

# Visualizing the cultural landscape gene of traditional settlements in China: a semiotic perspective

Zui Hu (✉ [fuyanghuzui@163.com](mailto:fuyanghuzui@163.com))

Hengyang Normal University <https://orcid.org/0000-0001-8638-599X>

**Strobl Josef**

University of Salzburg: Department of GeoInformatics

**Qingwen Min**

Institute of Geographic Sciences and Natural Resources Research CAS: Institute of Geographic Sciences and Natural Resources Research Chinese Academy of Sciences

**Min Tan**

Hengyang Normal University

**Fulong Cheng**

Chinese Academy of Sciences Aerospace Information Research Institute

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## Research Article

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# Abstract

China has a deep traditional culture and a very long history, and is very rich in traditional settlements (designated as “Famous Historic-Cultural Villages/Towns”, “China Traditional Villages” by China Government). To help people develop the traditional settlements to achieve the great goal of Chinese National Rejuvenation, Chinese scholar put forward the Cultural Landscape Gene Theory of Traditional Settlements (CLGTS) in 2003. Since then, CLGTS has been employed to solve the issues of Chinese traditional settlements, such as the identification and regionalization of cultural genes in traditional settlements, and the understanding of architectural features. Although CLGTS has made great strides in many fields, there is still a lack of scientific findings in exploring the symbol mechanism from a perspective of semiotics. To explore this, we first examine the core features of CLGTS through a dialectic perspective. We analyze two features of CLGTS in depth. First, CLGTS is the dialectic combination of macro settlement image and micro cultural factors of traditional settlements, material appearance and inherent traditional cultural implications, overall features and local self-renewal mechanisms, qualitative and quantitative methods, superiority of cultural factors and rich cultural connotation. Second, CLGTS is famous for its nonlinearity, self-organization, and self-iteration due to various spatial shape and complex structures. Based on the above, we present the concept of a CLGTS Symbolization Method. Then, we further elaborate the key features, classification methods, and corresponding representation methods of CLGTS symbols. Finally, by using Visual C#.net program language, we develop a prototype system of the Traditional Landscape Genetic Symbol Database (TLGSD) to create and manage CLGTS symbols. Test results show that TLGSD can meet the needs of constructing a CLGTS symbol database for a given region. This study is of great significance to explore and contribute to the CLGTS Symbolization Method.

## Introduction

The great goal of Chinese National Rejuvenation was officially put forward at the 19th National Congress of the Communist Party of China in 2017 [1]. Since then, China has paid more attention than ever before to the traditional settlements like “Famous Historic-Cultural Villages/Towns” and “China Traditional Villages” (designated and issued by China government) because they are rich in excellent traditional cultural heritage, such as ancient architectural technologies, ancient arts [2], planning concepts, and man-land relationship philosophy. At present, in the past decades, many research findings on key issues have been published, such as preservation [3, 4], eco-environment [5], architecture [6] and tourism value [7], etc. To a certain extent, these studies have helped to support the social strategies of China government, such as “Rural Revitalization” [8] and “New Urbanization” [9, 10].

However, through the current literature, there is a lack of results on the use of semiotic principles and methods to understand the geographic characteristics of cultural landscapes of traditional settlements. This directly makes it difficult to capture the holistic features of traditional settlements and establish a corresponding research framework from a scientific perspective.

As we all know, symbols play an important role in understanding the socio-cultural factors and as basic media for exchanging and transmitting information. Semiology provides the theoretical foundation to explore social cultures [11]. For example, we can use graphic variables [12] to establish a semiotic mechanism to improve the wisdom manufacturing systems [13], or semiotic methods for human-computer interaction [14], or icon design for engineering [15, 16]. This strongly hints that people can understand the socio-cultural meanings carried by cultural factors of traditional settlements from a perspective of semiotics.

Carl O. Sauer proposed the concept of cultural landscape in 1925. People have been attempting to address the evolution characteristics of regional cultures from different perspectives since then, such as “sequential occupation” [17] and “Morphogenesis” [18]. And now, some scholars elucidate the core cultural features of different settlements through a combination of quantitative methods and image [19]. For example, Wang Di [20] established a polar function to determine the relationships among dwelling areas, directions, and distances. However, current research can’t still address the geographical features of cultural landscapes in depth. It therefore is of paramount significance to establish a new method to analyze the cultural features of traditional settlements from a semiotic perspective.

The evolution of history and culture shows that spatial information has strategic value for human society [21]. In fact, this promotes the development of maps, which are considered as the third language of humans since it can help people describe, exchange, and transmit spatial information. People have made meaningful progress in many areas, such as development and evolution of the map symbols [22], map symbol standardizing [23], characteristics of information transmission [24], and representation models [25]. For example, He HW [26] put forward a new design method for map symbols through a combination of QR-code. In addition, people also made fruitful findings on the linguistic features, structures and constraint conversion into map symbols. This effectively promotes the implementation of automatic generation [27] and dynamic designs of map symbols.

Map symbols represent the semantic properties and features of geographical objects. They are also treated as media for communicating, transmitting, exchanging, and expressing spatial information [21]. Map symbols are the visual symbolic system and are akin to human natural language. From the perspective of semiotics, map symbols are an effective communication tool for expressing spatial information and geographical phenomena or expressing the development and evolutionary features of geographical systems. Map symbols can support the interpretation of cultural landscape features of traditional settlements.

It should be noted that traditional settlements are the civilization results of human activities and behaviors attached to natural landscapes. In part, traditional settlements have the attributes of natural landscapes. For example, the rural landscape including traditional rural settlements provides an important platform for integrating biological and cultural diversity for human well-being [28]. At the same time, traditional settlements are rich in historic and social information. Traditional settlements therefore are very special geographical entities. This challenges people to examine the socio-cultural properties and

historic cultural value of traditional settlements through the perspective of spatial information. So, with the support of principles of map symbols and visual symbol language, people can fully understand the geographic features of traditional settlements. This is also in line with the way of human thinking and understanding.

Liu PL first proposed the concept of cultural landscape genes of traditional settlements (CLGTS) in 2003 [29]. CLGTS is founded on cultural gene theory and biological analysis methods to understand the core characteristics of the cultural landscape of Chinese traditional settlements from a geographic perspective. To fully understand the geographic features of traditional settlements, with the support of bio-informatics and geo-information Tupu [30], CLGTS is mainly committed to determining the most outstanding cultural factors of traditional settlements in China and establishing a scientific framework of cultural landscape genome maps [31]. CLGTS is widely used to solve the issues of traditional settlement landscapes in China, mainly covering the identification and regionalization of cultural genes [32–34], understanding of architectural features, and supports the tourism development [29].

However, at present, some scientific issues of CLGTS, such as physical shape, appearance, spatial structure, and expression method, have not been thoroughly explored. The root of the former issues lies in the lack of using relevant principles and methods of semiotics to explore the natural characteristics of cultural landscape genes. This work attempts to explore the symbolization method of CLGTS from the perspective of semiotics. According to the core characteristics of CLGTS, this work is devoted to exploring the key issues of CLGTS symbols, such as symbol features, classification methods, and corresponding symbolization methods. One aim is to provide theoretical support for establishing the symbol application of CLGTS. We hope that this work can help to further frame the theoretical system of CLGTS and promote the use of CLGTS in a wide range of application domains.

## **The Scientific Features Of Clgts**

CLGTS is an important method for establishing CLGTS Tupu in China [31, 35]. It is of great significance to clarify the scientific characteristics of CLGTS.

## **The Dialectical Features**

Richard Dawkins first introduced the concept of gene into the socio-cultural areas, and proposed this as a “meme” in 1976. E. O. Wilson presented the theory of co-evolution of human gene and socio-culture based on the genetic characteristics of human socio-cultures [36]. Geographers mainly study the features of regional cultural genes from the perspective of humanism. For example, Conzen proposed the Morphogenesis Theory in 1988 [18].

CLGTS had been founded on the ancient ecological ideas, plan concepts, and man-environment relationship philosophies [37]. Since its introduction, CLGTS has developed a series of methods to identify the outstanding cultural factors in traditional settlements, such as pattern, text, element, and

structural features [31, 38]. CLGTS has important scientific significance since it provides cultural geography with natural science analysis methods to explore the features of traditional settlements. This is very meaningful from the perspective of scientific philosophy.

First, CLGTS is a dialectic combination of a macro image of traditional settlement landscapes and their micro cultural factors. From the concept scope of CLGTS, cultural landscape genes are uniquely identifiable [39]. In practices, people mainly think about the image features of traditional settlement landscapes from the holistic perspective to distinguish different settlement with similar cultural properties. For example, only by treating the three scattered blocks as a whole (Fig. 1) can we understand the dragon-shaped layout of Zhangguying Village [31] in Hunan Province, China. The cultural landscape genes usually hidden in different traditional settlements can reflect the cultural differences of settlements in different details or levels. For example, Ma Tau Wall is a common architectural decoration style in traditional Chinese courtyards, and they often have different cultural differences in different regions, which can only be distinguished by details such as shapes, arcs, and bends [40].

Second, CLGTS is a dialectic combination of physical appearance features and inherent traditional cultural meanings of traditional settlement landscapes. The cultural factors of traditional settlement landscapes usually have the corresponding physical carriers. In fact, even the intangible cultural factors of traditional settlements can reflect the key characteristics of related objects. For example, only by providing a certain space in Chinese traditional settlements can the Nuo Opera be performed, which is one kind of traditional opera originated in some rural areas in China [40]. As long as the following conditions are met, a cultural factor can be truly defined as a recognizable CLGTS: (i) it must carry the special functions conferred by traditional settlements; (ii) it must occupy a specific spatial position in traditional settlements; and (iii) it must reflect some social ethics, functions, or cultural meanings contained in traditional settlements. Note that meeting the above conditions, a CLGTS can be significant when capturing the spatial image of a given traditional settlement.

Third, CLGTS is a dialectic combination of the holistic features and local self-renewal mechanisms in the inheritance process. It is well known that biological genes can maintain their own characteristics in the genetic process without fundamental changes. However, a certain degree of trait changes in biological genes (e.g. mutation) also can be induced or triggered by some peculiar factors. For example, tobacco smoke associated DNA adducts may cause mutations in human larynx squamous cells [41]. The same is true of CLGTS in the process of inheritance. On the one hand, cultural landscape genes always try to keep their important features or attributes stable. On the other hand, due to different cultural ecological environments, the corresponding changes in cultural landscape genes will happen during transmission. This implies that a certain degree of self-renewal has emerged in some details. For example, for the Hakka Tulou, although their enclosure patterns have changed from square to quasi-square and then circular, their main features are still kept, such as function, social statute, and cultural meaning [42].

Fourth, CLGTS is a dialectical combination of qualitative and quantitative analysis methods of traditional settlement landscapes. The qualitative analysis has been the most important mainstream method in

geography history for a long time. And the quantitative analysis has gradually been the most popular method in geographic fields since the revolution of computation geography [43]. However, in the domains of cultural geography, qualitative methods are more popular. We notice that CLGTS has organically combined qualitative and quantitative methods by introducing some methods of bio-informatics. This will help to enrich the methodologies of cultural geography. For example, the research on identification of CLGTS spatial patterns of Hunan Province of China mainly used the qualitative methods [32]; however, the exploration on CLGTS genome maps in Hunan Province of China mainly used the quantitative methods [31].

Fifth, CLGTS is a dialectic combination of the holistic superiority of core features and the rich cultural connotations of traditional settlement landscapes. In the traditional settlement landscapes, CLGTS is one of the most recognizable cultural factors. For example, Gulou is the grandest and most majestic building in the Dong Minority villages, and vice versa: Gulou is also the most important cultural symbol to identify the Dong Minority villages. CLGTS usually contain rich cultural connotations. This means that CLGTS can reflect many important features of traditional settlements. Note that although the holistic superiority of core features and rich cultural connotations are the two aspects of CLGTS, they are consistent and not opposite.

Through the above dialectic relationships, we can conclude that CLGTS is a scientific concept (Fig. 1). CLGTS is not only an objective reality but also contains profound and rich traditional cultural characteristics, such as traditional social institution, traditional ethic, traditional philosophy, traditional custom, and clans, etc. In addition, CLGTS can not only extract the scientific features of traditional settlement landscapes from the perspective of natural science, but also generalize the traditional cultural features of traditional settlement landscapes from the perspective of cultural geography.

## Morphometric Features

CLGTS has its own physical characteristics and appearances. And CLGTS in traditional settlement spaces is full of close relationships, rather than existing in isolation. For example, the Dang Gate of Zhangguying Village (situated in the Yueyang county, Hunan Province, China) is composed of a series of Chinese traditional courtyard [44] buildings arranged on the same symmetric axis; its entire spatial layout is shaped like a Chinese character “回” (Fig. 1).

In the process of site selection, design, and construction, many Chinese traditional settlements have emphasized the need to be in line with traditional customs and show their own characteristics. They also pay attention to create a spatial image with rich traditional cultural meanings according to different geo-environments, times, places, and landforms [45]. In ancient China, people usually tended to create spatial shape with rich geomancy beliefs [46] in terms of the corresponding natural environments while constructing the settlements. For example, the Longjia Courtyard-Group in Heizuling Village (situated in the Xingtian County, Hunan Province, China) is famous for its “five-generation-in-one-hall” spatial layout (According to the Chinese traditional cultural meanings, this spatial layout means that five generations of

the same family live in the same courtyard and share the same hall. It hints that a large group of traditional courtyards have been built to accommodate an enormous family.). This objectively contributes to the diversity of spatial forms of CLGTS. For example, Hu Z et al. [31] pointed out that the spatial layouts of traditional settlements in Hunan Province mainly include sector and circle.

According to Liu PL et al. [47], the spatial forms of CLGTS mainly include square-series and circular-series, as well as a variety of geomantic forms based on environmental conditions (Fig. 2). The former includes different variations based on a square shape. For example, many spatial forms are derived from the courtyard dwellings/Siheyuan, such as Jing/yard, Hall, and patio/Tianjing [44]. The latter includes a couple of variations based on the circular shape, mainly including ellipse and quasi-circle. For example, the spatial forms of Tulou in Fujian Province [46] mainly include circle and ellipse. To sum up, the spatial forms of Chinese traditional settlements have changed from square to circle, and then to irregular shapes [47].

## Structural Features

CLGTS shows different characteristics in the way of spatial organization and forms various spatial structures with rich traditional cultural meanings [31]. With reference to existing research cases [31, 42, 47], it can be found that the spatial structures of CLGTS have characteristics of nonlinearity, self-organization, and self-iteration.

First, CLGTS is nonlinearly arranged in the traditional settlement spaces. As we all know, for the physical space in nature, the linear spatial structure is a common arrangement and can be accurately described through linear equations, such as the arrangement of honeycombs. In nature, there are also a huge number of nonlinear structures such as the hyperbolic non-helical structures of DNA.

The constituent elements of traditional settlements are nonlinearly arranged, which is determined by the natural geo-environment conditions in which the traditional settlements are located. The natural geo-environment is full of complexities, nonlinearities, and randomness. This makes it difficult for the different constituent elements of traditional settlement spaces to form a regular linear arrangement, such as the streets, lanes.

In fact, the layout of the constituent elements of traditional settlements must be in accordance with the geo-space where the settlements are located. The constituent elements of traditional settlements are difficult to be regularly arranged by the linear structures. Note that CLGTS can be understood as the mapping of various physical cultural factors in traditional settlement space on the socio-cultural dimension. This suggests that the cultural factors or non-material cultural factors in the traditional settlement space are also nonlinearly arranged. For example, the most ideal city in ancient China has been considered as a square city with a length of 3-Li (an ancient length unit in China) according to the records in "Kao-Gong-Ji"; however, due to the complexity of the geo-environments, it is difficult to find an ideal city with regular spatial forms in the real world.

Second, CLGTS shows the self-organizing features in traditional settlement space. We know that the size of a settlement will expand during the development process while the population growing. All the constituent elements of settlements gradually change from irregular to regular and from disorder to order. This is not only in accordance with the evolution law of natural systems, but also with the development process of human civilization.

The constituent elements of settlement with similar functions also tend to congregate together. This is because the congregated constituent elements (e.g. shops/stores) can ultimately share the common infrastructures of settlements and attract customers. For example, the intact Water-Street can still be found in the ancient towns south of China's Yangtze River, such as Zhouzhuang Ancient Town [48], Tongli Ancient Town. In addition, through organic planning of various constituent elements, many traditional settlements try to create spatial structures with special cultural significance. For example, Zhuge Ancient Village (located in Zhuji City, Zhejiang Province) is famous for "Eight-Diagram-Street-Lane" spatial structures [49].

Third, CLGTS also has the characteristics of self-iteration in traditional settlement space. Iteration is a regular self-similarity that can be accurately described by mathematics. In nature, the objective objects with iterative characterizations have precise spatial structures, such as honeycomb, tree texture, biological genes. Iteration can also be considered as a self-repair and self-development mechanism of natural systems during the evolution process. In fact, the self-iteration phenomena can also be found in the humanities and society. For example, the generation reproduction of families is a regular iterative process that can be recorded by genealogy [50].

CLGTS has self-iterative features similar to biological genes since its cultural connotation, appearance characteristics, and physical carrier are completely replicated and spread in the inheritance process. For example, in the field investigations of Jingshan Ancient Village (located in Rucheng County, Hunan Province), Hu Z et al. [51] found that the techniques and experience of making Hong-Meng-Liang, which originated hundreds of years ago, were completely inherited by craftsmen of this village.

## **The Connotation Of Clgts Symbol Mechanisms**

The natural languages are a kind of comprehensive symbolic expression systems. They have the special symbol systems and a wide range of socio-cultural constrained attributes. They are treated as the basic media for humans to record, communicate and disseminate information. As mentioned above, Chinese traditional settlements are rich in CLGTS. For example, cultural landscape genes of traditional architectural heritage [52] often own special physical carriers or media, can carry rich socio-cultural information, and express unique traditional cultural meanings, such as hollowed-out carving techniques, house shape, spatial layouts of settlements, spatial structures of settlements, establishing mode for building space, common places.

CLGTS' inheritance ways are very rich, not only including material appearances or carriers but also including restricted attributes, such as cultural connotation. CLGTS is very similar to linguistic symbols.



This suggests that the features of CLGTS can be illustrated from the perspective of semiotics.

## The Concept Of Clgts Symbolization Method

The CLGTS symbolization method (SM-CLGTS) means constructing the symbol description model and corresponding graphic expression systems. It analyzes the traditional cultural connotation and deep features of CLGTS through referring to relevant cartographic principles and methods. It can also support establishing and drawing the traditional settlement cultural genome maps for a given region [31]. From the viewpoint of semiotics, SM-CLGTS covers a wide range of topics, mainly involving CLGTS analysis, definition of symbolic model, symbol taxonomy, and graphic-expression ways. CLGTS can be considered as a symbol unit with socio-historical and cultural information, and be described by especial methods [53]. This work is contributed to explore the features of CLGTS symbols by reference to modeling methods, symbol variables, and graphic representation theories of map symbols.

However, the clear differences between CLGTS symbols and map symbols should be detailed. They are reflected by the nature of CLGTS. The socio-cultural and socio-historical information are the most essential features and main constraints of CLGTS. In addition, CLGTS also includes important geo-environmental features and geo-spatial position information. Map symbols mainly represent geo-spatial position and geographical semantics of geographical objects/phenomena.

SM-CLGTS deserves to be deeply explored because: (i) it is an important expansion of CLGTS theory from the perspective of linguistics and semiotics; (ii) it is helpful to rich the methods of CLGTS theory by referencing cartography; (iii) it can support drawing traditional settlement cultural genome maps for a given region; and (iv) for a given region, it provides a possible way to protect CLGTS with using digital technologies [54] and carrying out corresponding resource surveys.

## Clgts Symbol Features

From semiotics, the following two distinct features of CLGTS symbol are clear.

First, with the support of symbols, the socio-cultural connotation and spatial attributes of CLGTS can be fully abstracted and effectively represented. By constructing a symbolic representation system, we can fully capture the nuances of different CLGTS with similar cultural connotation or physical appearances. This is because symbols are a combination of pronunciation, form, as well as meaning, and can be recognized or observed due to their visual appearances. Note that some principles and methods of map symbol design can also help people recognize the different CLGTS. For example, we can use the visual variables of map symbols [12] to recognize the similar CLGTS, such as color, texture, and shape.

Second, in traditional settlement space, CLGTS is the combination of physical carriers with socio-cultural meanings (e.g. the spatial layout of traditional settlements) and traditional cultural information media with symbol significance. In other words, CLGTS is a combination of objectively existing entities and corresponding abstract symbolic meanings. This provides a theoretical basis for using corresponding

principles of map symbols to explore the features of CLGTS symbols. Each symbol of a natural language can correspond to an entity in the objective world because the language establishes its own representation system. Similar to linguistic symbols, each CLGTS can also correspond to a unique cultural factor in traditional settlements. This strongly suggests that there is a unique and objective correspondence between CLGTS and relevant cultural factors in traditional settlements. And this correspondence can be clarified through mapping, generalization, and semantic constraint. Mapping means that CLGTS is a symbol-level semantic description, which mainly describes the corresponding physical carrier or physical existence. That is to say, mapping is to establish a strict correspondence between CLGTS and the related objective entity, which is of great significance to construct the graphic representation model for CLGTS symbols. Generalization implies that CLGTS symbols must conform to certain specific design principles, recognition laws of linguistics and semiotics. In fact, generalization highlights that the most distinguished and important features of CLGTS should be accurately represented from a semiotic perspective. Semantic constraint means the special information carried by CLGTS with traditional cultural meanings, such as history culture, and social ethics. We point out here that it should keep in line with the semantic constraint when using symbols to express the CLGTS. For example, we can use square to represent the traditional courtyard, and then combine other symbol variables to express other forms of courtyard-heritage, such as shape, color (Fig. 3).

From a semiotic perspective, CLGTS symbols can represent the peculiar cultural meanings of traditional settlement spaces. We can combine the corresponding principles of semiotics to establish a graphic representation model for CLGTS.

## Clgts Symbol Classification

According to the cultural connotation of CLGTS and representation methods, CLGTS symbols can be thought of in four types (Table 1), which are graphics, pictures, texts, and spatial comprehensive layouts, respectively.

Table 1  
A Classification for CLGTS symbols

Symbol class	description	note
Graphic symbols	Using the graphic symbols composed of the basic elements to express the special meanings of CLGTS	Simple symbol
Picture symbols	Directly defining the pictures/images as the symbols to express some special meanings of CLGTS	Simple symbol
Texts symbols	Directly using text to describe the meanings of CLGTS	Textual symbol
Spatial comprehensive layout symbols	Combining the mapping functions of GIS software to intuitively express the meanings of the layout symbols of CLGTS	Compound symbol

For a given CLGTS, graphic symbols mean that we can use a combination of basic graphic elements or specific patterns to represent its connotation or important attributes. For example, for the CLGTS of the Phoenix Ancient City, we can design a series of graphic symbols in the shape of Phoenix Divine Bird to describe it.

For the certain CLGTS that are difficult to represent with graphic symbols, picture symbols mainly refer to using pictures or images to represent them. Some CLGTS that can only be recognized by local or detailed features can be represented directly by pictures or images. For example, according to field investigations in Rucheng County [51], we can directly use picture symbols to express the main cultural features of different style patterns used to decorate the clan temples of ancient villages.

Text symbols indicate people can directly use text to describe the main features or attributes of CLGTS. First, some non-material CLGTS are difficult to represent directly with graphic symbols or picture symbols. For example, the Fiery Dragon is a popular traditional custom with rich cultural connotation in Rucheng County, which can be directly described by text symbols [51]. Second, some cultural factors are described or recorded directly by text, such as Jiangyong Women Language. Third, the cultural connotation of some specific cultural factors is difficult to be directly generalized by graphic symbols or picture symbols. Note that the text symbols are the best choice, such as Bai-shou-tang's shapes of Tujia Minority.

Spatial comprehensive layout symbols mainly represent the holistic features of traditional settlements, such as geo-environmental features, spatial design model, and layout characteristics. In fact, the spatial layouts of Chinese traditional settlements are an organic combination of traditional ecological philosophy and wisdom, traditional social development knowledge, and geo-environments. The traditional ecological philosophy and wisdom mainly include site selection and settlement construction planning. The traditional social development knowledge mainly contains survival wisdom, man-environment relationships, and social ethics. For a given traditional settlement, its spatial layout is the central of entire features between design ideas, traditional cultures (e.g. ethics, religions, custom, etc.), and geo-environmental features. This suggests that the traditional cultural meanings of spatial layout of traditional settlements can be fully understood by people from a holistic view. We can use maps to summarize the design features and related ideas or other core cultural features of traditional settlements, then further generalize corresponding layout CLGTS. For example, in order to express the auspicious cultural meanings of traditional geomancy, some Chinese traditional villages have designed the habitable spaces based on surrounding natural conditions and features of geo-environment, such as Gaoyi Ancient Village (located in the Huitong County, Hunan Province), Suoyuan Ancient Village (located in the Jinghua City, Zhejiang Province), Lanxi Ancient Village (located in the Zhuji City, Zhejiang Province), and create unique spatial layouts with outstanding geomantic meanings.

## **Clgts Symbol Representation**

In practice, the cultural factors which qualify for the given conditions are often defined as CLGTS. These conditions mainly include the following: First, CLGTS has outstanding traditional cultural characteristics,

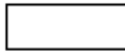

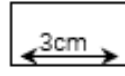


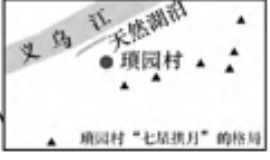
so it can be distinguished from similar cultural factors in other traditional settlements. This hints that the recognizable features are the most important attribute of CLGTS. For example, for a Wa Minority traditional village, the totem pillar decorated with the bull heads can be identified as its CLGTS [45]. Second, CLGTS has a strong sense of identification and recognition. To a certain degree, CLGTS can be regarded as an important cultural symbol of the spiritual space of traditional settlements [52], such as the Bai-shou-tang of Tujia Minority, the Gulou of Dong Minority (the highest, grandest, and most majestic traditional building in the village). Third, CLGTS is very famous for its important features of Chinese traditional philosophy, traditional social institutions, and traditional social ethics, such as the shapes and rules for constructing a gate of the clan temples. Fourth, the traditional cultural connotation of CLGTS can continuously remain its core features and stability even after a long history of inheritance, such as the shape of Tulou, the enclosure features of traditional courtyard. It can see that CLGTS is not only the generalization and abstraction of important attributes of cultural factors of traditional settlement at socio-ethical level but also the integration of cultural connotation of traditional settlements at symbol level, such as ancient social institutions, and ancient social ethics.

Note that, when examining a given CLGTS, in order to reveal its traditional cultural features, we must not only think about itself but also analyze it in its original cultural eco-environments. This implies that the visualization graphs/pictures/texts of CLGTS symbols must have accurate definition, simple composition, and intuitive representation model. It should point out that CLGTS can be considered as the smallest unit of historical and cultural information which exists in traditional settlement space. This hints that CLGTS has not only the attributes of spatial positions but also the rich traditional cultural information.

Despite CLGTS is only a conceptual description about the objective reality, it still is a formal logical framework established by generalizing or extracting important attributes or features of objective real entities, such as shapes, textures, sizes, patterns, colors and layouts (Table 2). This shows that people can fully recognize the outstanding features or attribute differences of CLGTS from the perspective of semiotics. For example, according to Liu PL and Dong SS [45], we can design a bull-head-shaped graphic symbol to express the totem CLGTS of Wa Minority (Wa Minority who is distributed in Yunan Province of China worships bulls. And there are often many bull-head-shaped decorations in their campus or villages.).

Symbol variables and their corresponding combinations can highlight the differences among CLGTS of different regions or cultural backgrounds, such as shapes, colors, sizes, textures, patterns, as well as layouts. This suggests that we can effectively emphasize socio-cultural meanings of CLGTS by the scientific use of symbol variables. This can help us to improve the design quality of corresponding CLGTS symbols, so that we can distinguish different CLGTS. For example, the enclosure CLGTS of Tulou with different shapes can be distinguished by different symbols (Fig. 4): the square enclosure Tulou can be represented by the square symbol; the circular enclosure Tulou can be expressed by the circle symbol; the elliptical enclosure Tulou can be represented by the ellipse symbol. From Fig. 4, we can see that the detailed differences of enclosure CLGTS of Tulou can be described through different shaped symbols.

Table 2 Basic Variables of CLGTS Symbols

variable	description	Symbol example	note
shape	The shape characteristics of the material carriers or indication objects of CLGTS		The enclosure shapes of the house or yard.
texture	The distribution characteristics of the regional CLGTS		Some CLGTS can be distributed across regions or areas.
size	The size of the material carriers or indication objects of CLGTS		The dimensions of houses, yards, primary common buildings.
pattern	Some special patterns with the given traditional cultural meanings of CLGTS		The decoration patterns are widely used in the traditional settlements.
color	Different colors can be used to distinguish the details of the similar CLGTS.		The traditional Siheyuan Building pedigree has many variations in China.
layout	The whole spatial layout CLGTS of a given traditional settlement is usually designed according to the geo-environment conditions.		Suoyuan Ancient Village (located in the Yiwu City of Zhejiang Province) is famous for the spatial layout “Seven-Star-Around-Moon”.

## A Prototype Of Clgts Symbol Application

In practice, symbol application is used to create or manage map symbols through referring to database principles or technologies. To a certain degree, symbolization is a special type of database application. It uses the database technologies to centrally manage the map symbols that serve the specific application tasks. People usually establish different symbol applications to centrally manage map symbols according to the needs of geographic information engineering tasks. The map symbols stored in a symbol database share the same styles, norms or standards [23]. They are also consistent with the technical standards of national specifications for mapping and surveying. This work established a Traditional Landscape Genetic Symbol Database (TLGSD) for a given region through combing the above theoretical results with the ideas and methods of a map symbol application based on the linguistic method [55].

TLGSD is directly developed from the bottom level by using Visual C#.net programming language. And some functions in ArcEngine Components have also been integrated into TLGSD (Fig. 5). TLGSD can

create or maintain CLGTS symbols, and can also carry out some basic operations on CLGTS symbols, such as create, edit, modify, code, and save.

TLGSD uses critical attributes of CLGTS to construct corresponding CLGTS symbols, such as symbol name, symbol class, symbol code (Fig. 6), symbol meaning. The symbol name is a unique name for corresponding CLGTS. The symbol class is the semiotic type of CLGTS, including graphs, pictures, texts, and comprehensive spatial layout. The symbol code is a unique identifier for corresponding CLGTS, which consists of 16 codes, including characteristics of geo-spatial positions and cultural attributes. The symbol meaning is a unique variable which describes the socio-cultural meanings and features of CLGTS.

In addition, the attributes of CLGTS symbols in TLGSD also include feature descriptions and typical cases of traditional settlements. To help users create or maintain CLGTS symbols, TLGSD integrates all attributes of CLGTS symbols into the same dialog window (Fig. 7).

In TLGSD, the symbol editing is the core step in creating CLGTS symbols. In terms of the theoretical results, TLGSD defines CLGTS symbols as four functions, including graph, picture, text, and compound (comprehensive spatial layout). Graph symbol function allows users to design or create CLGTS symbols using basic graphic elements that are well defined by TLGSD. According to picture symbol function, users can directly define picture CLGTS symbols through using original pictures or images obtained during the field investigations. If it is difficult for users to design graphs or use pictures/images while creating CLGTS symbols, text symbol function can directly define the feature description text of CLGTS as CLGTS symbols. Compound symbols are used to record the geo-environmental features and materials related to spatial layouts of traditional settlements. Note that, for a given traditional settlement, users must study its spatial layout according to geo-environmental features and traditional geomancy knowledge, such as landforms, watersheds, and rivers, etc. Maps can represent the main cultural features of spatial layouts of traditional settlements. In order to help users make compound CLGTS symbols using spatial layout map of traditional settlements, TLGSD can directly read the “.mxd” files of ArcGIS software through integrating the ArcEngine Components.

Besides, the primary functions of TLGSD also include saving CLGTS symbols and query. The function of saving CLGTS symbols consists of a series of operations, mainly including connecting database file, adding symbols into database, updating database. Symbol inquiry function can help users look up CLGTS symbols that have been already saved in files. And this function can query the CLGTS symbols according to symbol name, symbol code, or typical cases of traditional settlements.

The test results of TLGSD prototype (Fig. 8) clearly show that it can meet the needs of establishing a CLGTS symbol database for a given region and can run well.

## Conclusions And Outlooks

CLGTS plays a significant role in implementing the social strategy of the great Chinese National Rejuvenation because it describes the core features of traditional cultural settlements that are one of the most critical parts of Chinese excellent cultural heritages. This study presents a conceptual framework of SM-CLGTS and develops a prototype to create and centrally manage the corresponding CLGTS symbols through introducing the principles and methods of semiology and cartography.

Through this research, by elucidating the philosophical dialectical meanings, spatial shape, and structures of CLGTS, we can conclude that CLGTS is an abstractions and synthesis of the cultural collection of traditional settlements, which usually contains cultural institutions, social institutions, social ethics and traditional philosophies, etc. Note that each CLGTS has its own physical entities or objects in traditional settlement space. This lays the theoretical foundation for constructing CLGTS symbols, and has a positive significance for improving the theory of CLGTS.

In this work, the conception and connotation of CLGTS symbols are clearly defined. CLGTS symbols are the results of an in-depth analysis of the core cultural features of traditional settlements from a perspective of semiotics. They also can be considered as the visual graphic toolkit for analyzing the cultural connotation of traditional settlements. This is of important meaning to promote the wide applications of CLGTS in further work.

According to the classification and expression methods of CLGTS symbols, and referencing the corresponding map symbol methods, this paper develops TLGSD prototype program for making CLGTS symbols. This is of crucial significance of providing a potential technical way to visualize CLGTS symbols. This research therefore has methodological significance for advancing the preservations of traditional settlements and corresponding cultural landscapes.

Note that there are still some important issues which need to be studied in depth. First, an appropriate formal description model of CLGTS symbols should be established. It is very crucial to establish the design rules and a classification system for CLGTS symbols. Furthermore, there is still a lack of effective technical ways to construct CLGTS symbols and forward their applications, e.g. integrating the TLGSD symbols into mainstream GIS software. This will impact the digitalization of CLGTS. Through this study, the top priorities of the most important issues of CLGTS symbols include a formal description model, coding methods, symbol construction specifications, and symbol features.

## **Abbreviations**

CLGTS: cultural landscape gene theory of traditional settlements

TLGSD: traditional landscape genetic symbol database

SM-CLGTS: CLGTS symbolization method

## **Declarations**

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<https://orcid.org/0000-0001-8638-599X>

## Availability of data and materials

Not applicable

## Author's contribution

**Zui Hu** finished the whole research work, also designed and developed the prototype procedure abbreviated as “TLGSD” in this work, and wrote the manuscript.

**Josef Strobl** contributed his high writing skills for this manuscript and corrected the errors.

**Qingwen Min** was charged of the entire research thinking.

**Min Tan** was committed to improving the language of this manuscript.

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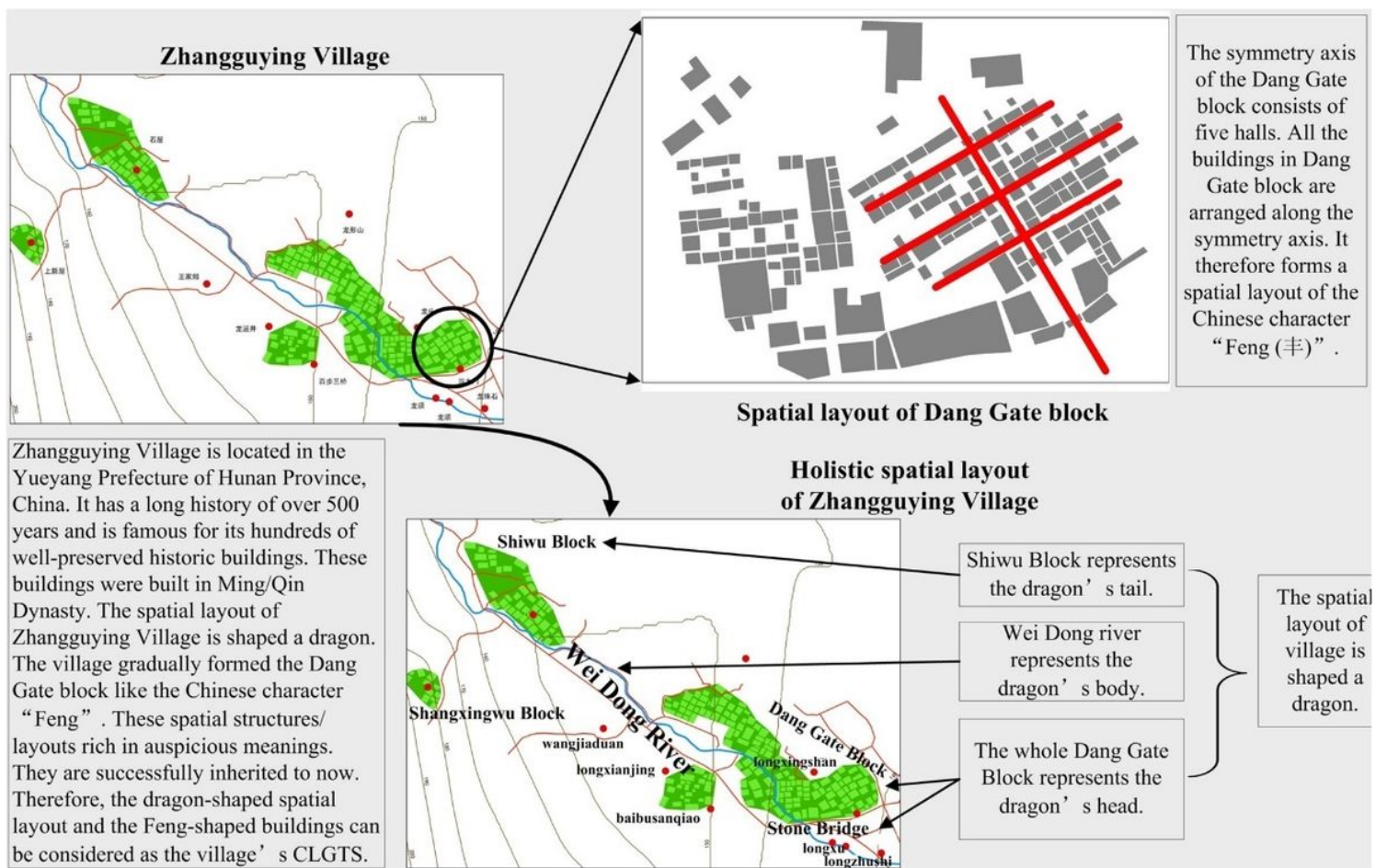
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## Figures



**Figure 1**

The concept of CLGTS: CLGTS means cultural factors that exist in traditional settlements, which can distinguish its host settlement from other cultural landscapes. Note that CLGTS can be inherited from generation to generation and plays a decisive role in the formation of cultural landscapes. And vice versa, CLGTS can also play a decisive role in recognizing the cultural landscapes. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion

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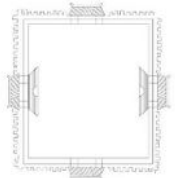
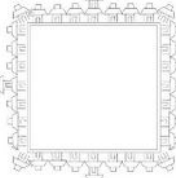


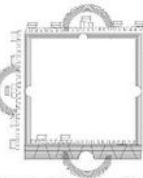
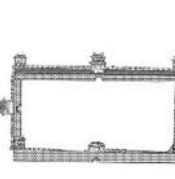

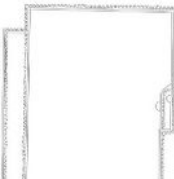
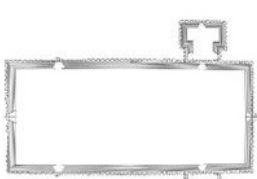
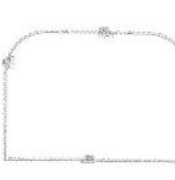
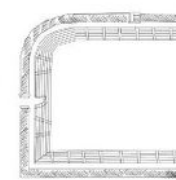

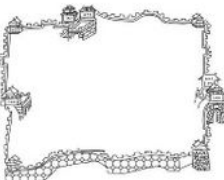









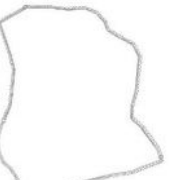




Basic shape	Typical ancient city/town				
Square	 <p>Changping County</p>	 <p>Xiajin County</p>	 <p>Wei County</p>	 <p>Pingyuan County</p>	 <p>Man Cheng, Gansu Province</p>
Rectangle	 <p>Zhenxiong County</p>	 <p>Changzhi County</p>	 <p>Miyun County</p>	 <p>Ningxia Fu</p>	
Quasi-rectangle	 <p>Guangnan Fu</p>	 <p>Guan County</p>	 <p>Wuding Zhou</p>	 <p>Zichuan County</p>	
Ellipse	 <p>Liling County</p>	 <p>Liuyang</p>	 <p>Zhanghua Coun</p>	 <p>Xingning, Guangxi Zhuang Autonomous Region</p>	
Circle	 <p>Yingcheng County</p>	 <p>Tongcheng County</p>	 <p>Yiyang</p>	 <p>Jiashan County</p>	 <p>Yunmeng County</p>
Irregular	 <p>Jianou County</p>	 <p>Puan Ting</p>	 <p>Zhenhai County</p>	 <p>Quanzhou</p>	 <p>Xiangcheng</p>

Figure 2

Examples for spatial layouts of traditional settlements (Liu PL, 2011)



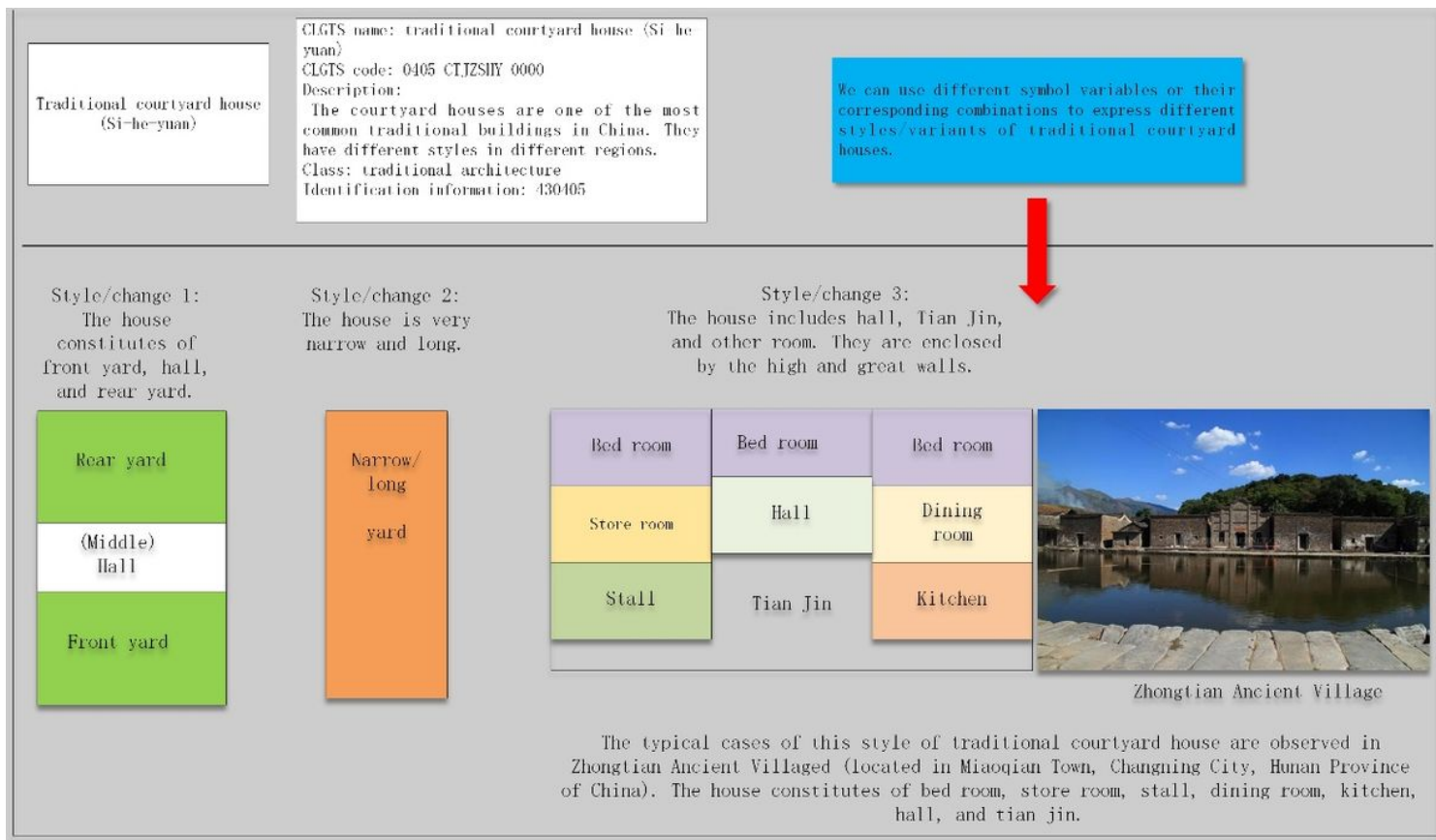


Figure 3

### CLGTS expression of traditional courtyard and its development by different variables

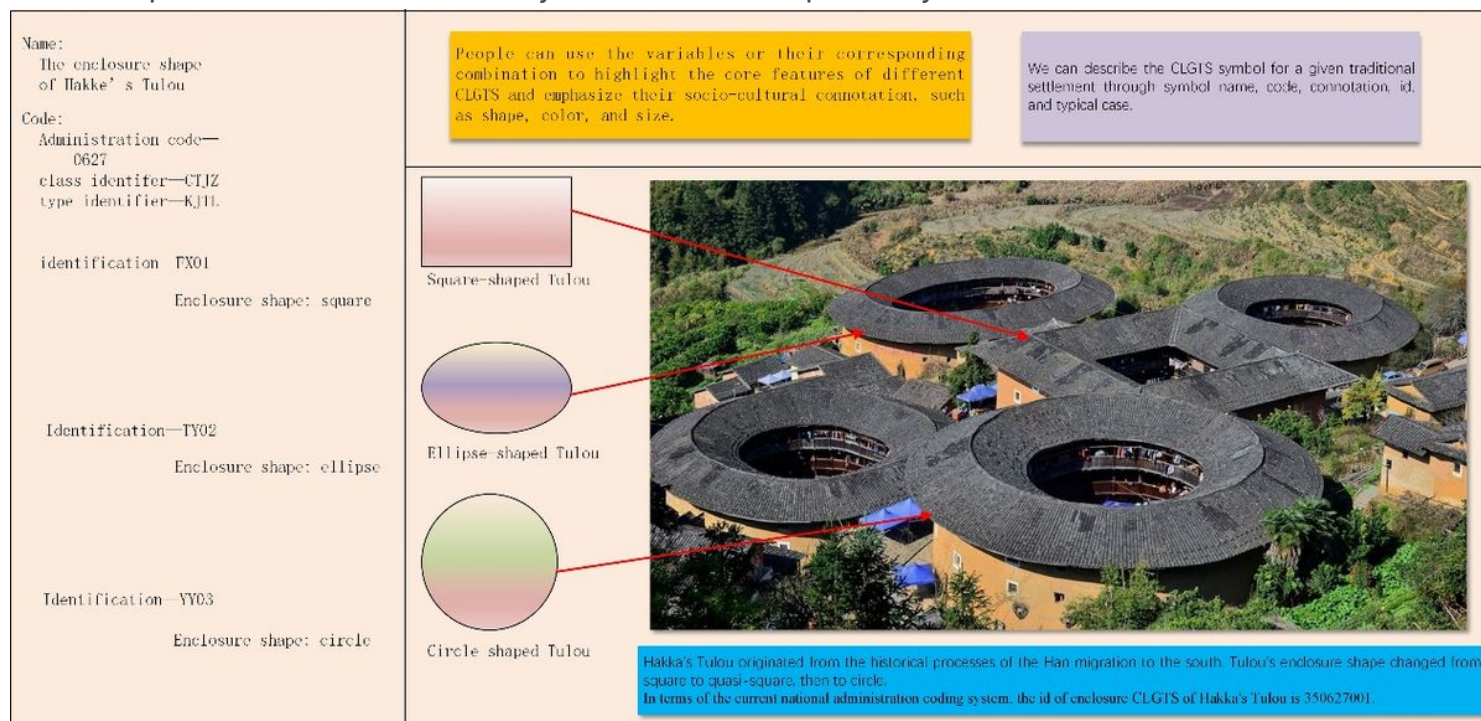


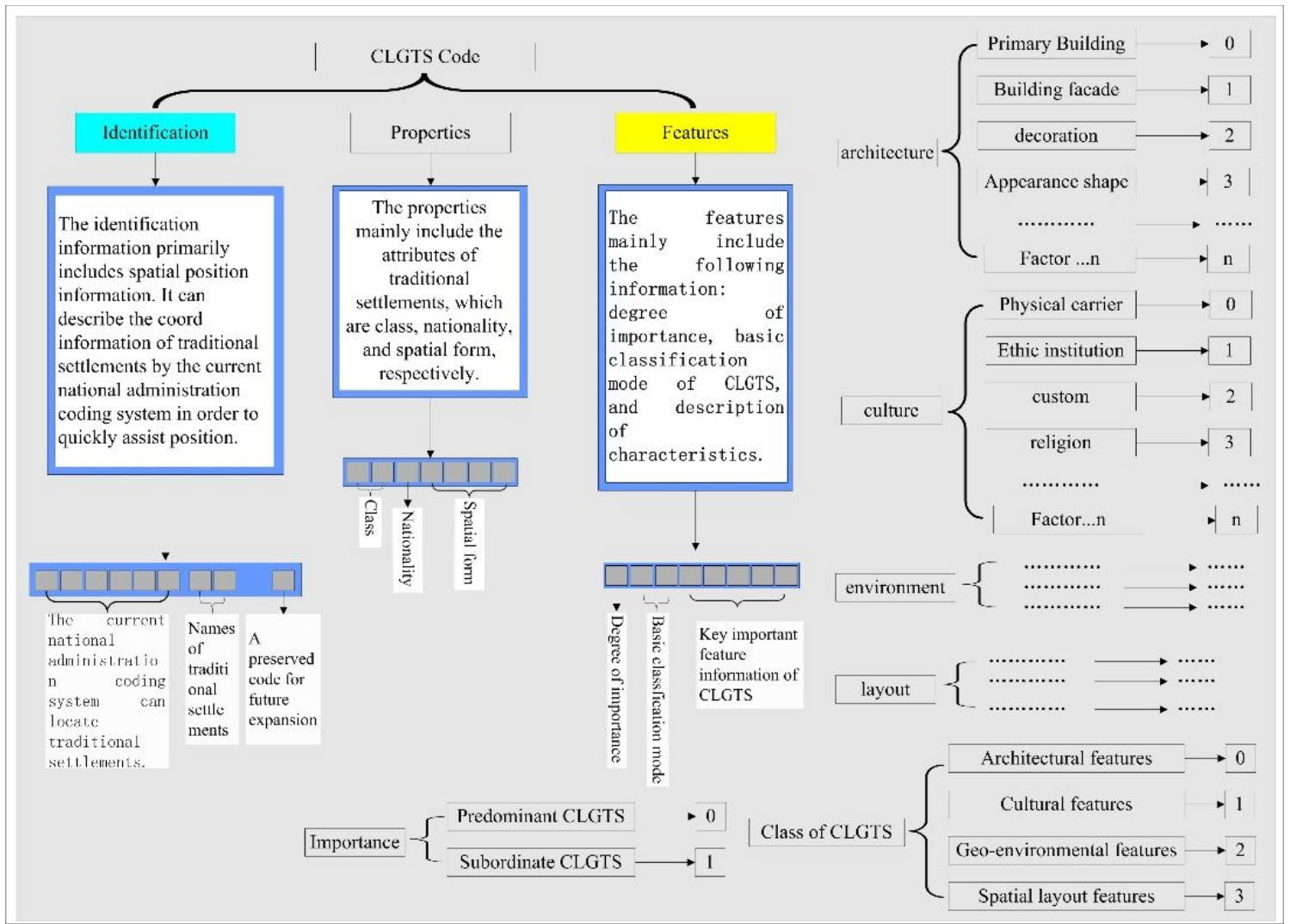
Figure 4

Design of CLGTS symbols for different Tulou's enclosure: This example includes square, elliptical, and circular enclosure shaped spatial forms of Tulou in Nanjin county of Fujian Province.



Figure 5

The prototype system of TLGSD. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.



**Figure 6**

CLGTS coding system: The coding system includes identification, properties, and features. Identification highlights the positioning information of CLGTS according to national administrative codes. Properties describe the key attributes of traditional settlements, such as classifications, nationalities, and spatial forms. Features detail the information of degree of importance, CLGTS' taxonomy, architectures, cultures, geo-environments, and layouts.



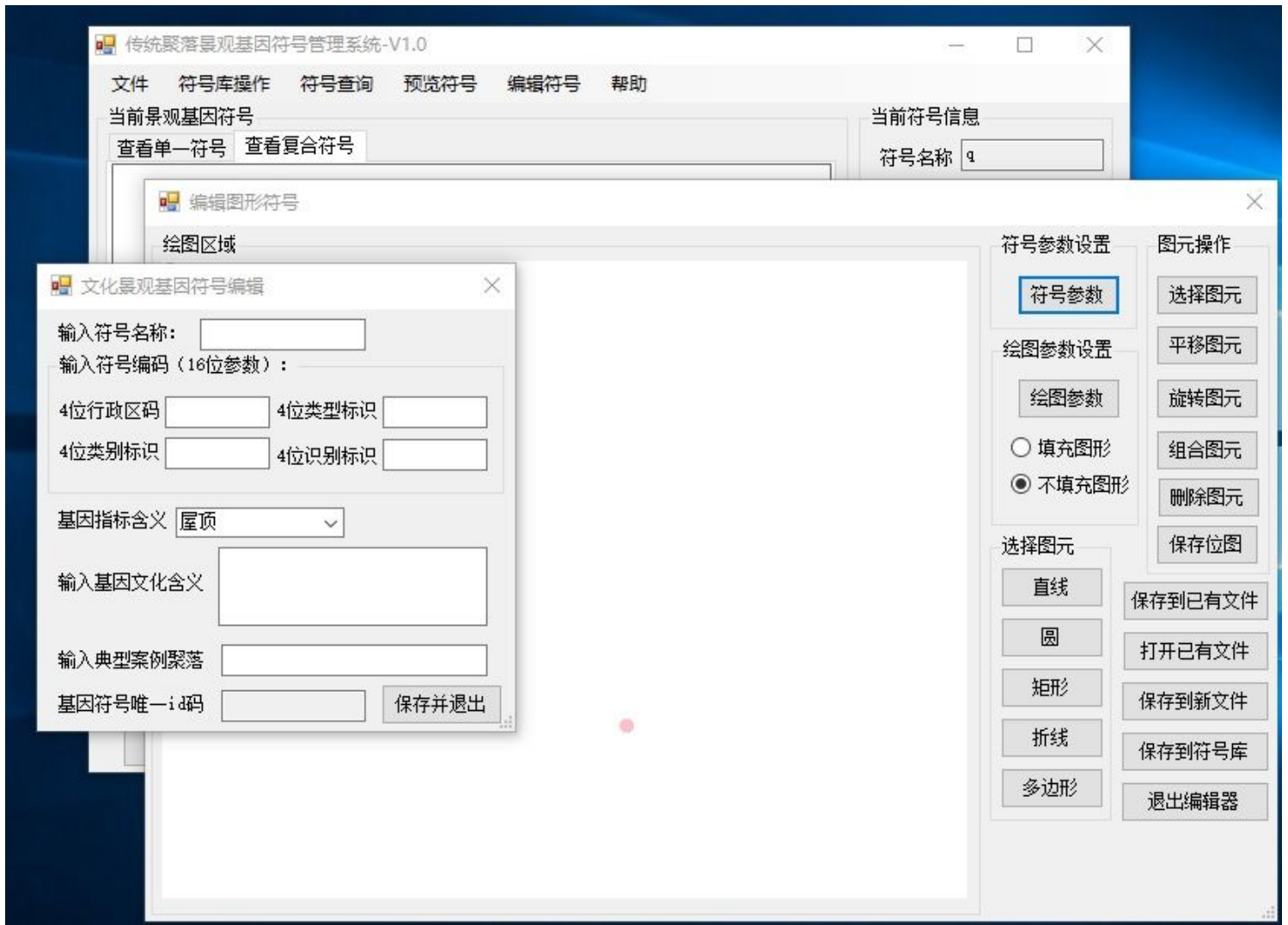
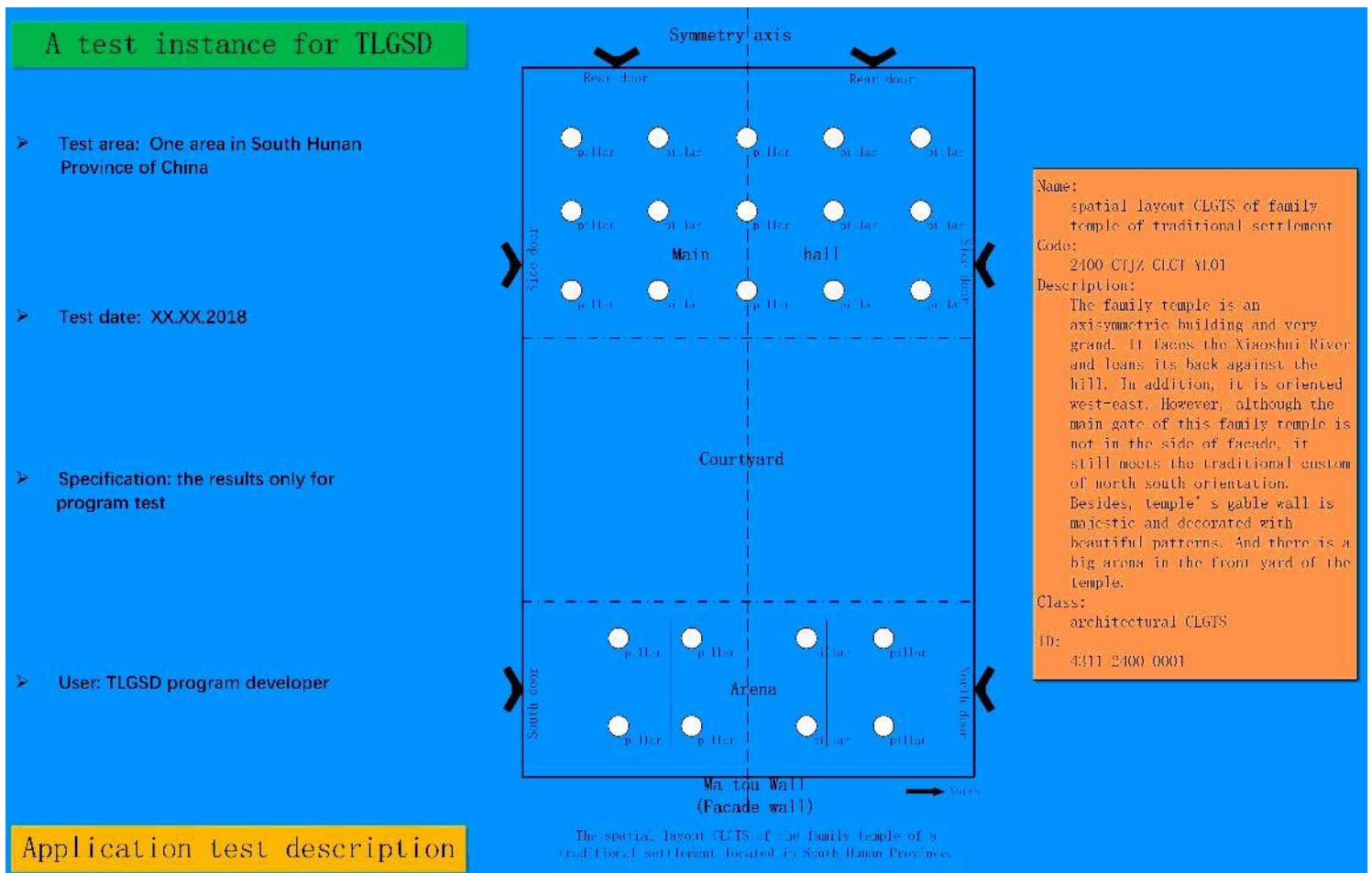


Figure 7

CLGTS symbol edit functions in TLGSD



**Figure 8**

An instance of CLGTS symbols: This instance of CLGTS symbols describes the main features of a family temple in an ancient village of one county located in Southern Hunan Province. This family temple is famous for its grand and majestic building with an apparent symmetrical axis. The entire building of family temple is oriented east to west, which is clearly different from the general Chinese family temples oriented north to south. Note that the main gate of this family temple is opened to south direction in order to keep in line with the Chinese traditional customs.