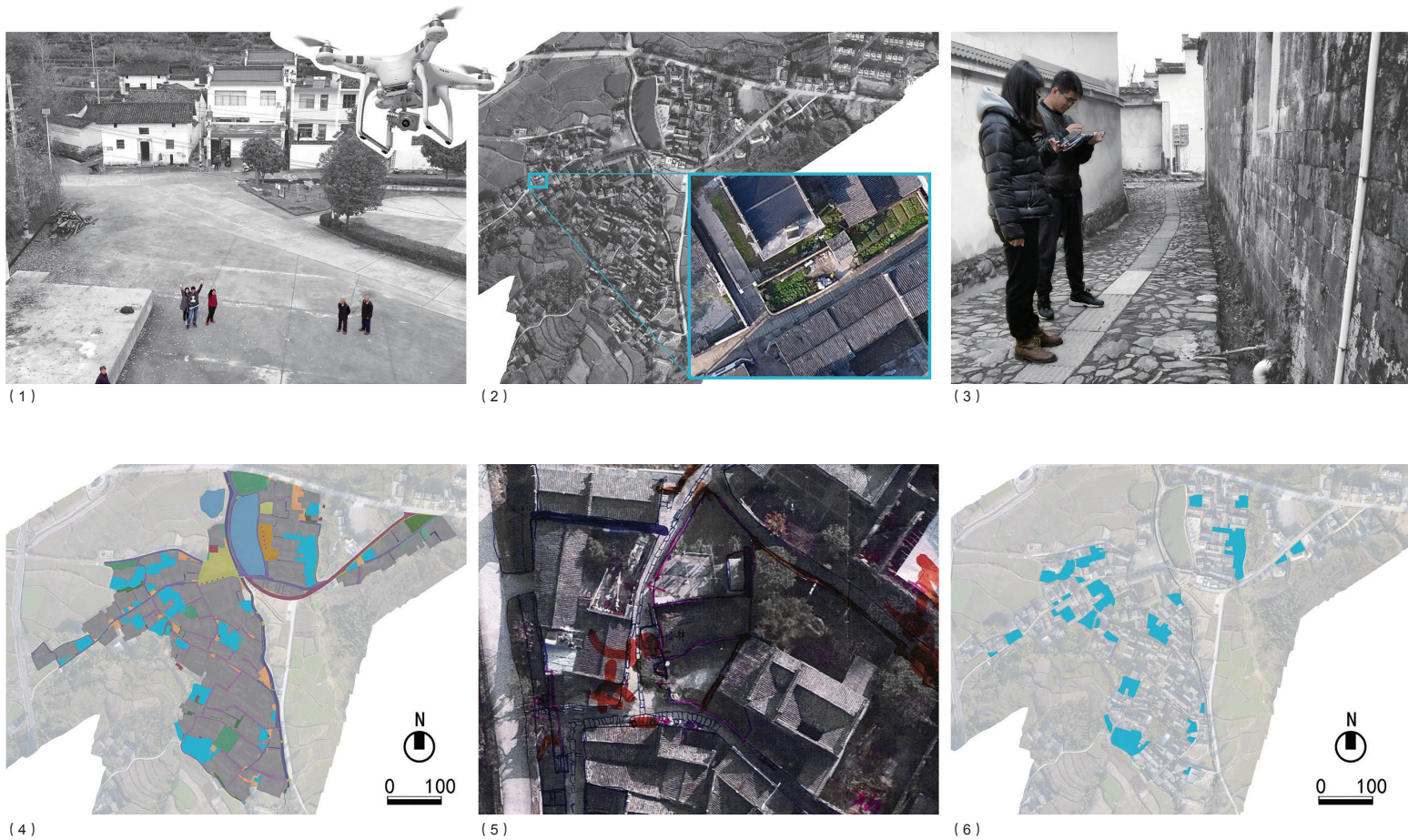
The Guanlu Village of Yi County in Huangshan City, Anhui Province was selected as one of China's Historic and Cultural Villages<sup>[29]</sup> and of Traditional Chinese Villages<sup>[30]</sup> (Fig. 1). Now there are more than 150 villagers who keep the traditional production patterns and lifestyles. The overall form and structure of the village is well preserved, including the spatial elements between village courtyards, making it an ideal place for case study.

#### 3.2 Categorization of the Spatial Elements between Village Courtyards

In this research, the spatial elements between village courtyards were categorized according to the collected data from interviews, field visits, and literature review with three steps: 1) primarily recording and categorizing the spatial elements by interviewing the elder (including the former village head, former



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2. 绘制宅间元素图式的6个步骤
2. Six steps of diagram drawing of the spatial elements between village courtyards

及含义，并对这些元素进行分类整理；2）与这些村民在村落中进行实地考察，并在地图上标记宅间元素的位置，查漏补缺；3）通过文献检索（包括县志、村落志，以及相关文件及出版物等）进一步收集、补充与该地区村落相关的宅间元素分类。

### 3.3 绘制宅间元素图式

古村落空间类型元素的边界确定工作十分复杂，针对这一问题，研究团队采用“六步骤”来绘制宅间元素图式（图2）：

1）研究团队借鉴王云才团队以Google Earth和AutoCAD为平台通过分析遥感影像获取图式的思路<sup>[31]</sup>，采用无人机结合Agisoft PhotoScan和AutoCAD的方法绘制采样精度为5cm的村落航拍平面图；设定无人机以

secretary of village committee, and local retired teachers); 2) conducting field investigations with the interviewed villagers to map the spatial elements and add the missing ones; and 3) further supplementing the spatial element categorization based on literature review, including county annals, village annals, and related documents and publications.

### 3.3 Diagram Drawing of the Spatial Elements between Village Courtyards

Diagram drawing of the spatial elements between village courtyards was very challenging, because the boundaries of such elements are difficult to measure or describe precisely. This research came up with a 6-step mapping method (Fig. 2) as a solution:

1) Inspired by Wang Yuncai et al.<sup>[31]</sup> who conducted diagram drawing with remote sensing image analysis by Google Earth and AutoCAD, the research team produced the village plan

100m左右的恒定高度飞行——过高难以保证拍摄照片的精度，过低则会造成透视角过大，不利于照片的后期合成；随后设定扫描轨迹和拍摄照片数量，保证每两张照片有2/3以上的重叠区域，对村落平面进行扫描。

2) 将扫描照片导入Agisoft PhotoScan，合成高精度村落平面图。

3) 以1:200的比例分区块在A2图纸上打印彩色村落平面图，确保所有宅间元素在地图上清晰可见，共打印了6张A2图纸；随后组织团队成员通过实地调研，在图纸上标记出各分区内不同元素之间的边界。

4) 将标记的元素边界转换为AutoCAD文件。

5) 如遇信息缺失或模糊的情况，则需返回场地重新描绘边界并补充信息。

6) 最后将宅间元素图式按照元素分类分层导出。

### 3.4 宅间元素平面特征量化分析

宅间元素图式可以使人们直观了解元素的综合形态特征，而平面特征量化分析则可以明确每个元素平面特征的数值范围，以对其特征有更为清晰具体的描述。宅间元素平面特征量化分析参考信息工程学图形特征计算方法，注重分析元素图式的轮廓特征，包括面积、圆形度、矩形度、紧凑度、宽长比5个方面<sup>[32][33]</sup>。其中，图式的面积描述了元素的大小，其数值可直接通过AutoCAD获取。

圆形度是用来表示元素图式圆形程度的指标，其常用计算公式如下：

$$C = \frac{P^2}{S_0}$$

式中， $C$ 为圆形度， $P^2$ 为该元素周长的平方， $S_0$ 为该元素的面积； $C$ 的最小值为 $4\pi$ ，元素形状越狭长， $C$ 值越大。

矩形度体现元素图式对其外接矩形的充满程度，其计算公式如下：

$$R = \frac{S_0}{S_{MER}}$$

式中， $R$ 为矩形度， $S_0$ 为该元素的面积， $S_{MER}$ 为该元素的最小外接矩形面积。 $R$ 的最大值为1，当元素为圆形时， $R$ 为 $\pi/4$ ；元素越狭长、弯曲， $R$ 值越小。

(accuracy of 5 cm) based on the photos taken by a UAV with Agisoft PhotoScan and AutoCAD. The UAV was set at a constant flight altitude of about 100 m, for accuracy and post-production considerations. Then, the flight path and the amount of photos to be taken were determined, ensuring that the overlapping area between two continuous photos is not less than 2/3 of the photograph.

2) All the UAV photos were uploaded into Agisoft PhotoScan to produce a high-resolution plan of the village.

3) The plan was color printed on 6 pieces of A2 sheets at the scale of 1:200, ensuring all spatial elements can be clearly identified. Then the research team marked the element boundaries on the map in field investigations.

4) All the marked boundary data were used to generate AutoCAD drawings.

5) The boundary data and other information were completed by re-mapping if blurred or missing.

6) Diagrams of the spatial elements between village courtyards were generated by categories.

### 3.4 Quantitative Analysis of the Morphologies of the Spatial Elements between Village Courtyards

Diagrams are used to visualize the overall forms and typologies of the spatial elements, and the graphic method sourced from Information Engineering can analyze and quantify the morphological characteristics of each element, including area, circularity, rectangularity, compactness, and width-length ratio<sup>[32][33]</sup>. Particularly, the area indicates the size of the element, data of which can be obtained from AutoCAD directly.

Circularity measures the roundness of an element. The commonly used calculation formula is as follows:

$$C = \frac{P^2}{S_0}$$

where,  $C$  is the circularity,  $P^2$  is the square of the element's perimeter, and  $S_0$  is its area. The minimum value of  $C$  is  $4\pi$ ; as the value grows, it indicates an increasingly elongated polygon.

Rectangularity measures the proximity of an element to its enclosing rectangular. The calculation formula is as follows:

$$R = \frac{S_0}{S_{MER}}$$

where,  $R$  is the rectangularity,  $S_0$  is the area of the element, and  $S_{MER}$  is the area of the minimal enclosing rectangle. The maximum value of  $R$  is 1, and for circles,  $R$  is  $\pi/4$ . The more elongated and curved the element is, the smaller the value will be.

表1: 关麓村宅间元素列表  
Table 1: The categories of the spatial elements between courtyards in Guanlu Village

类型 Categories	宅间元素名称 Items of the spatial elements between courtyards
节点 Node elements	平坦、埝、埠头、塘、晒场、宅间农田、花池、竹林、草坪（新建）、广场（新建） Flat ground in front of the gate, earth dike, pier, pond, sunning ground, farmland among courtyards, planting bed, bamboo forest, lawn (newly built), and square (newly built)
线域 Linear elements	滴水沟、塍、路、巷道、坝、排水渠、溪、茅草墙、石墙 Ditch, side slope, path, alley, dam, drainage channel, creek, twitch-grass wall, and stone wall
构筑物 Structure elements	门当、添灯（已毁）、桥、井、石阶、石凳、圈舍、棚架、树池（新建） Stone drum, ever-burning lamp (ruined), bridge, well, stone step, stone seat, colony house, canopy frame, and tree pool (newly built)

紧凑度是指图式边界的光滑度，常用计算公式如下：

$$F = \frac{4\pi S_0}{P^2}$$

式中， $F$ 为紧凑度， $S_0$ 为该元素的面积， $P^2$ 为该元素周长的平方。当元素为圆形时， $F$ 为1；当元素为其他形状时， $F < 1$ ；元素边界越弯曲、越复杂， $F$ 值越小。

宽长比是指图式最小外接矩形的宽长比，这一特征用于指征元素形态的狭长程度（或接近方形或圆形的程度），其计算公式如下：

$$r = \frac{W_{MER}}{L_{MER}}$$

式中， $r$ 为宽长比， $W_{MER}$ 为图式最小外接矩形的宽， $L_{MER}$ 为图式最小外接矩形的长。当元素为圆形和正方形时， $r$ 为最大值1；元素越狭长， $r$ 值越小。

## 4 研究结果

### 4.1 宅间元素分类及其图式

关麓村宅间元素共计28种，包括24种现存本土元素、1种已被破坏的本土元素、3种在村落旅游开发过程中新建的元素（表1）。为了清晰表述不同的元素类型，本研究将28种古村落宅间元素归纳为三类：

Compactness measures the smoothness of an element's boundary. It is often calculated as follows:

$$F = \frac{4\pi S_0}{P^2}$$

where,  $F$  is the compactness,  $S_0$  is the area of the element,  $P^2$  is the square of the perimeter. When the element is in a circular shape,  $F$  is 1; when in other shapes,  $F < 1$ . The more complicated or curved boundary of the element is, the smaller the value will be.

Width-length ratio refers to the ratio of the width and the length of an element's minimal enclosing rectangle. It indicates the elongated degree (or the square or circular degree) of an element and is calculated as follows:

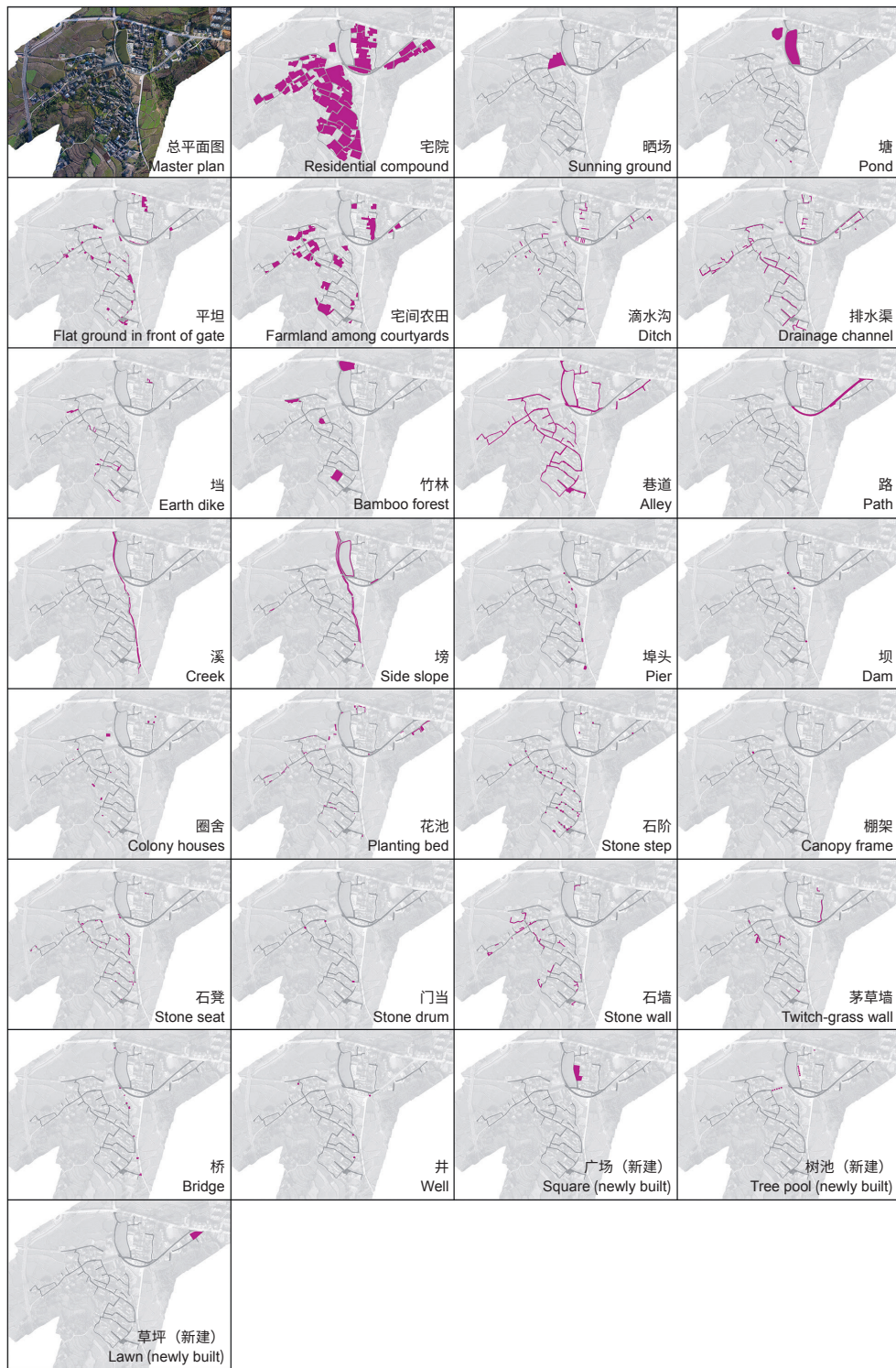
$$r = \frac{W_{MER}}{L_{MER}}$$

where,  $r$  is the width-length ratio,  $W_{MER}$  and  $L_{MER}$  are the width and length of the minimal enclosing rectangle, respectively;  $r$  reaches its maximal value, i.e.1, when the element is in a square or circular shape; an increasingly elongated element will have a smaller  $r$  value.

## 4 Research Findings

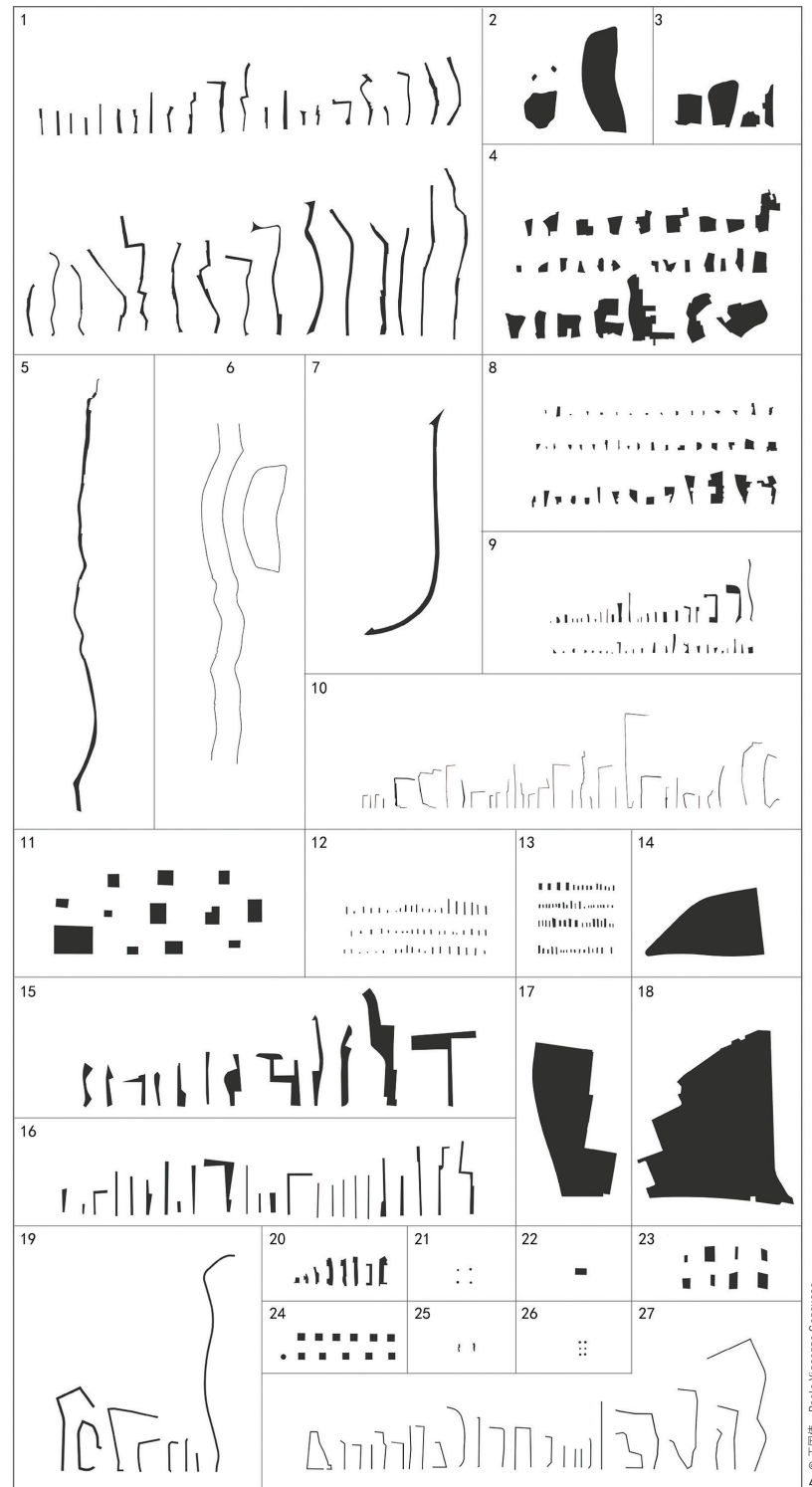
### 4.1 Categorization and Diagrams of the Spatial Elements between Village Courtyards

This research identified 28 sorts of the spatial elements between courtyards in Guanlu Village, including 24 existing indigenous spatial elements, 1 ruined indigenous element, and 3 new elements introduced during the tourism development (Table 1). These spatial elements were roughly in 3 categories, namely node



3. 关麓村宅间元素分布  
4. 关麓村宅间元素图式列表

3. The distribution of the spatial elements between courtyards in Guanlu Village  
4. The diagrams of the spatial elements between courtyards in Guanlu Village



图例 Legend

- |                                   |                         |                          |
|-----------------------------------|-------------------------|--------------------------|
| 1 巷道 Alley                        | 10 排水渠 Drainage channel | 19 茅草墙 Twitch-grass wall |
| 2 塘 Pond                          | 11 圈舍 Colony houses     | 20 埠头 Pier               |
| 3 竹林 Bamboo forest                | 12 石凳 Stone seat        | 21 井 Well                |
| 4 宅间农田 Farmland among courtyards  | 13 石阶 Stone step        | 22 棚架 Canopy frame       |
| 5 溪 Creek                         | 14 草坪 Lawn              | 23 桥 Bridge              |
| 6 塄 Side slope                    | 15 挡 Earth dike         | 24 树池 Tree pool          |
| 7 路 Path                          | 16 滴水沟 Ditch            | 25 坝 Dam                 |
| 8 平坦 Flat ground in front of gate | 17 广场 Square            | 26 门当 Stone drum         |
| 9 花池 Planting bed                 | 18 晒场 Sunning ground    | 27 石墙 Stone wall         |

节点、线域和构筑物。其中，节点和线域可用于界定空间，构筑物可涵盖空间中的设施和物品。

由于添灯这种元素在村落发展中已逐渐消失，所以关麓村仅包含27种宅间元素图式（图3）。研究团队进一步将属于同一类别的元素图式放在一起，以更清晰地展示不同元素的图形特征（图4）。

#### 4.2 宅间元素图形特征取值

通过上述公式，研究团队共计算了27种宅间元素共计500个图形在面积、圆弧度、矩形度、紧凑度和宽长比方面的具体取值、极值、均值和标准差（数值的离散程度）。图5是各个元素图式特征在上述5个方面的极值和数值范围，图6则体现了均值和标准差。

以石墙（元素27）和滴水沟（元素16）为例，在面积方面，滴水沟的均值（8.96:4.30）和标准差（7.03:2.84）是石墙的两倍多；但在圆弧度方面，石墙要比滴水沟的均值大得多（299.96:101.56），即石墙要比滴水沟更细长，石墙在圆弧度方面的标准差也比滴水沟更高（190.55:51.52）；在矩形度方面，滴水沟的均值是石墙的两倍多（0.73:0.30），但两者具体值的标准差非常接近（0.30:0.36）；在紧凑度方面，无论是均值（0.18:0.06）还是标准差（0.13:0.03），滴水沟都数倍于石墙；在宽长比方面，两者较为相近，石墙略高于滴水沟（0.24:0.16），两者具有相同的标准差（0.18:0.18）。

## 5 讨论

通过图4可知，古村落宅间元素与新设计元素存在明显区别。虽然平坦、塍、埠头、埕、滴水沟等元素反映了徽州古村落平面形态地域特征，但这些元素却很少出现在当地村落景观设计中。设计师经常使用城市平面元素，忽略了对本土元素的挖掘和传承。例如，关麓村针对部分区域进行的旅游景观提升项目中充斥着广场、草坪、树池等

elements, linear elements, and structure elements. The former two define the boundary of a place, and the latter one covers the facilities and objects in the place.

As the ruined ever-burning lamps are disappearing in the village, the research team further studied the other 27 sorts of elements (Fig. 3) by categories to clearly display the graphic characteristics of different elements (Fig. 4).

#### 4.2 Values of the Graphic Values of the Spatial Elements between Village Courtyards

The research calculated the values, extreme values, mean values, and standard deviations (the discreteness of the values) of the 27 sorts of elements (500 graphs in total) in the area, circularity, rectangularity, compactness, and width-length ratio. Figure 5 shows the extreme values and value range of the 5 graphic characteristics of each element, and Figure 6 indicates the corresponding mean values and standard deviations.

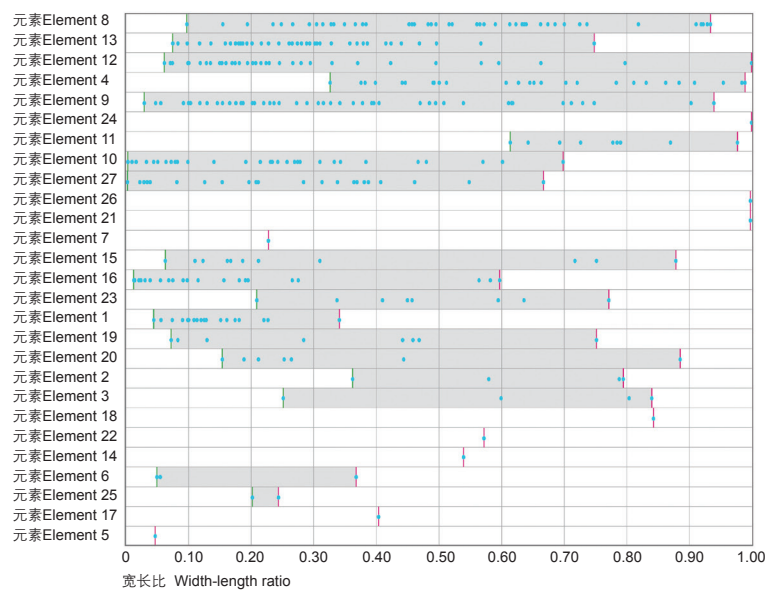
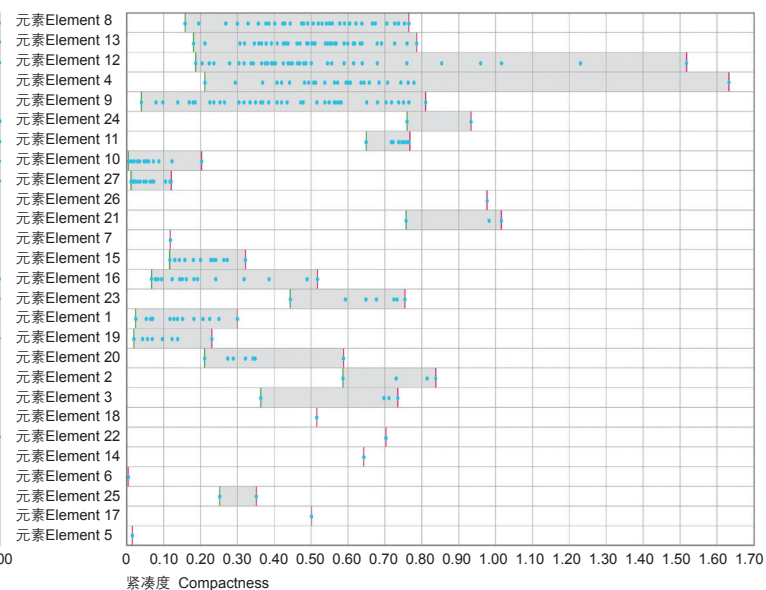
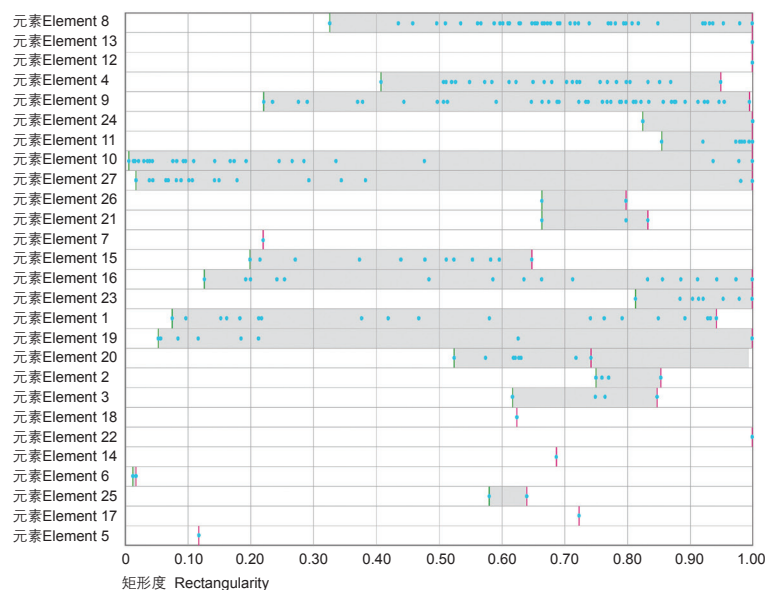
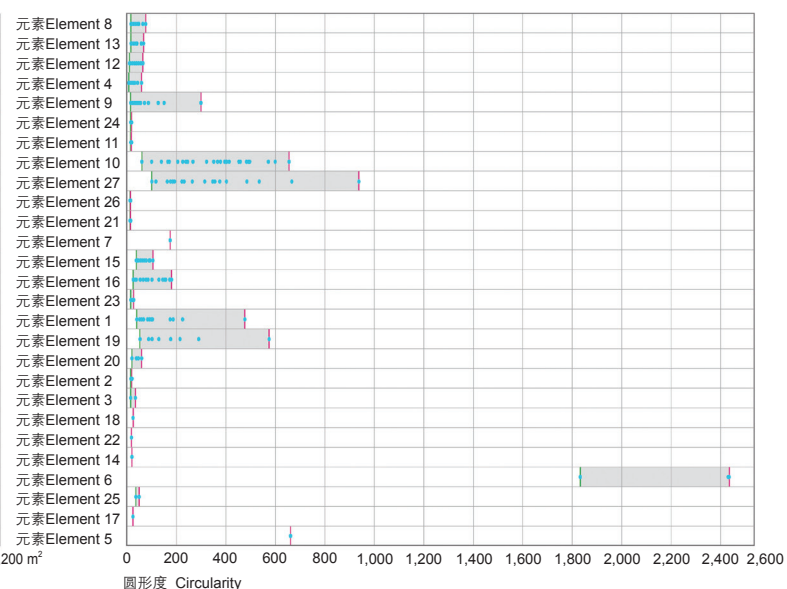
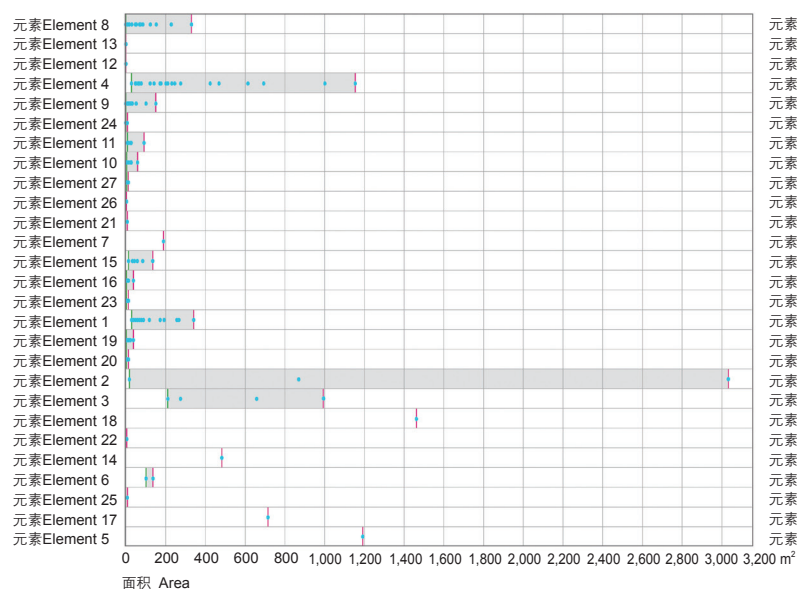
Stone wall (Element 27) and ditch (Element 16) are illustrated here for a further explanation. In terms of the area, ditches have a twice-higher value than stone walls in both the mean value (8.96:4.30) and standard deviation (7.03:2.84). The mean value of circularity of stone walls is much higher than that of ditches (299.96:101.56), suggesting that the stone walls in the village are more in elongated shapes than the ditches. The circularity standard deviation of the stone walls are higher than those of the ditches (190.55:51.52). The rectangularity of ditches is more than twice that of stone walls (0.73:0.30), but their standard deviations are very close (0.30:0.36). In terms of the compactness, the mean value (0.18:0.06) and standard deviation (0.13:0.03) of ditches are much higher than those of stone walls. The width-length ratio of stone walls is slightly higher than that of ditches (0.24:0.16), with the standard deviations (0.18:0.18) being the same.

## 5 Discussions

Figure 4 displays the significant differences between the existing spatial elements between village courtyards and the newly built elements. The indigenous spatial elements such as flat grounds in front of gate, side slopes, piers, earth dikes, and ditches all reflect the regional qualities of Huizhou villages, but are rarely found in the local landscape design, which are dominated by the generic use of urban landscape elements, ignoring the exploration and revitalization of local elements. For instance, squares, lawns, and tree pools were prevalently used in the tourism development (e.g. the Guanlu Village regeneration project) to reshape the village's image. For a

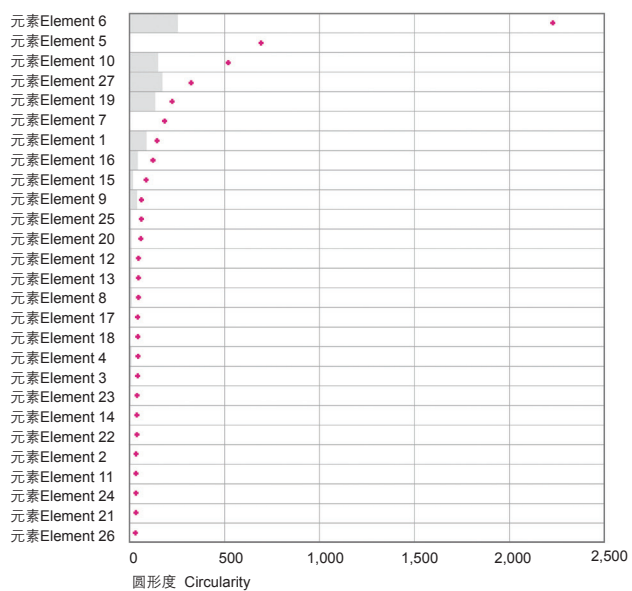
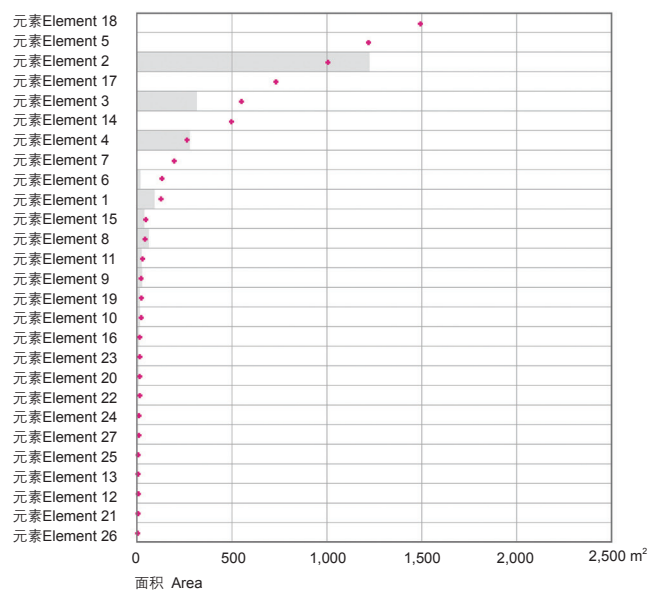
5. 宅间元素平面特征极值和数值范围

5. The extremums and value ranges of the morphological characteristics of the spatial elements between village courtyards

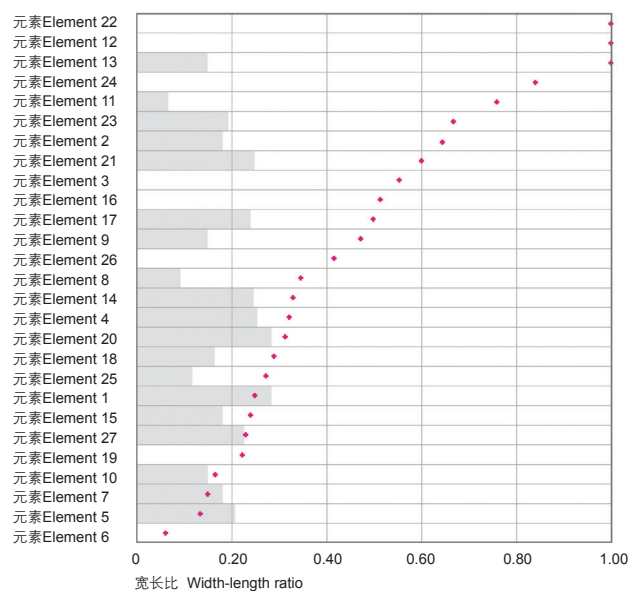
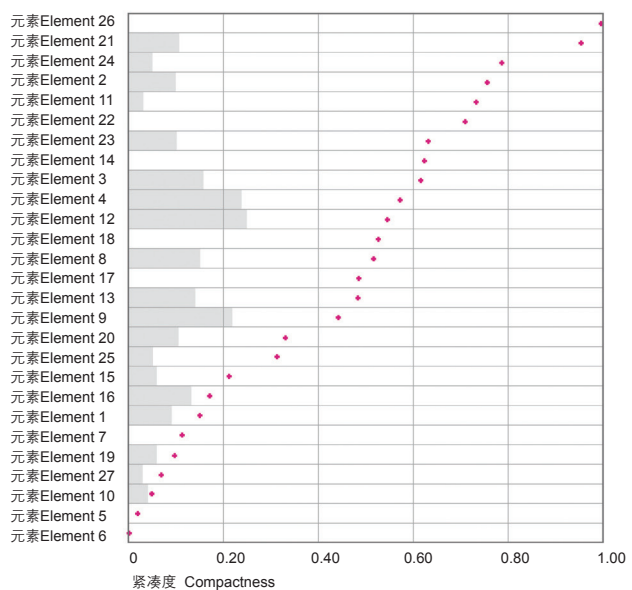
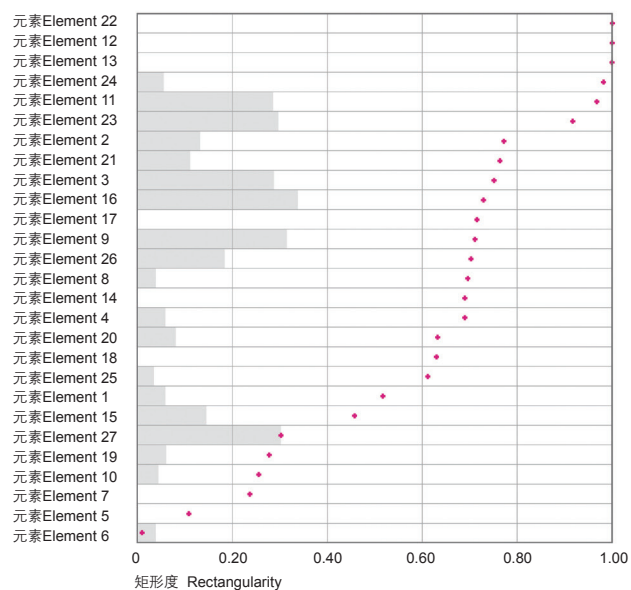


图例 Legend

- 最大值 Maximum value
- 最小值 Minimum value
- 数值 Values
- 数值范围 Value range



6. 宅间元素平面特征的均值和标准差
6. The mean values and standard deviations of the morphological characteristics of the spatial elements between village courtyards



图例 Legend

● 均值 Mean value

■ 标准差 Standard deviation

表2: 黄山市古村落(关麓村)与新建村落的宅间元素对比  
 Table 2: The comparison between historical village (Guanlu Village) and a newly built village in the same city in the spatial elements between village courtyards

	古村落(关麓村) Historical village (Guanlu Village)	新建村落 Newly built village
宅间元素 Spatial elements between village courtyards	平坦、挡、埠头、塘、晒场、宅间农田、花池、竹林、草坪(新建)、广场(新建)、滴水沟、塍、路、巷道、坝、排水渠、溪、茅草墙、石墙、门当、添灯(已毁)、桥、井、石阶、石凳、圈舍、棚架、树池(新建) Flat ground in front of the gate, earth dike, pier, pond, sunning ground, farmland among courtyards, planting bed, bamboo forest, lawn (newly built), square (newly built), ditch, side slope, path, alley, dam, drainage channel, creek, twitch-grass wall, stone wall, stone drum, ever-burning lamp (ruined), bridge, well, stone step, stone seat, colony house, canopy frame, and tree pool (newly built)	广场、儿童活动场、草坪、亭、岗亭、廊架、雕塑、车行道、人行道、挡土墙、羽毛球场、停车场、坡道、庭院墙、景墙、长凳、宅间绿化、树池 Square, playground, lawn, pavilion, watch house, corridor, sculpture, roadway, sidewalk, revetment, badminton court, parking lot, ramp, courtyard wall, landscaped wall, bench, greening among courtyards, and tree pool

元素。本文随机选择了与关麓村同属黄山市的一个新建村落, 将其宅间元素与关麓村进行比较, 结果显示差异元素的比例高达近87% (表2)。需要说明的是, 研究团队仅对构成宅间平面形态的核心元素进行了对比分析, 尽可能排除建筑细部构成元素(如灯柱、音箱、花钵等)对研究结果可能造成的影响。

元素平面特征的量化分析可以进一步明晰同类型元素的形式特征。例如, “石墙”“滴水沟”“排水渠”“巷道”均属于线域元素, 研究团队提取了这4种元素的图形特征数据, 将面积、圆弧度、矩形度、紧凑度、宽长比这5个平面特征影响因素作为象限坐标, 分别生成雷达图(图7), 呈现了同类型元素平面特征的不同之处。

此外, 当前村落景观设计多依赖主观经验指导设计, 设计师的个人能力与专业素养在很大程度上影响着设计品质, 这导致量大面广的村落景观设计品质良莠不齐。研究团队提出的这一基于元素分类、图式及其平面特征量化分析的方法模型从以下三个方面为以延续地域特征为目的的村落景观平面设计提供了客观依据: 1) 古村落宅间元素分类明确了元素在地方村落景观平面设计中的适用范围; 2) 宅间元素图式概括了元素的综合平面特征; 3) 宅间元素平面特征量化分析清晰地界定了元素平面的图形特征。

元素分类和图式的价值是辅助设计师进行初步设计, 而量化分析的意义则是校验设计元素是否契合面积、圆弧度、矩形度、紧凑度、

comparative study, this paper randomly selected a newly built village in the same city with the Guanlu Village, and examined the spatial elements between courtyards of the both villages. The analysis demonstrated the significant difference of such spatial elements (nearly 87%) between the villages in two contrastive typologies (Table 2). Specifically, the research team only analyzed the core spatial elements between village courtyards; architectural decorations such as lamp poles, sound boxes, and flower pots were excluded to avoid research bias.

Quantitative analysis of the morphological characteristics can highlight the differences among similar elements. For instance, stone wall, ditch, drainage channel, and alley are all linear elements. The research team visualized the area, circularity, rectangularity, compactness, and width-length ratio of the 4 elements in radar maps to clearly illustrate their morphological differences (Fig. 7).

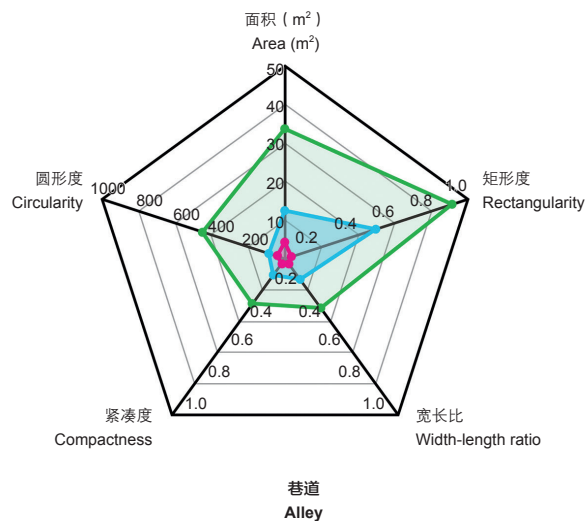
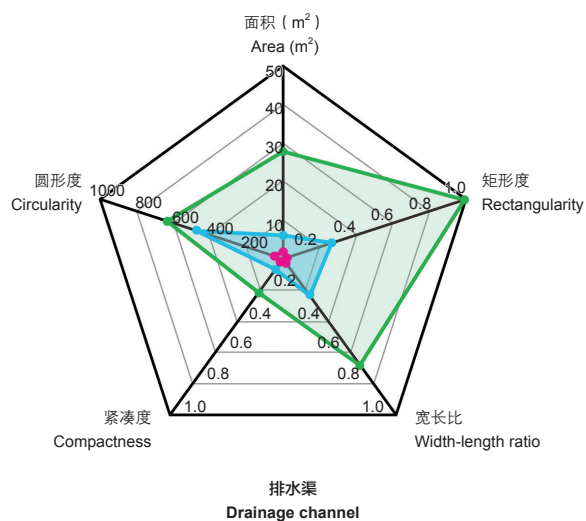
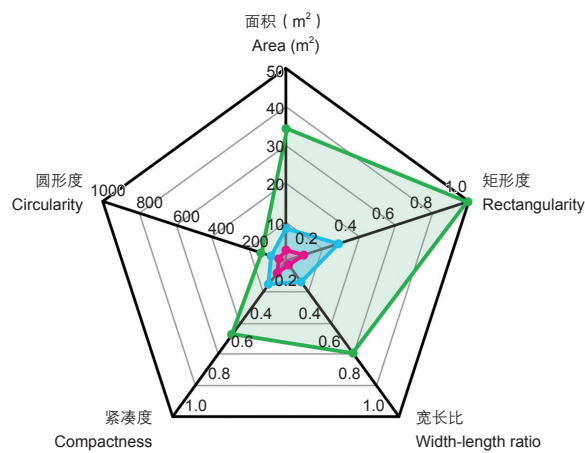
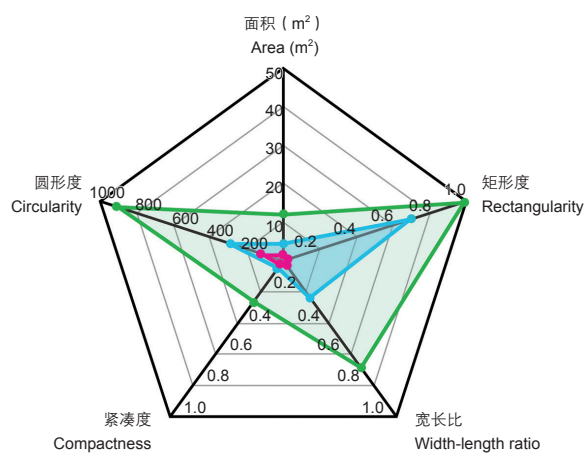
Besides, current practice of village landscape design is still guided by individual experience, and the design quality is largely subject to the designer's personal ability and capacity, resulting in disparities in design quality across the vast rural China. This village landscape design model constituted with element categorization, diagram drawing, and morphological quantitative analysis would provide scientific evidences that help inform the practices to revitalize village localities: 1) the categorization of the spatial elements between courtyards offers guidelines for the elements' regeneration; 2) the diagrams extract the overall characteristics of the elements; and 3) the quantitative analysis defines the values of the morphologies of the elements.

Element categorization and diagrams are used to help form preliminary design plans, and quantitative analysis

宽长比等元素的平面特征取值范围，在计算机辅助设计中，有助于实现设计方案的快速调整与迭代。以元素“石墙”为例，设计师首先初步设计元素形态，随后计算其平面特征的取值并与当地的真实元素进行对比，也可将设计元素的个体雷达图置入地方元素类型雷达图中，从而观察具体取值偏差并进行调整。平面特征量化分析提供了一个符合地域特征的设计区间，在区间内的设计既具有严谨性又不失灵活性（图8）。研究团队提出的这一村落景观设计方法模型，尽管可在计算

is used to verify whether the designed element' fit in its morphological value ranges in area, circularity, rectangularity, compactness, and width-length ratio. The computer-aided design process allows for prompt adjustments and iteration. Take the stone wall as an example: After the design of a conceptual or preliminary scheme, the values of the designed elements will be calculated and compared with those of the authentic elements; the designer can also compare their radar maps to identify deviations. The quantitative analysis helps define the “intervals” for element design and ensures the rationality and flexibility of the design (Fig. 8)—In this research, the computer-aided design process still greatly requires human intelligence and manual labor; In the future, software engineers are expected

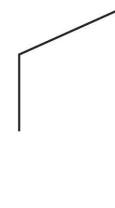
7. 线性元素图式取值对比  
7. Comparison of morphological characteristics of the linear elements



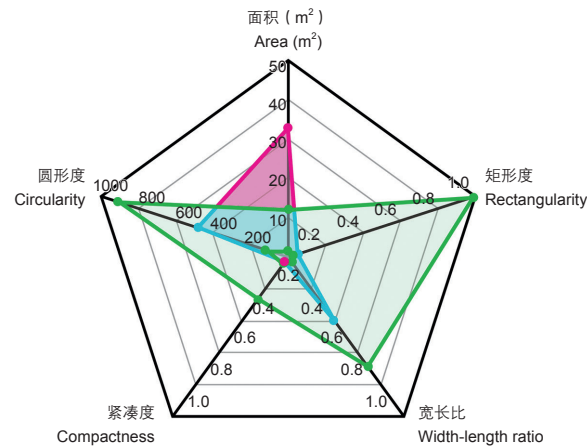
图例 Legend  
 最小值 Minimum value  
 均值 Mean value  
 最大值 Maximum value



既有的石墙元素图式  
Diagrams of the existing stone walls



设计石墙元素图式  
Diagram of the designed stone wall



石墙元素图式取值校准  
Diagram calibration of the stone wall

图例 Legend

- 数值范围 Value range
- 设计值 (符合) Design value (conformity)
- 设计值 (不符合) Design value (inconformity)

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8. “石墙”元素图式校准
8. Diagram calibration of the design of stone wall

机平台上进行辅助设计,但全程均离不开人工参与。如果软件工程师可以据此开发出一款根据设计元素平面特征进行动态数值校验并生成建议元素形状的工具,必将大大提高设计师的工作效率。

## 6 结语

首先,本文以黄山市关麓村为例梳理了当地28种古村落宅间元素分类及相应的元素图式,并量化分析了其平面特征。元素分类为设计师提供了更丰富的设计语汇,从而避免一味使用城市景观元素。虽然每个村落的形态特征不同,但在特定地区内,村落的宅间元素特征存在共性规律,元素图式及其量化分析则有助于设计师更好地辨识这些

to develop tools that support dynamic numerical verification on elements' changing morphological characteristics and offer design recommendations, which will greatly improve the design efficiency.

## 6 Conclusions

First, this paper identifies 28 sorts of the spatial elements between courtyards in Guanlu Village of Huangshan City and the corresponding diagrams, and quantifies their morphological characteristics. Element categorization provides designers with an enriched vocabulary, thus avoiding the mindless use of urban landscape elements. Although the morphological characteristics of different villages might vary, the spatial elements in a region see a consistent style, which can be used as references for village landscape design with aids of diagramming and quantitative analysis. As a methodological exploration, this paper also underlines the fact that the acquisition of the

特征，为元素在村落景观设计中的应用提供参考。地方元素特征取值区间的确定需要以大量案例数据的收集和统计为基础，本文仅作为一种方法论上的探索。宅间元素的形态特征亦不能用于直接解决村落的综合性生态、社会及文化问题。

其次，对元素平面特征的研究除了图形特征量化分析之外，还包括图像特征量化分析。本文聚焦于图形特征量化分析，通过数值区分不同元素图式的形状特征取值范围、辨别不同元素图式特征的差异，同时也允许不同元素间存在取值相似或相同的情况。图像特征研究方法包括元素的方向梯度直方图法、傅里叶功率谱法等<sup>[32]</sup>。未来，研究可关注如何将元素的图形和图像特征研究与计算机深度学习相结合，以实现村落宅间元素的自动识别。

最后，古村落宅间元素之于村落景观如同词汇之于语言——语言的完整性不仅包括词汇，还应包含语法结构、修辞与隐喻等<sup>[34]</sup>。研究团队认为，古村落宅间元素的分类及其平面特征的研究只是基础，未来需要进一步深入研究元素之间的空间关系，以建立村落景观语言体系，进一步探讨古村落平面形态的演变规律，从而促进村落平面形态演变模型的细化与完善，使其更具科学性和完整性。**LAF**

value ranges of local elements requires a large amount of data collection and statistics work, and the morphological characteristics of spatial elements cannot be used to deal with synthetic ecological, social, or cultural issues directly.

Second, in addition to the quantitative analysis of graphic characteristics, the study of element's morphology also includes the quantitative analysis of image characteristics. This paper focuses on the former, aiming to distinguish the value ranges of the graphs of different elements, where different elements may have similar or same morphological value ranges. Quantitative analysis of image characteristics includes gradient histogram and Fourier power spectrum<sup>[32]</sup>. In the future, the auto-identification of village spatial elements can be realized by combining deep learning technology with quantitative analyses of both graphic and image characteristics.

Last, the spatial elements between courtyards of historical villages to the village landscape is what the vocabulary is to the language—Languages are constituted not only by vocabulary, but also grammars, rhetoric skills, and metaphors<sup>[34]</sup>. The research team believes that the study on the categorization and the analysis of morphological characteristics needs more efforts in studying the spatial relations among the elements to form and complete the “lingual system” of village landscapes, exploring the evolution pattern of the morphology of ancient villages, refining the simulation of villages' morphological evolution, and contributing to the scientific and systematic development of associated research. **LAF**

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