RESEARCH

Spatial patterns, causes and characteristics of the cultural landscape of the Road of Tang Poetry based on text mining: take the Road of Tang Poetry in Eastern Zhejiang as an example

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Abstract

The Road of Tang Poetry in Eastern Zhejiang is a poetic cultural route linked by Tang poetry which is the pinnacle of ancient Chinese poetry history, and is a cluster of cultural landscapes where nature and humanity blend together under the narrative of Tang poetry. The research has mined and collated the text information of poems, such as trails, persons, places and landscapes, in 1593 poems written by 451 poets of the Tang Dynasty in Eastern Zhejiang, and discerned the overall route of the Road of Tang Poetry in Eastern Zhejiang based on the spatial location of all the text information in GIS. The spatial distribution pattern of the cultural landscape of the Road of Tang Poetry is analyzed and summarized from four levels: natural landscape, Buddhist and Taoist cultural landscape, celebrity cultural landscape and folk cultural landscape. The complex social network relationship between "poet-person" and "poet-landscape" is shown through the Gephi tools. The four causes and two characteristics of the Road of Tang poetry in Eastern Zhejiang are explained from the perspective of the logic of mathematical statistics.

Keywords: The Road of Tang Poetry, Cultural landscape, Spatial pattern, Causes of formation, Characteristics, Text mining

Introduction

In addition to the Silk Road, the Ancient Tea Horse Road and the Long March of the Red Army, which are cultural routes of trade, transport and thematic events, Chinese civilization with a long history has also produced a special type of cultural route that uses poetry as a link, of which the Road of Tang Poetry in eastern Zhejiang is a typical representative. The Road of Tang Poetry in eastern Zhejiang is based on the water and land transport trails of Tang poets along the western section of the East Zhejiang Canal, the Cao'e River and the Shanxi River, forming a unique whole in the area of one lake (Jinghu Lake), two basins (Shanzhong Basin and Wozhou Basin) and three mountain chains (Kuiji Mountain chain, Siming Mountain chain and Tiantai Mountain chain) in eastern Zhejiang, with poetry as the link between the rich and diverse natural and human resources [1]. 451 poets from the Tang dynasty have visited eastern Zhejiang in succession, accounting for one-fifth of the total number of poets included in *The Complete Tang Poems* , leaving behind 1593 poems. Among them, there are 173 individuals who are included in *The Biography of Tang talents*, accounting for 62% of the total number of Tang talents [2]. This unique cultural phenomenon has made the Road of Tang Poetry in eastern Zhejiang a road of

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Landscape tourism and residence, poetry creation, the spread of ideas and cultural integration, and the area covered by the road has become the birthplace of Chinese pastoral landscape poetry, the centre of the Chineseization of Buddhism, the birthplace of Taoist culture, the holy land of Chinese calligraphy and the gathering place of literati culture, and is of great importance in Chinese cultural history [3–5].

In October 2019, the Government of Zhejiang Province issued the "Notice on Printing and Distributing the Development Plan of the Poetry Road Cultural Belt in Zhejiang Province", proposing that "string culture with poetry " and "string belts with roads " to construct the "four poetry roads", which includes the Road of Tang Poetry in Eastern Zhejiang,the Grand Canal Poetry Road, the Qiantang River Poetry Road, and the Oujiang Landscape Poetry Road [6]. In April 2020, the "Notice on Printing and Distributing the Three-Year Action Plan for the Construction of the Road of Tang Poetry in Eastern Zhejiang (2020–2022)" was released, and took the lead in launching and building the cultural belt of the Road of Tang Poetry in Eastern Zhejiang [7]. This makes the research on the Road of Tang poetry in Eastern Zhejiang an important and urgent practical need.

At present, the research on cultural routes worldwild mostly focuses on concept identification [8], charter interpretation [9], value identification [10, 11], heritage protection and development strategies [12–14], and community renewal based on the concept of cultural routes [15], industrial heritage development [16], rural landscape construction [17], regional rural revitalization and old city renewal [18, 19] and tourism development [20, 21]. Since Zhu Yuebing first proposed the concept of "the Road of Tang Poetry" in the 1980s and 1990s [1], scholars have continued to study it from various perspectives such as Literature, Sociology, History, and Geography. It mainly focuses on the causes and historical evolution [22–24], the textual research of specific people and places [25, 26], feature identification and value interpretation [27], protection and activation strategies [28–30] and so on. However, the basic research based on the information mining of poetry texts and the analysis of the characteristics of related cultural landscape resources is still relatively lacking, and it is difficult to provide effective support for the construction of cultural routes linked by poetry such as the Road of Tang Poetry in Eastern Zhejiang. This paper summarizes the spatial distribution characteristics of the cultural landscape of the poetry road and the poets' social network relationship of "person-place-landscape" based on the text information of1593 poems of 451 poets of the Tang Dynasty, and explains the causes and characteristics of the Road of Tang Poetry in Eastern Zhejiang with

quantitative data. This not only has important theoretical significance and application value for the construction of the cultural belt of the Road of Tang Poetry in Eastern Zhejiang, but also has reference significance for the research and construction of many poetic cultural routes bred by the Chinese culture with a long history.

Research objects, research ideas and research methods
Research objects

(1) Tang poetry: Poetic data comes from *The Road of Tang Poetry: The Collection of Tang Poetry* by Mr. Zhu Yuebing, a pioneer in the study of the Road of Tang Poetry in Eastern Zhejiang, which contains a total of 1593 poems written by 451 poets of the Tang Dynasty in the Eastern Zhejiang region [31].

(2) Trails of poets:The data on the trails of poets are taken from the book by Mr Zhu Yuebing, *The Road of Tang Poetry: A Study of the Trails of Poets in the Tang Dynasty* [32], which contains the text information of trails of 451 poets from Eastern Zhejiang in three parts. According to the level of detail of the poets' trails recorded in the book, a total of 70 poets have been selected for analysis.

(3) The Eastern Zhejiang region: It is a geospatial region comprising four Chinese prefecture-level cities (namely Shaoxing, Ningbo, Zhoushan and Taizhou), and 29 districts and counties.

Research ideas

(1) Extraction and collation of poetry text information: (a) Take pictures of the entire paper book of *The Road of Tang Poetry: The Collection of Tang Poetry*, and then import the pictures into the OCR tool (CS CamScanner software) for text recognition, and finally vectorize all the texts of the 1593 Tang poems in *The Road of Tang Poetry: The Collection of Tang Poetry*. And carry out comprehensive manual inspection and error correction to ensure the accuracy of the information of each ancient poem; (b) Select key text information such as "places of writing", "places of description", "name of person" and "name of landscape" from the title and content of each ancient poem by manual interpretation; (c) During the process of collation,constantly classify and summarize the words themselves and words with "polysemy" or many words that mean the same thing, and establish a lexical meaning information database of ancient poems; (d) Continuous manual training and correction of the lexical meaning infor-

mation database of ancient poems to ensure that all the text information of ancient poems selected from the titles and contents can represent specific objects; (e) Finally, the text information extracted from all ancient poems is classified according to "person-place-landscape". Among them, "person" is divided into two parts: "the person who wrote the poem" and "the person mentioned in the poem"; the "place"is composed of "writing place" and "description place"; "landscape" includes six parts: famous mountains , rivers and lakes, administrative zones, Buddhist temples and Taoist temples, residences of celebrities, and folk culture.

(2) Identification of the Road of Tang Poetry in Eastern Zhejiang based on poets' trails: (a) Based on the water and land transportation network of the Tang Dynasty in *the History of Ancient Road Transport in Zhejiang* [33]. All the trails of 70 poets in *The Road of Tang Poetry: A Study of the Trails of Poets in the Tang Dynasty* are spatially located in the GIS, and the overall route of the Road of Tang Poetry in Eastern Zhejiang is identified. (b) According to the number of poets' trails on each section of the route, the trails are divided into different levels for visualization, and thus the main and branch lines of the Road of Tang Poetry in Eastern Zhejiang are identified.

(3) Spatial distribution pattern of the cultural landscape of the poetry road based on poetry text information: (a) Spatially locate the text information of poetry such as "place" and "landscape" in the GIS. (b) Using the nearest neighbor index method and the kernel density estimation method, the spatial distribution pattern of the cultural landscape of the Poetry Road was analyzed and summarized in five aspects, including the places depicted in ancient poems, the natural landscape, the Buddhist and Taoist cultural landscape, the celebrity cultural landscape and the folk cultural landscape.

(4) Social network relationship of poets based on poetry text information: (a) Visualize poetry text information such as "poet", "the person mentioned in the poem"and "landscape" in Gephi tools, and build "poet-person mentioned in the poem" and "poet-landscape" social network relationship. (b) The network characteristics are analyzed from the two aspects of the overall network structure and the node importance.

(5) Combined with the conclusions of the mathematical analysis of the spatial distribution pattern of cultural landscapes and the poet's social network relationship, explain the causes and characteristics of the Road of Tang poetry in Eastern Zhejiang.

Research methods

The study adopts the nearest neighbor index method and the kernel density estimation method, and uses GIS tools to analyze the spatial distribution pattern of the cultural landscape of the Road of Tang Poetry; using the social network analysis method, the "poet-person mentioned in the poem" and "people-place-landscape" social network relationships are analyzed and visualized by the Gephi tools.

The nearest neighbor index method

The spatial distribution types of point-like elements can be divided into three types: aggregated, random and uniform. The nearest neighbor index can reflect the spatial distribution of point-like elements. The calculation formula for the nearest neighbor index is:

$$R = \frac{\bar{r}_1}{\bar{r}_e} \tag{1}$$

In formula (1): $\bar{r}_1$ is the actual nearest neighbor distance, $\bar{r}_1 = \frac{1}{n}\sum_{i=1}^{n} r_i$; $\bar{r}_e$ is the theoretical nearest neighbor distance, $\bar{r}_e = \frac{1}{2\sqrt{\frac{n}{A}}}$; R is the nearest neighbor index; n is the number of points within the study area; A is the area of the study area. When $R < 1$, it means that the study object tends to be aggregated distribution, when $R > 1$, it means that the study object tends to be uniformly distributed, and when $R = 1$, it means that the study object tends to be randomly distributed.

The kernel density estimation method

The kernel density estimation method provides a clear representation of the spatial distribution of geographical elements and their aggregation characteristics. The calculation formula is:

$$f_n(x) = \frac{1}{nh} \sum_{i=1}^{n} k\left(\frac{x - X_i}{h}\right) \tag{2}$$

In formula (2): f is the kernel density; h is the search radius (bandwidth), and $h > 0$; $k(\ )$ is called the kernel function; n is the number of known points within the bandwidth, that is, the number of study samples; $x - X_i$ indicates the distance from the estimated point x to the sample point X_i. The larger value of $f_n(x)$ indicates that the geographic elements are more aggregated.

Social network analysis method

A social network is a collection of social action subjects and their relationships. The social network mode can be seen as a diagram describing a social network, consisting of "points" and "lines", where the points refer to the

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Table 1 Description and significance of network structure indicators

Level	Characteristics indicators	Formula	Note	Indicator meaning
Overall level	Degree Central Potential	$C = \frac{\sum_{i=1}^{n}(C_{ADmax} - C_{ADi})}{n^2 - 3n + 2}$	C_{ADi}: the absolute centrality of point i; C_{ADmax}: the maximum absolute centrality of the points in the graph; n: Number of points in the graph	This reflects the overall balance of the network and portrays the overall centrality of the network. The higher the value, the more unbalanced the network is, and the more likely there is a "core-edge" network structure.
–	Average Degree	$\bar{k} = \frac{1}{V}\sum_{v \in V} k_v$	V the number of nodes in the network k_v the degree value of the vth node in the network	This reflects the overall connection intensity of the network.
–	Graph Density	$D = \frac{2E}{V(V-1)}$	E the number of edges in the network V the number of nodes in the network	This reflects the connection intensity of each node in the network. The higher the value, the stronger the connection between nodes.
Individual level	Degree	k_v	the number of edges connected to the node v	This reflects the number of other nodes connected to the node, the important node is the node with many connections.
–	Intensity	$s_v = \sum_{u \in V} W_{vu}$	W_{vu} the weight value from node v to node u	This reflects the level of participation of a node in the network, and is a true representation of the connection intensity of a node with other nodes.

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action subjects in the real society, and the lines refer to the mutual relationships or roles between social subjects [34]. In this study, indicators such as average degree, graph density, and degree central potential are selected at the overall level to reflect the overall structure of the network; at the individual level, indicators such as degree and intensity are selected to reflect the node importance, the specific index meanings and calculation formulas are shown in Table 1. In terms of network layout, the Fruchterman Reingold layout method is selected, which is suitable for most network data sets. The aim is to reduce the intersection of edges in the layout and to keep the length of the edges as consistent as possible, achieving a better symmetry and local aggregation with a more aesthetic effect.

Research results

Identification of the Road of Tang Poetry in Eastern Zhejiang based on text information about the poet's trails

The hierarchical visual analysis of the data from 70 poets' trails shows that: The Road of Tang Poetry in Eastern Zhejiang is divided into three routes. The first begins in Xiaoshan District, Hangzhou, and follows the East Zhejiang Canal westwards to Shaoxing, then go upstream the Cao'e River and the Shanxi River in Shangyu, through Shengzhou and Xinchang to Tiantai, and finally southwards along the Shifeng River to Linhai. Generally, there is a water transport link of approximately 200 km in length between the western section of the East Zhejiang Canal, the Cao'e River, the Shanxi River and the Shifeng River; the second route runs from Shangyu along the East Zhejiang Canal eastwards through Yuyao to Ningbo and then northeastwards across the East China Sea to the Zhoushan Islands; the third route runs from Linhai westwards to Xianju and southwards along the Jiaojiang River to Taizhou, Huangyan and Wenling, with a total length of about 800 km.

The "Xiaoshan-Shaoxing-Shangyu-Shengzhou-Xinchang-Tiantai" route is the main line of the Tang poets' trails, with the largest number of poets travelling along it. The "Shangyu-Ningbo" and "Tiantai-Linhai" routes are the two branch lines of the Tang poets' trails, with fewer poets travelling on them (Fig. 1).

Spatial distribution pattern of the cultural landscape of the poetry road based on poetry text information

Places depicted in ancient poems

The 1593 poems involve a total of 79 places depicted in ancient poems, which are classified into four categories, including natural landscapes, residences of celebrities, Buddhist temples and Taoist temples, and administrative zones. The nearest neighbor index analysis of the places depicted in ancient poems shows that the actual nearest

distance $\bar{r}_1$ is 7.5 km, the theoretical nearest distance $\bar{r}_e$ is 12.8 km, and the nearest neighbor index R is $0.58 < 1$, indicating that the spatial distribution type of the places depicted in ancient poems is aggregation type. The kernel density analysis for it shows that: the places depicted in ancient poems have formed four aggregation groups. The "Xiaoshan-Shaoxing-Shangyu" and "Shengzhou-Xinchang-Tiantai" groups have a high kernel density, and the "Linhai-Xianju-Huangyan" and "Ningbo-Zhoushan" groups have a low kernel density (Fig. 2).

Natural landscape

The 1593 poems involve a total of 47 natural landscapes, of which 36 are related to mountains and 11 to water landscape, such as Mount Tiantai, Mount Wozhou, Mount Wanwei, Jinghu Lake, Ruoye River and Shanxi River. The nearest neighbor index analysis shows that the actual nearest proximity distance $\bar{r}_1$ is 11.2 km, the theoretical nearest proximity distance $\bar{r}_e$ is 16.1 km, and the nearest neighbor index R is $0.7 < 1$, indicating that the spatial distribution type of natural landscape is aggregation type. The kernel density analysis of the natural landscape shows that the "Xiaoshan-Shaoxing-Shangyu" group and the "Shengzhou-Xinchang-Tiantai" group are the main aggregation centres. In the "Xiaoshan-Shaoxing-Shangyu" group: Mount Kuiji, Mount Yunmen, Mount Qinwang, Mount Wanwei, Jinghu Lake, Ruoye River and other mountain and water landscapes are aggregated. In the "Shengzhou-Xinchang-Tiantai" group: Mount Tiantai, Mount Tianmu, Mount Tongbai, Mount Chicheng, Shanxi River and Dongxi River and other mountains and water landscapes are aggregated (Fig. 3).

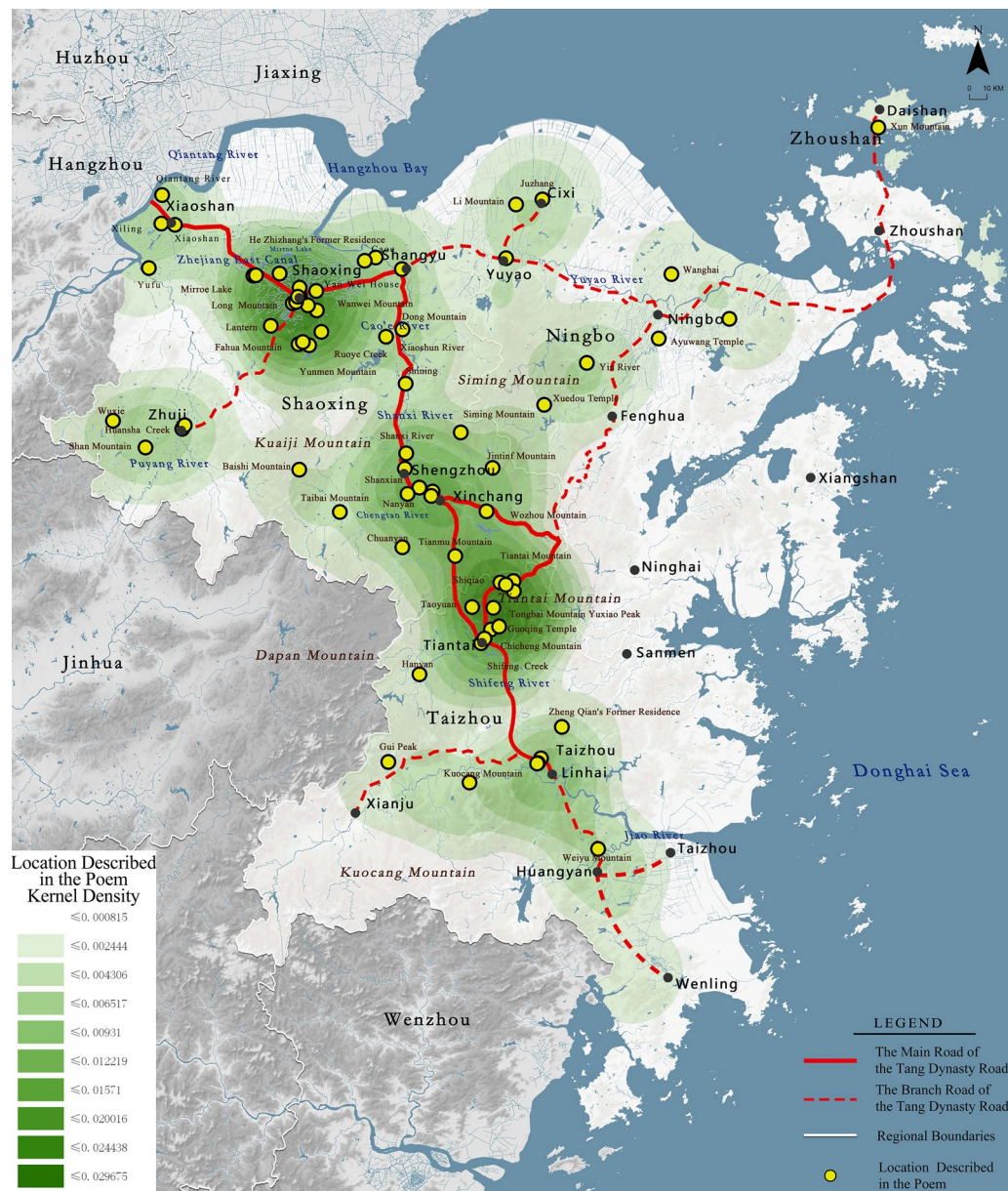#### Buddhist and Taoist cultural landscape

There are 72 Buddhist temples recorded in the 1593 poems , such as Xinchang Buddha Temple, Yunmen Temple, Fahua Temple, Huading Temple and Guoqing Temple. There is 1 Taoist temple, it is Tongbai Temple. There are 14 Cave Paradise in total, of which 3 are large Cave Paradise, namely, the Yu Cave Heaven, the Chi Cheng Cave Heaven and the Jucang Cave Heaven; 4 are small Cave Paradise, namely, the Siming Mountain There are four small Caves, namely Siming Cave Heaven, Kuiji Cave Heaven, Gaijushan Cave Heaven and Jinting Cave Heaven, and seven Paradise, namely Dongxiangyuan, Xixiangyuan, Lingxu, Wozhou, Tianmu Cen, Ruoye Xi and Si Ma Hui Mountain. The nearest proximity index analysis of the Buddhist and Taoist cultural landscape shows that the actual nearest proximity distance $\bar{r}_1$ is 9.2 km and the theoretical nearest proximity distance $\bar{r}_e$ is 15.6 km, with a nearest proximity index R of $0.6 < 1$, indicating that the spatial distribution of the cultural landscape is of the

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Fig. 1 Map of the number of poets' trails

aggregation type. A kernel density analysis shows that three groups of Buddhist and Taoist cultural sites are formed along the Road of Tang Poetry, the first being the 'Xiaoshan-Shaoxing-Shangyu' group at the beginning of the main line, the second being the 'Shengzhou-Xinchang-Tiantai' group at the end of the main line, and the third being the 'Linhai-Xianju-Huangyan' group along the Taizhou branch line. In the "Xiaoshan-Shaoxing-Shangyu" group, Yunmen Temple, Fahua Temple, Chenxin Temple, Wozhou Blessed Place, Kuijishan Cave Heaven, and other Buddhist temples and Taoist temples are aggregated. In the "Shengzhou-Xinchang-Tiantai" group: Guoqing Temple, Xinchang Dafo Temple, Huading Temple, Tongbai Temple, Jintingshan Cave Heaven, Chicheng Cave Heaven, and other Buddhist temples and Taoist temples are aggregated. In the "Linhai-Xianju-Huangyan" group, Lingshan Temple, Longxing Temple, Gaizhu Cave Heaven, Cang Cave Heaven, Dongxiangyuan Blessed Place, and

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Fig. 2 Spatial distribution and kernel density analysis map of ancient poetry described

other Buddhist temples and Taoist temples are aggregated (Fig. 4).

Celebrity cultural landscape

The 1593 poems involve four residences of celebrities, they are Lanting (Wang Xizhi's house), He Zhizhang's house, Zheng Qian's house and Yan Wei's house; and there are nine places where famous allusions and legends took place, These allusions and legends are: Ma Zhen building a lake, visiting Dai in the snowy night, elegant meeting at Lanting, staging a comeback, fishing

for turtles at Nan Yan, Queen Mother of Heaven, eighteen famous scholars, eighteen eminent monks, Liu Ruan encountering immortals, and Sima regretting on the mountain. The residences of celebrities and legends and allusions basically are distributed along the main line of the Road of Tang Poetry, and most are in the vicinity of Shaoxing and Tiantai (Fig. 5).

Folk cultural landscape

The 1593 poems have mentioned seven kinds of specialties, such as the perch and Brasenia of Eastern Zhejiang, the
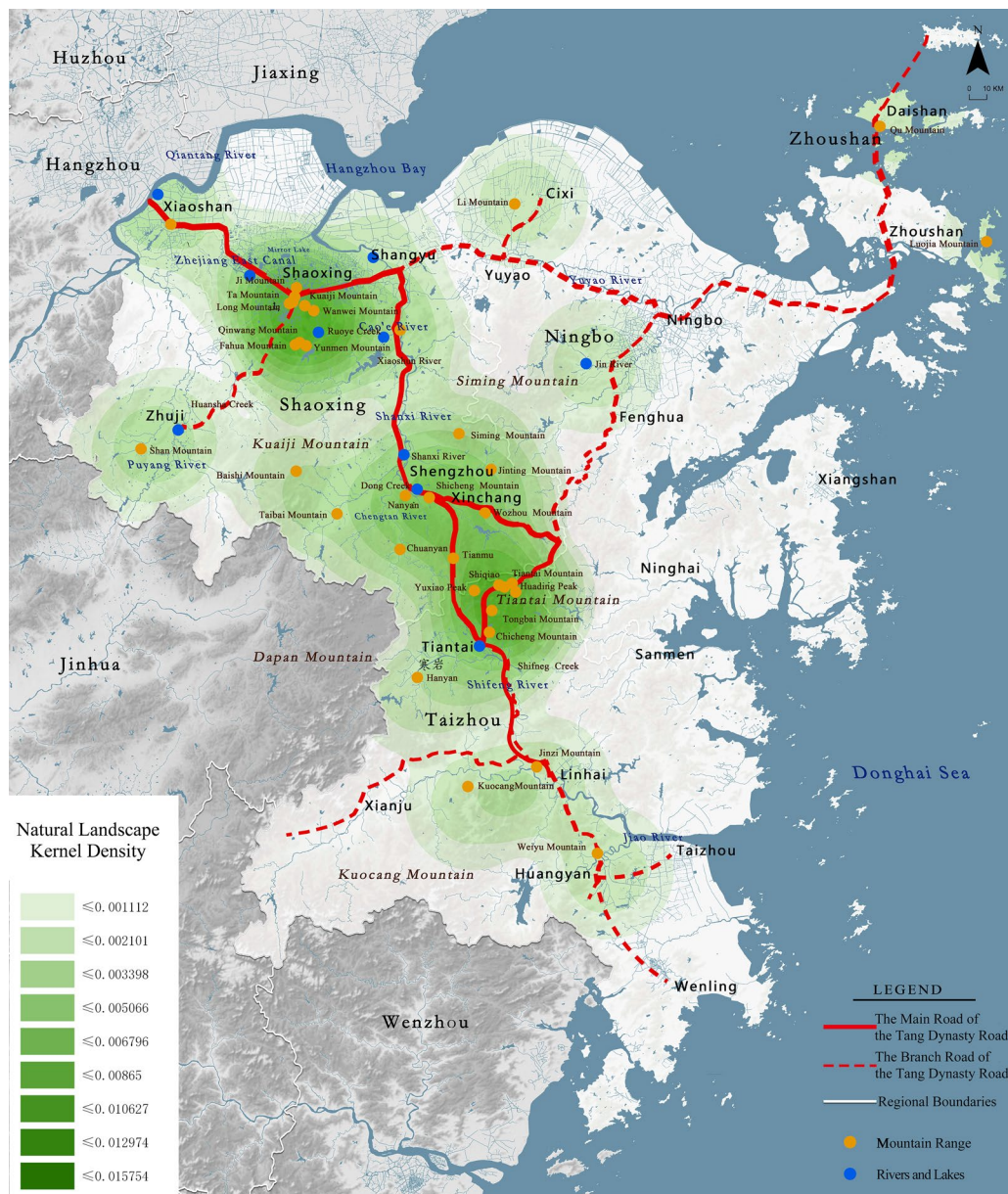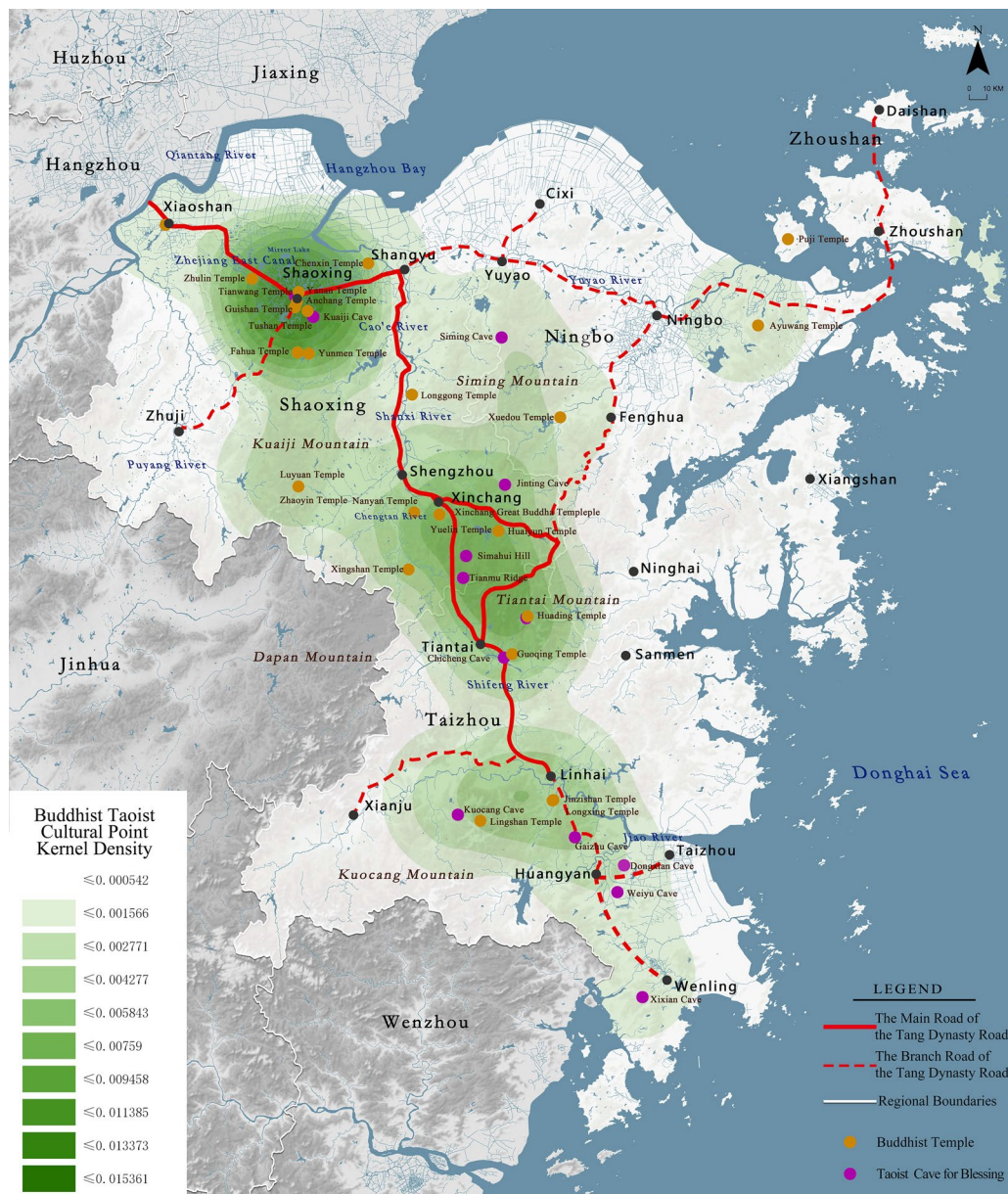
Fig. 3 Spatial distribution and kernel density analysis map of natural landscape

Shan paper and wine of Shaoxing, the famous tea of Eastern Zhejiang from the Shanxi River and the Mount Tiantai, the various kinds of valuable medicinal herbs produced in the Mount Tiantai, and the rattan of Yuezhong, the Huading Rattan, which was preferred by the literati. The spatial distribution of these folk cultural resources is shown in Fig. 6, with most of them distributed in the cities along the main line of the Road of Tang Poetry and the branch line of Mingzhou.

Analysis of poets' social network based on poetry text information

The "poet-person" social network

The "poet-person" social network refers to the network relationship formed between "poet-poet" and "poet-person mentioned in the poem". According to statistics, this network contains 948 nodes and an undirected network of 1072 edges. The stable network obtained after running based on the Fruchterman Reingold layout is shown

Fig. 4 Spatial distribution and kernel density analysis map of buddhist and taoist cultural landscape

in Fig. 7. The characters in the figure can be divided into three parts according to their dynasties: "Ancient Times–Han Dynasty (before 220 A.D)", " Wei Dynasty–Sui Dynasty (220 A.D-618 A.D)",and "Tang Dynasty (618 A.D-907 A.D)".

From the overall network structure, the average degree of the network is 2.068, which is much smaller than the number of nodes (948), and the graph density is 0.002. It can be seen that the network as a whole is a sparse, unbalanced, and low-density network. The degree of closeness of the nodes is low, and most of the nodes are

weak connections; the central potential of the degree is 0.05, indicating that the network has a tendency to concentrate in certain locations, and there is a "core-edge" structural feature.

From the results of degree and intensity, only 12.44% of the nodes have a degree greater than the average degree, indicating that there are a few nodes with multiple co-occurrence connections in the network. Fang Gan, Li Bai, Bai Juyi, Du Fu, Liu Changqing and others are ranked in the top five in terms of degree value and intensity value, and they belong to the core figures in the poet network
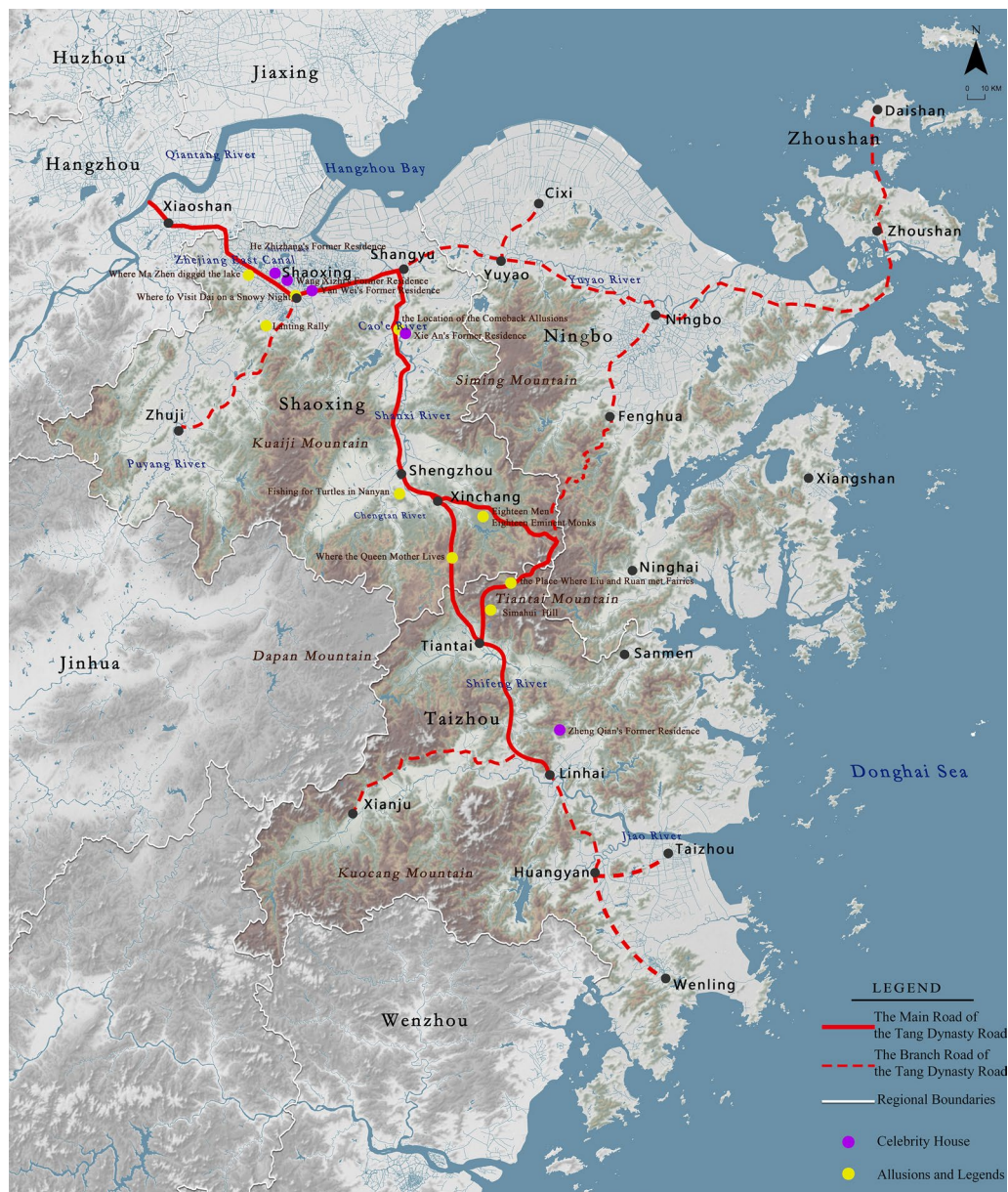
Fig. 5 Spatial distribution map of celebrity cultural landscape

of the Road of Tang Poetry. 63 poets have mentioned 31 contemporary poets , involving 113 poems; 175 poets have mentioned 570 contemporary "the person mentioned in the poem", involving 670 poems. This forms the first circle in the Fig. 7, which is closely related.

56 poets of Tang Dynasty have mentioned 64 "the person mentioned in the poem" in the ancient poems of " Wei Dynasty– Sui Dynasty", including Xie An (13 poems), Wang Xizhi (10 poems), Xie Lingyun (10 poems), Zhi Dun (8 poems), Zi You (3 poems) and they are in the top five in degree value and intensity value, forming the second circle that is closely related to the first circle in the Fig. 7; 60 poets of Tang Dynasty have mentioned 105 "person mentioned in the poem" from "Ancient Times to Han Dynasty", among them Liu Chen (16 poems), Xi Shi (15 poems), Ruan Zhao (15 poems), Gou Jian (8 poems), Fu Chai (4 poems) and they are in the top five in degree value and intensity value, forming the third circle that is closely related to the first circle in the Fig. 7.

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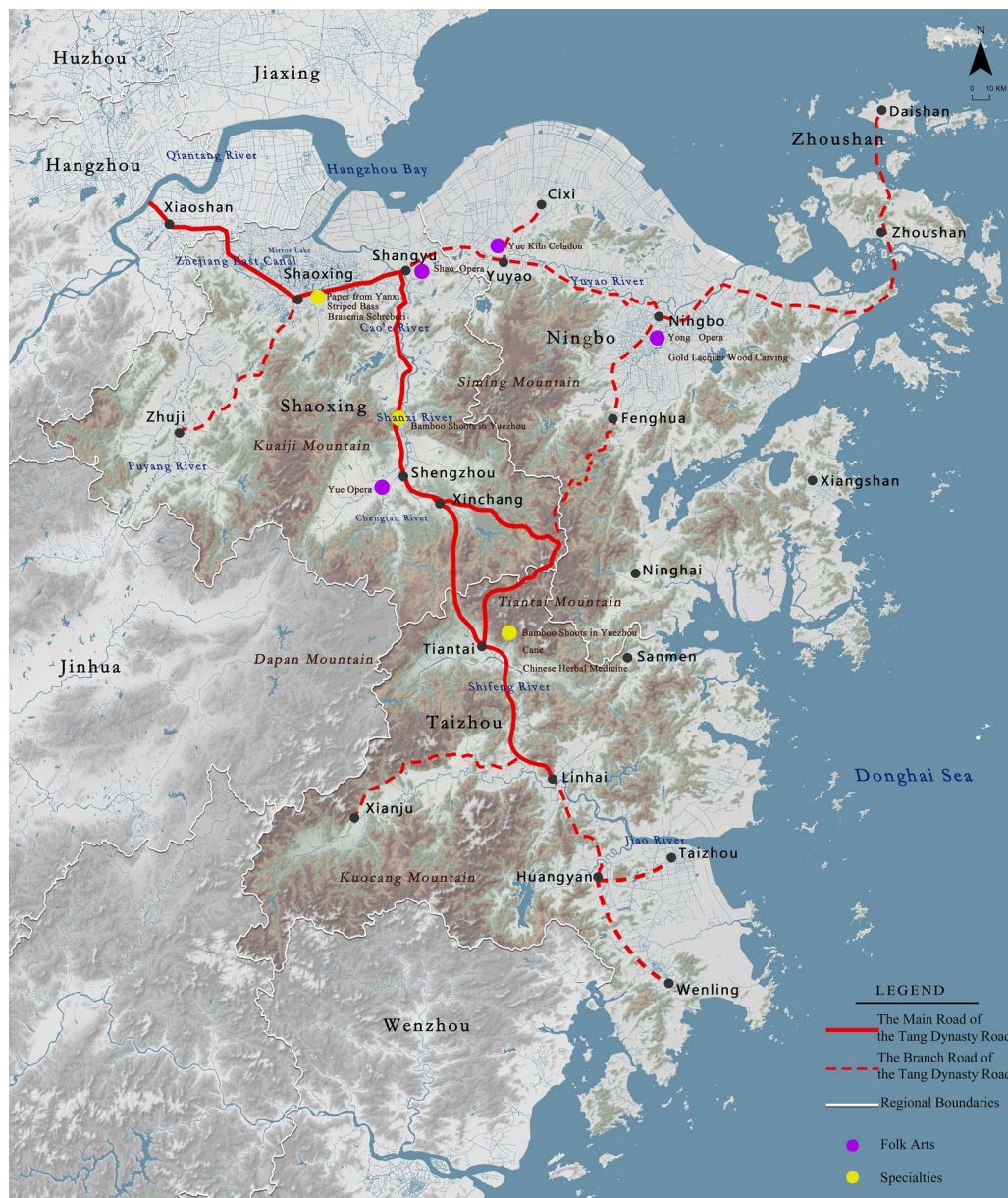
Fig. 6 Spatial distribution map of folk cultural landscape

The "Poet-landscape" social network

The "poet-landscape" social network refers to the network relationship formed between poets and the landscape of famous mountains , rivers and lakes, administrative zones, Buddhist temples and Taoist temples, residences of celebrities, and folk culture described in ancient poems. According to statistics, this network contains 490 nodes and a directed network with 1878 edges. The stable network obtained after running based on the Fruchterman Reingold layout is shown in Fig. 8.
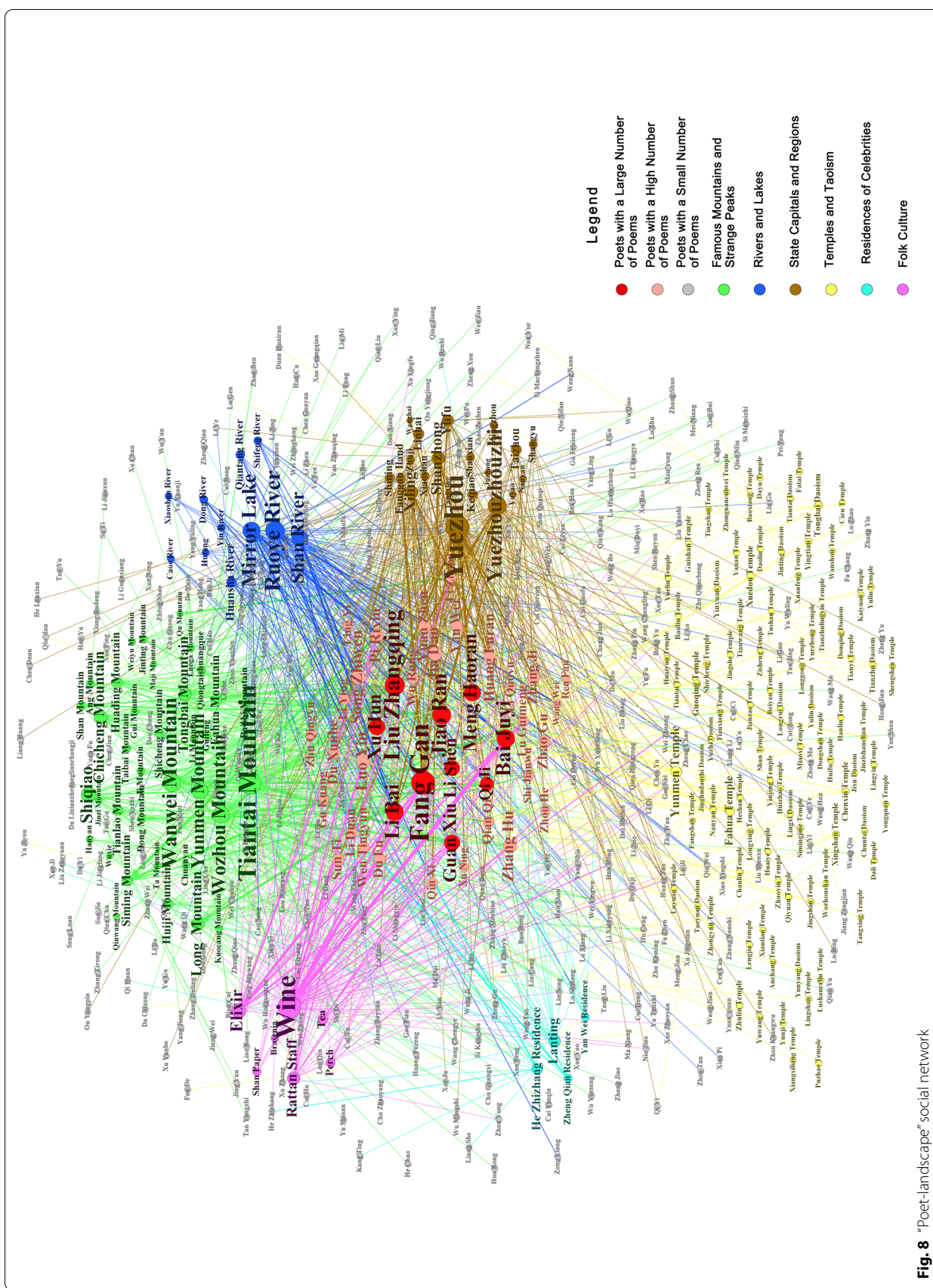
From the overall network structure, the average degree of the network is 2.792, which is much smaller than the number of nodes (490), and the graph density is 0.005. It can be seen that the network as a whole is a sparse, unbalanced, and low-density network. The degree of connection of nodes is low, and most of the nodes are weak connections; the central potential of the degree is 0.13, indicating that the network has a tendency to concentrate in certain locations, and there is a "core-edge" structural feature.
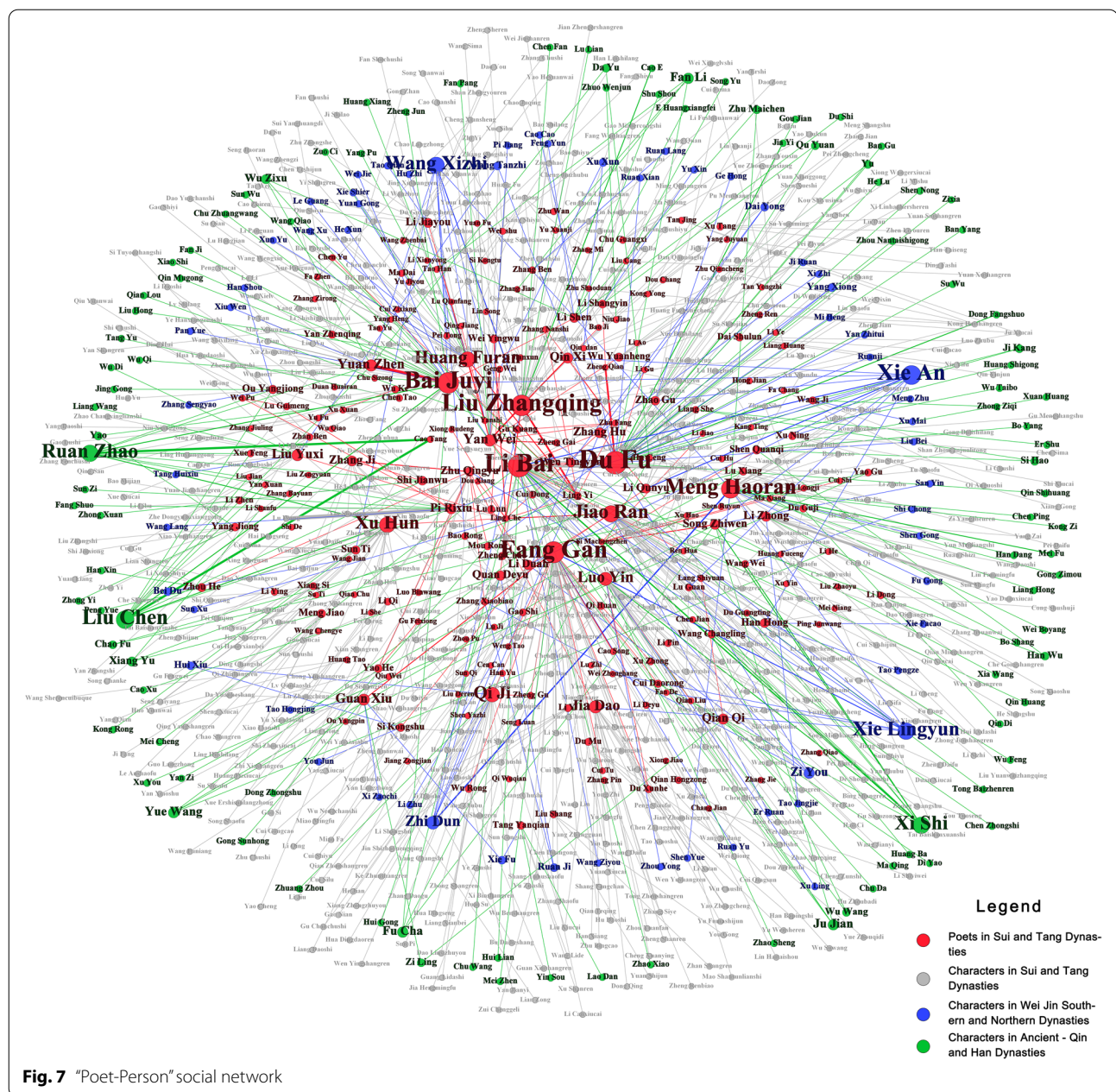
Fig. 7 "Poet-Person" social network

From the results of degree and intensity, 223 poets have described 36 famous mountains, with higher values for places such as Mount Tiantai (87 poems), Mount Wanwei (64 poems) and Mount Wozhou (63 poems). 126 poets have described 11 rivers and lakes, with higher values at Jinghu Lake (66 poems), Ruoye River (64 poems) and Shanxi River (50 poems). 152 poets have described 21 administrative zones, with higher values for Yuezhou (113 poems), Yuezhou Prefecture (71 poems) and Shanzhong (41 poems). 86 poets have described a total of 72 Buddhist temples and 16 Taoist temples, with higher values for Yunmen Temple (23 poems), Fahua Temple (18 poems), Xuedou Temple (8 poems), Tongbai Temple (6 poems), Tianzhu Temple (4 poems) and Guanyin Temple (3 poems). 45 poets have described four residences of celebrities, they are Lanting (22 poems), He Zhizhang's house (21 poems), Zheng Qian's house (12 poems) and Yan Wei's house (8 poems). 104 poets have described seven specialties: wine (123 poems), elixir (55 poems), rattan sticks (29 poems), tea (20 poems), perch (11 poems), Shan paper (8 poems), and Brasenia (6 poems).

Fig. 8 "Poet-landscape" social network

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Differentiation and analysis of the causes and characteristics of the Road of Tang Poetry in Eastern Zhejiang based on mathematical analysis
The causes of formation of the Road of Tang Poetry in Eastern Zhejiang under the logic of mathematical statistics

(1) From the statistics of the relationship between poems and landscapes, it is found that 23 poets have described 36 famous mountains, and 126 poets have described 11 rivers and lakes. And there are more poems on mountain and water landscape such as Mount Tiantai (87 poems), Mount Wozhou (64 poems), Mount Wanwei (63 poems), Jinghu Lake (66 poems), Ruoye River (64 poems) and Shanxi River (50 poems). From the perspective of spatial distribution, the landscape is characterized by the "Xiaoshan-Shaoxing-Shangyu" group and the "Shengzhou-Xinchang-Tiantai" group as the main gathering centers. In the "Xiaoshan-Shaoxing-Shangyu" group, the landscape of Mount Kuiji, Mount Yunmen, Mount Qinwang, Mount Wanwei, Jinghu Lake and Ruoye River are aggregated. In the "Shengzhou-Xinchang-Tiantai" group, the landscape of Mount Tiantai, Mount Tianmu, Mount Tongbai, Mount Chicheng, the Shanxi River and the Dongxi River are aggregated.

The cause of formation of this is that: poets often "use poetry to embellish the scenery, displaying the beautiful landscape and profound history and culture", showing the beauty of the landscape and the profound history and humanity in their poems; at the same time, they "use their poems to express their aspirations", reflecting their emotions, ideals, perceptions and the context of their time in the landscape. In the Southern Dynasty(420–589 A.D), Xie Lingyun adopted the increasingly sophisticated five-line poetic style, creating and forming one of the earliest pastoral landscape poetry school in China. In his poem, *Crossing the Shining Villa*, he has written, "…White clouds surround the distant rocks, and the green tender bamboo looks charming beside the clear waves of water…" And in *Ascending Chi Shang Lou*, he has written, "…The pond is already full of spring grass, and the songbirds on the willows in the garden have changed their species and their voices…" With his delicate brushwork and remote artistic conception, the beauty of his landscapes became famous throughout the world along with his poetry. Throughout the course of a lifetime, Li Bai "…entered Zhejiang four times, entered Shanzhong three times, went to Tiantai twice, and went to Siming once…". In his

poem, he has written, "…The Mount Tianwu seems to be connected to the sky that blocks the sky. It is higher than the Five Mountains and it overshadows Mount Chicheng…" (*Dreaming of a Trip to Tianwu and Staying Behind*). Bai Juyi visited the east of Zhejiang three times in his life, he wrote 42 poems to praise the beauty of the landscape and the humanities in Yuezhong, including "…The dragon chants the ancient stone buildings, the tiger roars the pavilions of the rocks…" (*Staying at Yunmen Temple*),and "…The mountain is a painted screen for the lotus palace, the buildings and terraces are gradually plunged into the sky…" (*Tian Yi Temple in Mount Fahua*). The poems provide an important historical testimony to the beauty of the landscape in eastern Zhejiang.

(2) From the statistics of the relationship between poems and Buddhist temples and Taoist temples, it is found that 86 poets have described a total of 72 Buddhist temples and 16 Taoist temples, with more poems describing Yunmen Temple (23 poems), Fahua Temple (18 poems), Xuedou Temple (8 poems), Tongbai Temple (6 poems), Tianzhu Temple (4 poems), and Guanyin Temple (3 poems). From the perspective of spatial distribution pattern, the Buddhist and Taoist cultural landscapes are characterized by the "Xiaoshan-Shaoxing-Shangyu" group, the "Shengzhou-Xinchang-Tiantai" group and the "Linhai-Xianju-Huangyan" group as the main gathering centers. In the "Xiaoshan-Shaoxing-Shangyu" group, Buddhist temples and Taoist temples such as Yunmen Temple, Fahua Temple, Weixin Temple, Wozhou Blessed Place and Kuijishan Cave Heaven are aggregated. In the "Shengzhou-Xinchang-Tiantai" group, Guoqing Temple, Xinchang Dafo Temple, Huading Temple, Tongbai Temple, Jintingshan Cave Heaven, Chicheng Cave Heaven Heaven, and other Buddhist temples and Taoist temples are aggregated. In the "Linhai-Xianju-Huangyan" group, Buddhist temples and Taoist temples such as Lingshan Temple, Longxing Temple, Gaijushan Cave Heaven, Cangshan Cave Heaven and Dongxiangyuan Blessed Place are aggregated.

The cause of formation of this is that: Taoism has been developed in Yuezhong since the Qin dynasty(221 B.D–207 B.D), and its influence reached a climax in the Tang dynasty, when the generation master Sima Chengzhen emerged and was highly valued by the central government of the Tang dynasty, leading many poets to come to Yuezhong Tiantai. Buddhism flourished in Yuezhong mainly during the" Wei Dynasty– Sui Dynasty",

represented by the founder of the Tiantai sect of Buddhism, eminent monk Zhiyi. Tiantai Buddhism was popular in the intellectual, philosophical and religious circles of the Tang Dynasty. It made all monks and lay people follow the trend [22]. Li Bai wrote "… this time I am away from home, not for the sake of greed, but to visit the famous mountains and rivers, so I go to Shanzhong…" (*Down to Jingmen in Autumn*), The purpose of his trip to Mount Tiantai was to meet Sima Chengzhen and to take a "curved path" to be an official. Meng Haoran wrote, "…I have travelled far to learn the way of longevity…"(*The Lodging in the Tongbai Temple in Tiantai*), this is a poem about going to Mount Tiantai to learn the way of longevity from a Taoist priest and to take food to seek immortality. Jia Dao went to Mount Tiantai because he admired the eminent monk Zhiyi. "…The master grinds and gives a lecture, saying that we should be aligned with the wise traces…"(*Sending a monk back to Tiantai*). The poems fully reflect the important social trend of seeking "immortality, Taoism, Buddhism and seclusion" in the Tang Dynasty.

(3) From the statistics of the relationship between poems and celebrity culture, it is found that 45 poets have described 4 residences of celebrities, including Lanting (Wang Xizhi's house), He Zhizhang's house, Zheng Qian's house and Yan Wei's house. 60 poets have remembered Liu Chen (16 poems), Xi Shi (15 poems), Ruan Zhao (15 poems), Gou Jian (8 poems), Fu Chai (4 poems) and other 105 celebrities in their poems from "Ancient Times to Han dynasty", 56 poets have remembered Xie An (13 poems), Wang Xizhi (10 poems), Xie Lingyun (10 poems), Zhi Dun (8 poems), Zi You (3 poems) and other 64 celebrities in their poems from the" Wei Dynasty– Sui Dynasty". From the perspective of the spatial distribution pattern, the celebrity cultural landscape presents the spatial characteristics of the distribution along the main line of the Road of Tang Poetry.

The cause of formation of this is that the traditions, ethos and cultural lifestyle shaped by the famous literati of the " Wei Dynasty–Sui Dynasty" greatly influenced the poets of the Tang Dynasty, and the veneration and remembrance of their predecessors and sages in this area, as well as the search for the places where their masterpieces were composed, allowed the cultural spirit of the literati of " Wei Dynasty–Sui Dynasty"'s to accumulate and be passed on in the area along the poetry road. Li Bai wrote, "…Mount Tiantai is next to Mount Siming, Mount Huading is higher than Mount Bai-

yue. The gate is marked by the cloud of Mount Chicheng, and the building is perched on the moon of Cangdao…"(*The Dawn View of Tiantai*). This is a response to Sun Chao's Fugue of Tiantai Mountain in the Eastern Jin Dynasty. "…With my feet in Xie Gong's clogs, I climbed the ladder to the green clouds…" (*Dreaming of a Trip to Tianwu and Staying Behind*). It is a tribute to his idol, Xie Lingyun. The poems reflect the stories of Sun Chao's Fugue on Mount Tiantai, Wang Xizhi's Orchid Pavilion, Xie An's staging a comeback, Wang Ziyou's visiting to Dai in the snowy night, Ren Gongzi's fishing trip at Nan Yan, Liu Ruan's encountering with the immortals, Queen Mother of Heaven, the 18 eminent monks, the 18 famous literati, and Sima's regret on the bridge. These are important reasons why the literati of the Tang dynasty constantly sought out and traced the trails and context of their predecessors and sages, 'using the poems as a basis', reflecting the important social trend of the Tang period to admire the demeanor of the " Wei Dynasty–Sui Dynasty" and the romance of the celebrities.

(4) From the statistics of the relationship between poems and folk cultural landscapes, it is found that 104 poets have described 7 kinds of specialties, namely: wine (123 poems), elixir (55 poems), rattan sticks (29 poems), tea (20 poems), perch (11 poems), Shan paper (8 poems), and Brasenia (6 poems). From the perspective of spatial distribution pattern, the folk cultural landscape presents the characteristics of distribution along the main line of the Road of Tang Poetry and the branch line of Mingzhou.

The cause of formation of this is that, after the Southern Crossing of Yongjia (307–311 A.D), the eastern Zhejiang region, with its unique geographical and peaceful social environment, was like a " pot of treasures", constantly attracting literary groups from other cultures and forming a relatively prosperous and developed economic base by the Tang period. In Gu Kuang's poem, "…Shan paper is made of Shan rattan sticks, and after spraying and pounding, it is turned into banana leaves…"(*Song of Shan Paper*), and the monk poet Jiao Ran once said, "…The Yue people sent me tea from Shanxi, I picked the young shoots of the tea leaves and cooked them in the tea set…"(*Flirting with Cui Shi ambassador's inability to drink tea*). The 1593 poems have mentioned seven kinds of specialties, including perch and Brasenia , Shaoxing's Shan paper, the famous tea "Yue bamboo" from Shanxi River and Mount Tiantai, various kinds of valuable medicinal herbs from Mount Tiantai, and the "Huading stick", a rattan stick from

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Yuezhong, preferred by the literati, as well as five kinds of folk arts, including Shengzhou Yue Opera, Shangyu Shao Opera, Ningbo Yong Opera, gold lacquer wood carving and Yuyao celadon. The poetry road provides an important historical witness to the diverse cultural intermingling and diverse folk life of Eastern Zhejiang.

Characteristics of the road of Tang Poetry in Eastern Zhejiang under the logic of mathematical statistics

(1) There is an obvious "circle layer-network" relationship between "the poets of the Tang Dynasty–the famous celebrities in the " Wei Dynasty– Sui Dynasty"—the characters in the "Ancient times to Han dynasty". The poets of the Tang Dynasty such as Li Bai and Du Fu who belonged to the first circle have a close network connection. 63 poets have mentioned 31 contemporary poets in their poems, reflecting that the poets in the same historical period have formed a strong connection through the poetic response with each other, and the level of poetic creation have accumulated and elevated to a higher literary level between the poetic response; there is a strong degree of network connection between Wang Xizhi, Xie An and other celebrities of the " Wei Dynasty–Sui Dynasty" belonging to the second circle and the poets of the Tang Dynasty in the first circle, with a total of 56 poets mentioning 64 celebrities of the " Wei Dynasty–Sui Dynasty", which reflects the tribute and remembrance of the poets of the Tang Dynasty to their predecessors and sages through their poems. It is the tradition, ethos and cultural lifestyle shaped by the poetry of the celebrities of this historical period that caused the poets of the Tang Dynasty to continue to travel to Eastern Zhejiang and leave poems in remembrance and tribute; Liu Chen, Xi Shi, etc., who belong to the third circle, do not have poems for descendant, and some characters are just folklore, but 60 poets have mentioned 105 characters in the period of "Ancient times to Han dynasties", forming a strong degree of network connection with the poets of the Tang dynasty in the first circle, which reflects the poetic writing technique in which the poets of the Tang Dynasty used ancient characters to express their yearning for a certain ideal life or express their life situation.

(2) The poets have formed an obvious "circle layer-network" relationship with the famous mountains , rivers and lakes, administrative zones, Buddhist temples and Taoist temples, residences of celebrities, and folk culture. 223 poets have described 36 famous mountains , 126 poets have described 11 rivers and lakes, 86 poets have described a total of 72 Buddhist temples and 16 Taoist temples, 45 poets have mentioned the residences of celebrities, and 104 poets have described 7 kinds of specialty. It can be seen that when the poets are creating the poems, they are often moved by things, express their aspirations with poetry, express their feelings in the scenery, and use the scenery to express their emotions. Through the words of the poems, it comprehensively reflects the beautiful landscape and profound history and humanities in Eastern Zhejiang, reflects the poetic artistic conception of the perfect blend of human and nature, and fully and vividly shows the natural landscape, social customs and spiritual realm of the Tang Dynasty.

Through the identification and analysis of the causes of the Road of Tang Poetry in Eastern Zhejiang under the logic of mathematical statistics, two characteristics of the Road of Tang Poetry in Eastern Zhejiang can be summarized. Firstly, the talented literati of various dynasties travelled to the Eastern Zhejiang and praise its beautiful landscape and profound humanities, creating poems that expressed their feelings, ideals, perceptions and the context of their time, reflecting the interactive characteristic of "Merging Feeling with Scenery". Secondly, the traditions, customs and cultural lifestyles shaped by the famous literati of the " Wei Dynasty–Sui Dynasty" attracted poets of the Tang dynasty to travel to the eastern Zhejiang to pay tribute to their ancient saints and sages, and the famous poems of the Tang poets would in turn influence the literati of later dynasties to continue to travel to the eastern Zhejiang to leave new works, a phenomenon of continuous accumulation and innovation of literary poetry, reflecting the cultural characteristic of "deep root and tremendous influence".
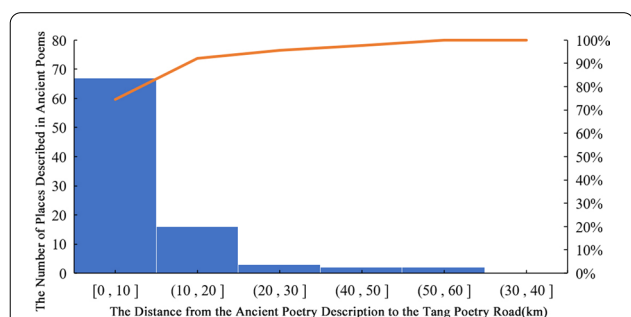
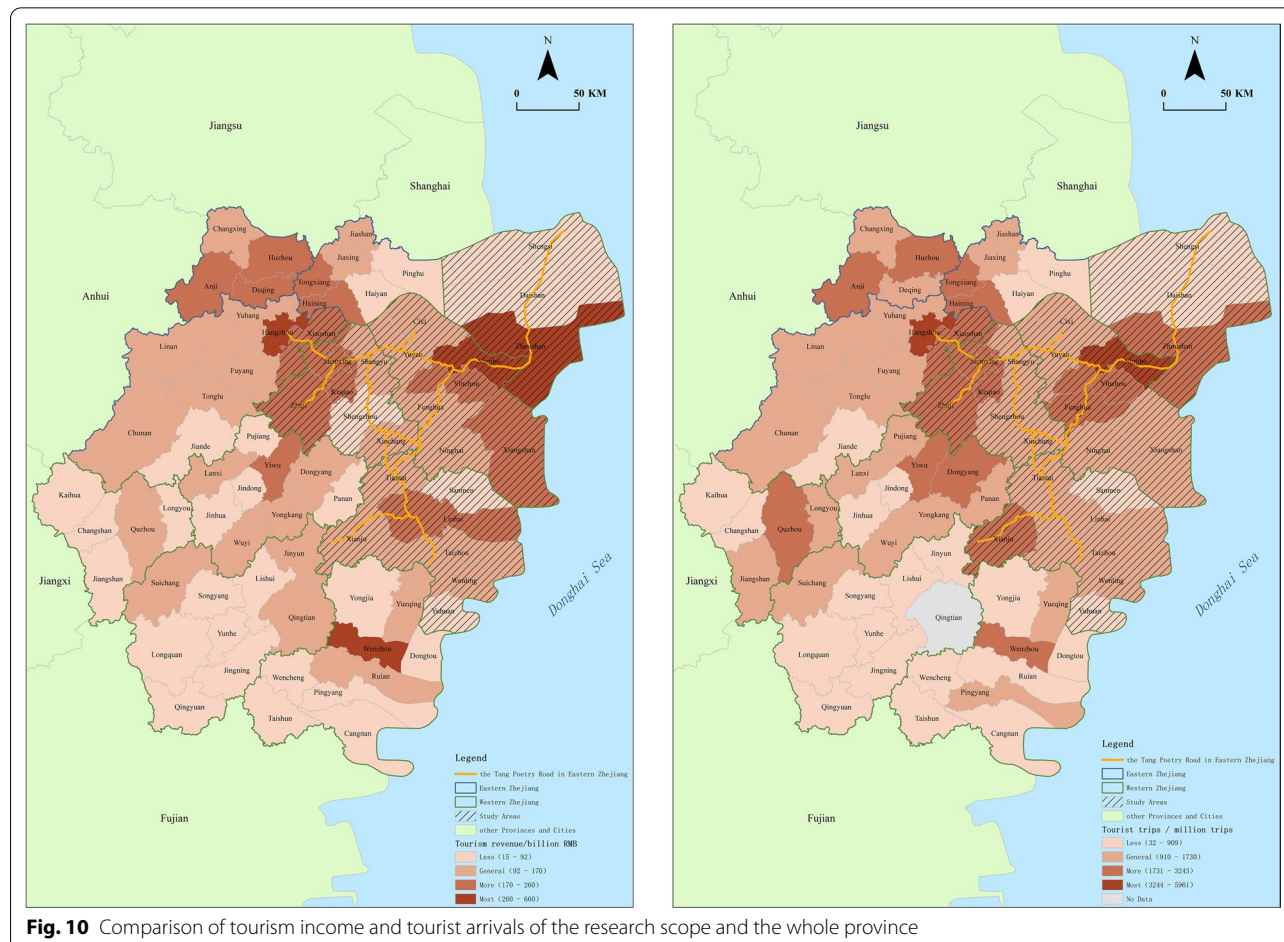**Fig. 9** Statistical chart of the distance from ancient poetry described places to the Road of Tang Poetry

Discussion

This study also shows that:

(1) 75% of the places depicted in the ancient poems are within 10 km from the Road of Tang Poetry, as shown in Fig. 9, showing the close spatial relationship between the natural and human resources within 10 km on both sides of the Road of Tang Poetry and the road itself.

(2) There are 347 present A-rated scenic spots within 10 km of the close spatial relationship between the resource and the route, and only 17 A-rated scenic spots are related to the places depicted in the ancient poems in the Tang poetry, accounting for about 6% of the total number of A-rated scenic spots. There are 22 Chinese cultural relic protection units related to the sites mentioned in the Tang poetry, accounting for only 1% of all cultural relic protection units. This indicates that the current level of protection and sustainable use of resources related to the cultural landscape of the Road of Tang Poetry in Eastern Zhejiang is not yet high.

(3) In terms of the number of tourists and the contribution rate of tourism output in Zhejiang Province in 2018 , Hangzhou, Zhoushan in Ningbo and Taizhou, the starting and ending points of the Road of Tang Poetry in eastern Zhejiang, are the metropolitan areas with high population and economic concentration in the province, as well as the best development of tourism industry and the highest tourism contribution rate in the province. The cities and counties including Shengzhou, Tiantai, Xinchang and Linhai, which are in the core area of the study area of the Road of Tang Poetry in Eastern Zhejiang, along the Cao'e River and Shanxi River, are still in the relatively weak area of the development of tourism industry in the province, as shown in the Fig. 10. It shows that the natural and human resources of the Road of Tang Poetry, with its deep cultural heritage, rich and diverse types, have not been effectively transformed into tourism resources

Fig. 10 Comparison of tourism income and tourist arrivals of the research scope and the whole province

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to drive the development of local economies along the route.

Therefore, full advantage should be taken of the strategic opportunity to create four cultural tourism belts of the poetry road [28] in Zhejiang Province, on the basis of this study:

(1) To clarify the composition of resources, identify the current state of preservation, and build a spatial and temporal database of natural and human resources of the poetry road;
(2) "Using poetry as a vein" to sort out cultural connotations, refine cultural themes, explore and cultivate industries such as historical classics, cultural creativity, leisure and recreation, intangible cultural heritage experience and special products, and build a cultural tourism industry development path with Tang poetry as a link;
(3) Through the creation of special tourism lines, natural and humanistic resources, towns and villages are strung together into a "chain", showing the world an "ecological picture" of the beautiful scenery of Eastern Zhejiang and a "humanities book" in which beautiful landscapes and cultural life are intermingled and harmonious. To enable single heritage elements to extend their new value connotations in the context of the overall cultural route, thereby enhancing the sense of regional cultural identity, forming an integrated regional approach of conservation and sustainable development, and achieving balanced development between regions and cities and villages along the poetry road.

The limitations of this study are as follows:

(1) Tang poetry is the pinnacle of the ancient Chinese literature history and ancient poetry history. It is skilled in creation techniques, has a wide range of themes, and has a profound artistic conception. It has pushed the artistic characteristics of ancient Chinese poetry with refined words and harmonious syllables to an unprecedented height. This brings a major challenge to the accurate interpretation of the text information of poems. In this paper, there are still some limitations in the interpretation method of artificially discriminating the content of poems from the three levels of "person,place and landscape", and it does not go deep into the word class and syllable level of a single word in each poem. Using artificial intelligence tools to further analyze and summarize the cultural characteristics of the Road of Tang Poetry from the perspective of a single word requires further research.

(2) This study is based on1593 poems written by Tang poets in Eastern Zhejiang, and does not cover the historical periods before and after the Tang dynasty. The content of these poems is found to be closely related to the poetry and events of the local celebrities of the " Wei Dynasty– Sui Dynasty", resulting in an accumulation and innovation of poetry. In addition, there was a longer period of history after the Tang Dynasty, which lasted for more than 1,000 years, and a large number of excellent poems were also written in Eastern Zhejiang to reflect the natural and human landscape conditions, social customs and spiritual world of the time. These poems are not included in the statistical category of this study, and there are limitations in the comprehensiveness of the research object, which will be further studied in the future.
(3) This paper uses GIS to spatially locate the cultural landscape expressed in the poem on the modern map. The spatial location of these cultural landscape is basically the same as that of the Tang Dynasty, but the spatial scope of some resource points has changed. For example, Jinghu Lake, according to historical records [35], had an area of about 310 km^2 in the Tang Dynasty, but now the area is only 15.6 km^2, and its spatial location has not changed. There are some historical information points in ancient poems whose spatial coordinates cannot be determined. Such data whose spatial location information cannot be determined are not included in the analysis object of this paper.

Conclusion

The Road of Tang Poetry in Eastern Zhejiang is a poetic cultural route linked by the Tang poetry, the pinnacle of ancient Chinese poetry history, and a historical and cultural landscape where nature and humanity are fused under the narrative of Tang poetry, a collection of historical and contemporary resources stretching over a thousand years and spanning time and space. It has important theoretical significance and application value to study the Road of Tang Poetry from the perspectives of ancient literature, history, geography, and landscape, to comprehensively interpret the "cultural gene code" of a large number of historical and cultural landscapes nurtured by the history of Chinese civilization with a long history, to reveal the broad and profound connotation of Chinese poetry and culture, and to show the unique core value of Chinese regional cultural landscape.

This paper takes the 1593 poems written by 451 poets of the Tang Dynasty in Eastern Zhejiang as the research objects. Firstly, it sorts out the information including the

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poets' trails, the places described in ancient poems, the natural landscape, the Buddhist and Taoist cultural landscape, the cultural landscape of celebrities and the folk cultural landscape from the poetry text. Secondly, using GIS to spatially locate it, to identify one main line and two branch lines of the Road of Tang Poetry in Eastern Zhejiang. Through the kernel density analysis method and the nearest neighbor index method, the spatial pattern of the cultural landscape of the Road of Tang Poetry is analyzed and summarized. Thirdly, the social network relationship of "poet-person" and "poet-landscape" reflected in the text information of poems is analyzed and visualized by using Gephi tools. Finally, combined with the spatial distribution pattern of the cultural landscape of the Road of Tang Poetry and the poet's social network relationship, the four causes and two characteristics of the Road of Tang Poetry in Eastern Zhejiang are analyzed from the perspective of the logic of mathematical statistics.

Declarations

Competing interests
The authors declare that they have no competing interests.

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