

Spatial Patterns, Causes and Characteristics of the Cultural Landscape of the Tang Poetry Road Based on Text Mining—Take the Tang Poetry Road in Eastern Zhejiang as an example

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Abstract

The Tang Poetry Road in eastern Zhejiang is a poetic cultural route linked to 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. The study extracted and collated the textual information of 1593 poems written by 451 Tang poets in the eastern part of Zhejiang, and spatially located the trails, places and scenes in ArcGIS to identify the main and branch lines of the Tang Poetry Road in eastern Zhejiang. The spatial distribution pattern of the cultural landscape of the Tang Poetry Road is analyzed and summarized at four levels: natural landscape, Buddhism and Taoism culture, celebrity culture and folk culture; the complex spatio-temporal networks between "poet-person", "poet-places" and "poet-landscape" are revealed through the Gephi tool; the four causes and three characteristics of the Tang Poetry Road in eastern Zhejiang are explained from the perspective of mathematical statistical logic.

1. 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, the history of China's 5,000-year civilization has also produced a special type of cultural route that uses poetry as a link, of which the Tang Poetry Road in eastern Zhejiang is a typical representative. The Tang Poetry Road 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 (Mirror Lake), two basins (Shanzhong Basin and Wozhou Basin) and three mountains (Kuaiji Mountain, Siming Mountain and Tiantai Mountain) in eastern Zhejiang, with poetry as the link between the rich and diverse natural and human resources[1]. 451 poets from the Tang dynasty had visited eastern Zhejiang in succession, accounting for one-fifth of the total number of poets included in the "the whole tang poetry", leaving behind 1,593 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 Tang Poetry Road in eastern Zhejiang a road of landscape residence, poetry creation, the spread of ideas and cultural integration, and the area covered by the road has become the birthplace of Chinese 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 scholarly culture, and is of great importance in Chinese cultural history.

In October 2019, the Notice of the person's Government of Zhejiang Province on the Issuance of the Development Plan of the Poetry Road Cultural Belt of Zhejiang Province was released, proposing to "string literature with poetry (poems and songs)" and "string belts with roads (ancient waterways)" to draw the "four poetry roads", which includes the Tang Poetry Road in Eastern Zhejiang, the Poetry Road of the Grand Canal, the Poetry Road of the Qiantang River and the Poetry Road of the Ou River[3]. To implement the above plan, in April 2020, the Notice on the Issuance of the Three-Year Action Plan for the Construction of the Tang Poetry Road in Eastern Zhejiang (2020–2022) was released, taking the lead in launching and building the cultural belt of the Tang Poetry Road in Eastern Zhejiang, covering Ningbo, Shaoxing, Taizhou, Zhoushan and Xiaoshan and Binjiang districts of Hangzhou[4]. It provides a solid and reliable policy background for research related to the Tang Poetry Road in Eastern Zhejiang.

Since Zhu Yuebing first proposed the concept of the 'Road of Tang Poetry' in the 1980s and 1990s, scholars have been studying it from a variety of perspectives, including literature, sociology, history and geography. In general, the current domestic and international research on cultural routes has derived from categories such as concept identification [5], charter interpretation [6], value identification [7–8], and heritage conservation and development strategies [9–11] to community renewal [12], industrial heritage development [13], vernacular landscape creation [14], regional rural revitalization and old town revival [15–16], and tourism development [17–18], which are based on the concept of cultural routes. The research on the Tang Poetry Road in eastern Zhejiang focuses on the causes and historical evolution [19–21], identification of specific person and places [22–23], identification of characteristics and interpretation of values [24], and preservation and revitalization strategies [25–27]. In the case of poetry-based cultural routes, which are collections of cultural landscape linked by poetry, there is a relative lack of fundamental research. It is difficult to provide effective support for the construction of the four poetry road cultural belts proposed by the person's Government of Zhejiang Province, including the Tang Poetry Road in eastern Zhejiang. Based on the 1593 poems of 451 poets of the Tang Dynasty, this paper summarizes the spatial distribution characteristics of the cultural landscape of the Poetry Road through GIS. It is of great theoretical and practical significance to the study of the many poetry-based cultural routes nurtured by five thousand years of Chinese culture, such as the Tang Poetry Road in eastern Zhejiang, and the construction of the Poetry Road Cultural Belt.

2. Research Objects, Research Ideas And Research Methods

2.1 Research Objects

(1) Tang poetry: Poetic data comes from the *"General Collection of Tang Poems on the Road 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 1,593 poems written by 451 poets of the Tang Dynasty in the Eastern Zhejiang region[28].

(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 Traces of Poets in the Tang Dynasty"*, which contains the trails of 451 poets from eastern Zhejiang in three parts. A total of 70 poets have been selected for analysis based on the level of detail and ease of spatial visualization of their trails[29].

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

2.2 Research Ideas

(1) Extraction and collation of poetry text information: ☐ The text information of the 1,593 poems in the General Collection of Tang Poems on the Road of Tang Poetry is extracted and collated using OCR (text recognition) technology, such as "title", "author" and "content", and manually checked and corrected. ☐ The words "title" and "content" are collated separately by manual identification, which include characters (from ancient times to the Qin and Han dynasties, the Wei, Jin, North and South Dynasties, and the Sui and Tang

dynasties), places depicted in ancient poems, and landscape (six categories: famous mountains, rivers and lakes, prefectures, Buddhist temples and Taoist sites, former residences of celebrities, and folk culture).

(2) Identification of the Tang poetry road in eastern Zhejiang based on poets' trails: The water and land transport network of the Tang dynasty in the History of Ancient Road Transport in Zhejiang[30] is used as the base map in ArcGIS, and the trails of 70 poets in "The Road of Tang Poetry: A Study of the Traces of Poets in the Tang Dynasty" are spatially reset according to the base map. The number of poets on each section of the route is used to visualize the poets' trails in five levels, thus identifying the main and branch lines of the Tang Poetry Road in eastern Zhejiang.

(3) Spatial distribution pattern of the cultural landscape of the poetry road based on poetry text information: The geographical information such as "writing place" in the poetry text information is spatially located in ArcGIS. Using the nearest proximity 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) The spatio-temporal network of the poet's "person-place" based on the textual information of the poem: In Gephi, based on the poetry text information, the words "author", "person", "place" and "landscape" are used to construct the social networks of "poet-person", "poet-place" and "poet-landscape", of which the social network of "poet-landscape" includes six types of refined networks: famous mountains and peaks, rivers and lakes, prefectures, Buddhist temples and Taoist sites, former residences of celebrities, and folk culture. The individual networks are analyzed in terms of both the overall structure of the network and the importance of the nodes.

(5) The causes and characteristics of the Tang Poetry Road in eastern Zhejiang are explained in relation to the spatial distribution pattern of the cultural landscape and the poets' spatio-temporal network of "person and places".

2.3 Research Methods

The study uses the nearest proximity index method and the kernel density estimation method to analyze the spatial distribution pattern of the cultural landscape of the Tang Poetry Road in ArcGIS software; and the social network analysis method is used to analyze and visualize the spatio-temporal network relationship of the poets' 'person-place' in Gephi software.

2.3.1 Nearest Proximity Index Method

The spatial distribution type of point-like elements can be divided into three types: aggregation type, random type, symmetrical type, and the nearest proximity index can reflect the spatial distribution type of point-like elements. The calculation formula for the nearest proximity index is

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

1

In formula (1): \bar{r} is the actual nearest proximity distance, \bar{r}_1 is the theoretical nearest proximity distance, R is the nearest proximity index; n is the number of points within the study area; and 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 by the kernel density estimation method, and when $R = 1$, it means that the study object tends to be randomly distributed.

2.3.2 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

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

2

In formula (2): f is the kernel density; h is the search radius (bandwidth) and $h > 0$; $k(\cdot)$ is called the kernel function; n is the number of known points within the bandwidth, i.e. the number of samples studied; $(x - X_i)$ denotes the distance from the estimated point x to the sample point X_i . A larger value of $f_n(x)$ indicates a greater aggregation of geographical elements.

2.3.3 Social network analysis method

A social network is a collection of social actors and their relationships. The social network mode can be seen as a diagram describing a social network, consisting of "points" and "lines", where points are the actors in the real society and lines are the interrelationships or interactions between social actors[31]. In this study, indicators such as average degree, graph density and degree central potential are chosen to reflect the overall structure of the network at the overall level, while indicators such as degree and intensity are chosen to reflect the importance of nodes at the individual level, the meanings of the specific indicators and calculation formula are shown in Table 1. For the network layout, the Fruchterman Reingold layout is chosen, which is suitable for most network datasets. 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.

Table 1
Description and significance of network structure indicators

Level	Characteristics Indicators	Formula	Note	Indicator Meaning
Overall level	degree central potential	$C = \frac{\sum_{i=1}^n (C_{ADmax} - C_{ADi})}{n^2 - 3n + 2}$	<p>C_{ADi} : the absolute centrality of point i</p> <p>C_{ADmax} : the maximum absolute centrality of the points in the graph</p> <p>n:Number of points in the graph</p>	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	$\bar{k} = \frac{1}{V} \sum_{v \in V} k_v$	<p>V:the number of nodes in the network</p> <p>k_v:the node in the network degree of the node</p>	This reflects the overall intensity of the network's connections.
	graph density	$D = \frac{2E}{V(V-1)}$	<p>E:the number of edges in the network</p> <p>V:the number of nodes in the network number of nodes</p>	This reflects the intensity of the connectivity of the nodes in the network. The higher the value, the stronger the connection between the nodes.
Individual level	Degree	k_v	the number of edges connected to node v	This reflects the number of other nodes connected to the node. A significant node is a node that has many connections.

Level	Characteristics	Formula	Note	Indicator Meaning
	Indicators			
	Intensity	$s_v = \sum_{u \in V} W_{vu}$	W_{vu} : 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 intensity of a node's connections with other nodes.

3. Research Results

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

A hierarchical visual analysis of the data from 70 poets' trails shows that:

The Tang Poetry Road 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 up the Cao'e River and the Shanxi River in Shangsu, through Shengzhou and Xinchang to Tiantai, and finally southwards along the Shifeng River to Linhai. Generally, there is a water transport link of approximately 200km 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 800km.

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)

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

3.2.1 Places depicted in ancient poems

The 1,593 poems involve a total of 79 places depicted in ancient poems, which are classified into four categories, including natural landscapes, former residences of celebrities, Buddhist temples and Taoist sites, and Sichuan regions. The nearest proximity index analysis of the places depicted in ancient poems shows that the actual nearest distance r_1 is 7.5km, the theoretical nearest distance r_e is 12.8km, and the nearest proximity index R is $0.58 < 1$, indicating that the spatial distribution type of the places depicted in ancient poems is aggregation type. Therefore, a visual analysis of the number of poems and a kernel density analysis are carried out for the places depicted in ancient poems (Fig. 2). From the perspective of kernel density, the places depicted in ancient poems form four groups: the "Xiaoshan-Shaoxing-Shangyu" and "Shengzhou-Xinchang-Tiantai" groups, which have a high kernel density, and the "Linhai-Xianju-Huangyan" and "Ningbo-Zhoushan" groups, which have a low kernel density. In terms of quantity, the "Xiaoshan-Shaoxing-Shangyu" group and the "Shengzhou-Xinchang-Tiantai" group on the main line of the Tang Poetry

Road have more poetic works, such as in the areas of Mirror Lake, Mount Wanwei, Mount Kuaiji, Mount Yunmen, Shanxi River, Mount Siming, Mount Wozhou, Mount Tiantai and Mount Chicheng, while the "Linhai-Xianju-Huangyan" group on the branch line of Taizhou and the "Ningbo-Zhoushan" group on the branch line of Mingzhou have fewer poetic works.

3.2.2 Natural landscape

The Poems of the Tang Poetry Road in Eastern Zhejiang recorded a total of 47 natural landscapes, of which 36 are related to mountains and 11 to water systems, such as Mount Tiantai, Mount Wozhou, Mount Wanwei, Mirror Lake, Ruoye River and Shanxi River. The nearest proximity index analysis (Fig. 3) shows that the actual nearest proximity distance r_1 is 11.2km, the theoretical nearest proximity distance r_e is 16.1km, and the nearest proximity index R is $0.7 < 1$, indicating that the spatial distribution type of natural landscape is aggregation type. A 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 Kuaiji, Mount Yunmen, Mount Qinwang, Mount Wanwei, Mirror 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 mountain and water landscapes are aggregated.

3.2.3 Buddhist and Taoist Cultural Landscape

There are 72 Buddhist temples recorded in the Poems of the Tang Poetry Road in Eastern Zhejiang, such as Xinchang Dafa Temple, Yunmen Temple, Fahua Temple, Huading Temple and Guoqing Temple. There are 16 Taoist temples, such as Tongbai Temple, Tianzhu Temple and Guanyin Temple. There are 14 mountain caves and blessed places in total, of which 3 are large mountain caves, namely, the Yu Cave Heaven, the Chi Cheng Cave Heaven and the Jucang Cave Heaven; 4 are small mountain caves, namely, the Siming Mountain There are four small caves, namely Siming Cave Heaven, Kuaiji Cave Heaven, Gaijushan Cave Heaven and Jinting Cave Heaven, and seven blessed places, 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 r_1 is 9.2km and the theoretical nearest proximity distance r_e is 15.6km, with a nearest proximity index R of $0.6 < 1$, indicating that the spatial distribution of the cultural landscape is of the aggregation type. A kernel density analysis shows (Fig. 4) that three groups of Buddhist and Taoist cultural sites are formed along the Tang Poetry Road, 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, Kuaijishan Cave Heaven, and other Buddhist temples and Taoist sites 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 sites are aggregated. In the "Linhai-Xianju-Huangyan" group, Lingshan Temple, Longxing Temple, Gaizhu Cave Heaven, Cang Cave Heaven, Dongxiangyuan Blessed Place, and other Buddhist temples and Taoist sites are aggregated.

3.2.4 Celebrity cultural landscape

The Poems of The Tang Poetry Road in Eastern Zhejiang has recorded four former residences of celebrities and nine places where famous legends and allusions took place. The spatial distribution is shown in Fig. 5, with the former residences of celebrities and legends and allusions basically distributed along the main line of the Tang Poetry Road, and mostly in the vicinity of Shaoxing and Tiantai.

3.2.5 Folk cultural landscape

The poems of The Tang Poetry Road in Eastern Zhejiang mention seven kinds of specialties, such as the perch and water shield of Eastern Zhejiang, the Shan paper 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 Tang Poetry Road and the branch line of Mingzhou.

3.3 Spatio-temporal network relationships of the poet's "person-place" based on the poetry text information

3.3.1 The "poet-person" social network

The 'poet-person' social network is a network relationship between the author of an ancient poem, the title of the ancient poem and the characters contained in its content. This network is an undirected network of 948 nodes and 1072 edges. The stable network is shown in Fig. 7 after running the Fruchterman Reingold layout. The characters in the figure can be divided into three sections according to their dynasties: Upper Ancient Times to Qin and Han, Wei, Jin, North and South Dynasties, and Sui and Tang.

From the overall network structure, the average degree of this network is 2.068, both values are much smaller than the number of nodes (948), while the graph density is 0.002, which shows that the network as a whole is sparse, unbalanced and low-density, the connection of each node in the network is less tight, and most of the nodes are weakly connected to each other. The central potential of degree 0.05 indicates that the network has a tendency to concentrate at certain places, and there is a "core-edge" structural feature.

The partial statistics for node importance are shown in Table 2, with only 12.44% of the nodes having a degree greater than the average degree, indicating that there are fewer nodes in the network with multiple co-occurring links. A total of 779 Sui and Tang figures are connected through ancient poems, with Fang Gan (56 poems), Li Bai (51 poems), Bai Juyi (49 poems), Du Fu (48 poems), Liu Changqing (45 poems), and they are in the top five in terms of degree and intensity values, belonging to the core figures of the poets' network of the Tang Poetry Road.

56 Sui and Tang poets have mentioned 64 figures from the Wei, Jin and North-South dynasties in their ancient poems, with Xie An (13 poems), Wang Xizhi (10 poems), Xie Lingyun (10 poems), Zhi Zun (8 poems) and Zi You(3 poems) in the top five in terms of degree and intensity values.60 poets from the Sui and Tang dynasties have mentioned xx figures in their poems, from the upper ancient times to the Qin and Han

dynasties, with Liu Chen(16 poems), Xi Shi(15 poems), Ruan Qing(15 poems), Gou Jian(8 poems) and Fu Chai(4 poem) in the top five in terms of degree and intensity values, and these figures are among the main objects of remembrance and homage by Sui and Tang poets.

Table 2
Node index ranking

Dynasty	Order	Node name	Degree	Node name	Intensity
Sui and Tang dynasties	1	Fang Gan	51	Fang Gan	56
Sui and Tang dynasties	2	Li Bai	45	Li Bai	51
Sui and Tang dynasties	3	Du Fu	43	Bai Juyi	49
Sui and Tang dynasties	4	Bai Juyi	38	Du Fu	48
Sui and Tang dynasties	5	Liu Chanqing	38	Liu Chanqing	45
Wei, Jin and North-South Dynasties	1	Xie An	11	Xie An	13
Wei, Jin and North-South Dynasties	2	Wang Xizhi	9	Wang Xizhi	10
Wei, Jin and North-South Dynasties	3	Xie Lingyun	9	Xie Lingyun	10
Wei, Jin and North-South Dynasties	4	Zhi Dun	6	Zhi Dun	8
Wei, Jin and North-South Dynasties	5	Zi You	3	Zi You	3
Ancient times to the Qin and Han dynasties	1	Liu Chen	10	Liu Chen	16
Ancient times to the Qin and Han dynasties	2	Xi Shi	9	Xi Shi	15
Ancient times to the Qin and Han dynasties	3	Ruan Qing	9	Ruan Qing	15
Ancient times to the Qin and Han dynasties	4	Gou Jian	8	Gou Jian	8
Ancient times to the Qin and Han dynasties	5	Fu Chai	4	Fu Chai	4

3.3.2 The 'poet-place' social network

The 'poet-place' social network is a network relationship between the author of an ancient poem and the place described in the poem. This network is a directed network with 485 nodes and 1620 edges. A stable network based on the Fruchterman Reingold layout is shown in Fig. 8.

From the overall network structure, the average degree of this network is 2.489, all values are much smaller than the number of nodes (485), while the graph density is 0.005, which shows that the network as a whole is sparse, unbalanced and low-density, the connection of each node in the network is less tight, and most of

the nodes are weakly connected to each other. The central potential of degree 0.13 indicates that the network has a tendency to concentrate at certain places, and there is a "core-edge" structural feature.

The partial statistics of node importance are shown in Table 3. Because the connections of the network are all pointed to places by the poets, the in-degree reflects the number of times the places are depicted by the ancient poems, and the out-degree reflects the number of poems written by the poets. From the results of the in-degree and entry intensity, a total of 160 places are counted, among which Yuezhou (113 poems), Mount Tiantai (87 poems), Yuezhou Prefecture (71 poems), Ruoye River (64 poems), and Mirror Lake (66 poems), which are among the places that have been described by more poets and have survived more ancient poems. The top ten places are also mostly of the type of famous mountains and peaks, rivers and lakes and prefectures, with lower values for Buddhist temples and Taoist sites and former residences of celebrities. A total of 325 poets participated in the statistics from the results of out-degree and out intensity, including 10 poets with a high number of descriptions of places (number above 30), 30 poets with a high number (number 10 to 30), and 285 poets with a low number (number below 10).

Table 3
Node index ranking

Order	Node name	Degree of entry	Node name	Intensity degree of entry	Node name	Degree of out	Node name	Intensity degree of out
1	Yuezhou	66	Yuezhou	113	Fang Gan	38	Fang Gan	74
2	Mount Tiantai	58	Mount Tiantai	87	Liu Changqing	30	Li Bai	52
3	Ruoye River	48	Yuezhou Prefecture	71	Jiao Ran	28	Liu Changqing	50
4	Yuezhou Prefecture	45	Mirror Lake	66	Bai Juyi	24	Jiao Ran	48
5	Mount Wanwei	44	Ruoye River	64	Xu Hun	23	Bai Juyi	37
6	Mirror Lake	42	Mount Wozhou	64	Meng Haoran	23	Xu Hun	37
7	Mount Wozhou	41	Mount Wanwei	63	Li Bai	23	Li Shen	37
8	Mount Yunmen	37	Mount Yunmen	58	Li Shen	20	Qi Ji	36
9	Shanxi River	37	Shanxi River	50	Guan Xiu	18	Meng Haoran	34
10	Stone Bridge	33	Shanzhong	41	Luo Yin	17	Guan Xiu	33

Yuezhou in the Tang dynasty led six counties: Kuaiji (the state of Shanyin and Kuaiji), Zhuji, Yuyao, Shan and Xiaoshan. Yuezhou Prefecture in the Tang Dynasty refers to Shangyin and Kuaiji counties.

3.3.3 The "Poet-landscape" Social Network

"The Poet-landscape social network consists of six subcategories: famous mountains and peaks, rivers and lakes, prefectures, Buddhist temples and Taoist sites, former residences of celebrities, and folk culture. All six networks are directed networks and the number of nodes and edges in each network is shown in Table 4. The stable network is shown in Fig. 9 after running on the basis of the Fruchterman Reingold layout.

From the overall network structure, the average degree values of all six networks are much smaller than the number of nodes, and the graph density is also low, which shows that the network as a whole is a sparse, unbalanced and low-density network, and the connection of each node in the network is less tight, and most of the nodes are weakly connected to each other. The central potential of the degree is high, which indicates that the network has a tendency to concentrate in certain places and there is a "core-edge" structural feature.

The results for node importance show that 223 poets have described 36 famous mountains and peaks, 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 high values at Mirror Lake (66 poems), Ruoye River (64 poems) and Shanxi River (50 poems). 152 poets have described 21 prefectures, with high 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 high 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 former residences of celebrities, namely Lanting (22 poems), the former residence of He Zhizhang (21 poems), the former residence of Zheng Qian (12 poems) and the former residence of Yan Wei (8 poems). In folk culture, 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 water shield (6 poems).

Table 4
"Landscape – Poet" Network Indicator

Category	Number of nodes	Number of edges	Average degree	Degree central potential	Figure density	Number of scenery
Famous Mountains and Peaks	259	682	1.919	0.21	0.007	36
Rivers and Lakes	137	253	1.372	0.34	0.01	11
Prefecture area	173	441	1.803	0.37	0.01	21
Buddhist temple and Taoist temple	177	188	0.93	0.09	0.005	88
Former residences of celebrities	49	63	1.02	0.39	0.021	4
Folk culture	111	252	1.432	0.57	0.013	7

3.4 Identification of the causes and characteristics of the Tang Poetry Road in Eastern Zhejiang based on the conclusions of mathematical analysis

3.4.1 The causes of the Tang Poetry Road in Eastern Zhejiang under Mathematical and Statistical Logic

(1)The natural 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 Kuaiji, Mount Yunmen, Mount Qinwang, Mount Wanwei, Mirror 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 statistics on the relationship between poets and landscape reveal that 223 poets have described 36 famous mountains and peaks, 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), Mirror Lake (66 poems), Ruoye River (64 poems) and Shanxi River (50 poems).

The cause of this is that poets often 'use their poems to enhance the beauty of the scenery', 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, Xie Lingyun adopted the increasingly sophisticated five-line poetic style, creating and forming one of the earliest schools of landscape poetry in China. In his poem, 'Crossing the Shi Ning Shu', 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).When Bai Juyi visited the east of Zhejiang three times in his life, he wrote 42 poems, 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) And other poems have praised the beauty of the landscape and the humanities in Yuezhong. The poems provide an important historical testimony to the beauty of the landscape in eastern Zhejiang.

(2)The Buddhist and Taoist cultural landscape is 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 Kuaiji shan 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. Statistics on the poets' relationships with Buddhist temples and Taoist temples reveal that 86 poets have described a total of 72 Buddhist temples and 16 Taoist temples, with more poems from 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).

The cause of this is that Taoism has been developed in Yuezhong since the Qin and Han dynasties, and its influence reached a climax in the Tang dynasty, when the great 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 Northern and Southern Dynasties, represented by the founder of the Tiantai sect of Buddhism, Master 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[17]. 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 Zen master 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) The cultural landscape of celebrities is characterized by a spatial distribution along the main line of the Tang poetry road, with four major former residences of celebrities, including Lanting, the former residence of He Zhizhang, the former residence of Zheng Qian and the residence of Yan Wei. Statistics on the cultural relationships between poets and celebrities reveal that 45 poets have described the four former residences of the above-mentioned celebrities, 60 poets have remembered 105 celebrities in their poems, including Liu Chen (16 poems), Xi Shi (15 poems), Ruan Qing (15 poems), Gou Jian (8 poems), and Fu Chai (4 poems), and 56 poets have remembered 64 famous scholars of the Wei, Jin and Northern and Southern Dynasties, including Xie An (13 poems), Wang Xizhi (10 poems), Xie Lingyun (10 poems), Zhi Zun and others (8 poems), and Zi You (3 poems).

The cause of this is that the traditions, ethos and cultural lifestyle shaped by the famous scholars of the Six Dynasties greatly influenced the poets of the Tang Dynasty, and the veneration, remembrance and memorialization of their predecessors in this area, as well as the search for the places where their masterpieces were composed, allowed the cultural spirit of the scholars of the Wei and Jin dynasties 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 Baiyue. 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 rising from the ashes, Wang Ziyou's visiting to Dai in the snowy night, Ren Gongzi's fishing trip to Nan Yan, Liu Ruan's encounter with the immortals, Wang Mu's Heavenly Mother, the 18 monks, the 18 famous scholars, and Sima's regretful bridge. These are important reasons why the literati of the Tang dynasty constantly sought out and traced the trails and literary lines of their predecessors, 'using the poems as a basis', reflecting the important social trend of the Tang period to admire the style of the Wei and Jin dynasties and the celebrities.

(4)The folk culture landscape shows a spatial distribution along the main line of the Tang Poetry Road and the branch line of Mingzhou. From the statistics of the poets' relationship with folk culture, it is found that 104 poets have described seven 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 water shield (6 poems).

The cause of this is that, after the Southern Crossing of Yongjia, 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 poems in The Tang Poetry Road of Eastern Zhejiang mention seven kinds of specialties, including perch and water shield, 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 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 testimony to the diverse cultural intermingling and diverse folk life of eastern Zhejiang.

3.4.2 The characteristics of the Tang poetry road in eastern Zhejiang under mathematical and statistical logic

Through the identification of the causes of the Tang poetry road in eastern Zhejiang under mathematical and statistical logic, three characteristics of the Tang poetry road in eastern Zhejiang can be summarized. Firstly, the talented scholars of various dynasties travelled to the eastern Zhejiang region and sang about its beautiful landscape and profound culture, creating poems that expressed their feelings, ideals, perceptions and the context of their time, reflecting the interactive characteristic of "feelings mingling with scenes". Secondly, the mountains and rivers, humanistic monuments and folk specialties of eastern Zhejiang are linked together by Tang poetry and intermingled as a whole, reflecting the artistic characteristic of "poems mingling with drawings". Thirdly, the traditions, customs and cultural lifestyles shaped by the famous scholars of the Six Dynasties attracted poets of the Tang dynasty to travel to the eastern Zhejiang to pay tribute to their ancestors, 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 'accumulation and a long history.

4. Discussion

This study also shows that:

(1) 75% of the places depicted in the ancient poems are within 10km of the Tang Poetry Road, as shown in Fig. 10, indicating that the natural and human resources within 10km on both sides of the Tang Poetry Road are closely spatially related to the route itself.

(2) There are 347 A-rated scenic spots within 10km 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 cultural heritage protection units related to the monuments mentioned in the Tang poetry, accounting for only 1% of all cultural heritage protection units. This indicates that the current level of protection and sustainable use of resources related to the cultural landscape of the Tang poetry road 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 (Zhejiang Statistical Yearbook, 2019), Hangzhou, Ningbo Zhoushan and Taizhou, the starting and ending points of the Tang Poetry Road in eastern Zhejiang, are the metropolitan areas with high population and economic concentration in the province, as well as the best tourism industry development and the highest tourism contribution rate in the province. The cities and counties of Shengzhou, Tiantai, Xinchang and Linhai, which are in the core area of the study area of the Tang Poetry Road in eastern Zhejiang, along the Cao'e River and Shanxi River, are still in the relatively weak area of tourism industry development in the province, as shown in the figure. It shows that the natural and human resources of the Tang Poetry Road, with its deep cultural heritage, rich and diverse types, have not been effectively transformed into tourism resources to drive the development of local economies along the route.

Therefore, full advantage should be taken of the strategic opportunity of creating a cultural tourism belt of four poetry roads in Zhejiang Province, based on 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 scroll" of the beautiful scenery of eastern Zhejiang and a "humanities scroll" in which beautiful landscapes and cultural life are intermingled and concealed. To enable individual 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 to 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 history of ancient Chinese literature and ancient poetry, with its skillful compositional techniques, wide range of subjects and profound moods, taking the artistic characteristics of ancient Chinese poetry, with its refined words and harmonious syllables, to an unprecedented height. This poses a major challenge to the accurate interpretation of ancient poetry text information. In this paper, the decoding method using a combination of machine recognition and expert manual discriminations still has some limitations. Whether the natural and human landscapes, social customs and the spiritual world of the Tang people behind the refined ancient words are fully and accurately represented requires further study.

(2) This study is based on 1,593 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-Jin-Sui period, 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 scope 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 landscapes represented in the poems on modern maps, and it remains to be proven whether these corresponding spatial locations are consistent with those represented in the Tang poetry.

5. Conclusion

The Tang Poetry Road in eastern Zhejiang is a poetic cultural route linked to Tang poetry, the pinnacle of ancient Chinese poetry history, a historical and cultural landscape where nature and humanity blend together under the narrative of Tang poetry, and a collection of resources that stretches across time and space, both historical and contemporary, spanning millennia to the present day. The study of ancient literature, history, geography and landscape is of great theoretical significance and application value to the comprehensive interpretation of the "cultural genetic code" of the numerous historical and cultural landscapes nurtured by the 5,000 years of Chinese civilization, to reveal the profound connotation of Chinese poetry and culture, and to show the unique core values of Chinese regional cultural landscapes.

This paper takes the 1,593 poems written by 451 poets of the Tang Dynasty in the eastern Zhejiang region as the object of study. Firstly, it collates information from the poetry texts on the 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. Secondly, GIS is used to spatially locate them and to identify one main line and two branch lines of the Tang Poetry Road in eastern Zhejiang. The spatial pattern of the historical and cultural landscape of the Tang Poetry Road has been analyzed and the distribution pattern has been summarized through the kernel density analysis method and the nearest

proximity index method. Thirdly, Gephi software is used to analyze and visualize the spatiotemporal network relationships of 'poet-person', 'poet-place' and 'poet-landscape' reflected in the poetry text information. Finally, the spatial distribution pattern of the cultural landscape of the Tang Poetry Road and the spatiotemporal network relationship of " person- place" of the poets are combined to identify the causes and characteristics of the Tang Poetry Road in eastern Zhejiang from the perspective of mathematical and statistical logic. It can be seen that these Tang poems provide an important historical testimony to the beautiful landscape of eastern Zhejiang. It reflects the important social trend of seeking "immortality, Taoism, Buddhism and seclusion" and admiring the style of Wei and Jin dynasties and famous scholars during the Tang Dynasty; it also presents the diversified cultural integration and the diverse folk life in the eastern Zhejiang region. Thus, the cultural landscape of the Tang Poetry Road has three major characteristics, namely, feelings mingling with scenes, poems mingling with drawings and with accumulation and a long history. In the context of the current construction of China's ecological civilization, this cultural route linked by Tang poetry will definitely become a beautiful ecological belt, a charming humanistic belt, a golden tourism belt and a rich economic belt that can promote urban-rural integration and high-quality development in the whole eastern Zhejiang region.

Declarations

Author Contributions: X.X is responsible for project conceptualization and methodology; X.A completed the data analysis; G.Z is responsible for investigation; ; X.A and S.L is responsible for curation , visualization; X.X and X.A completed the writing of the manuscript ; G.Z and S.L have been reviewed and edited the writing of the manuscript;. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare that they have no competing interests.

Availability of data and materials: Data are available via request xixuesong@cau.edu.cn

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Figures



Figure 1

Map of the number of poets trails

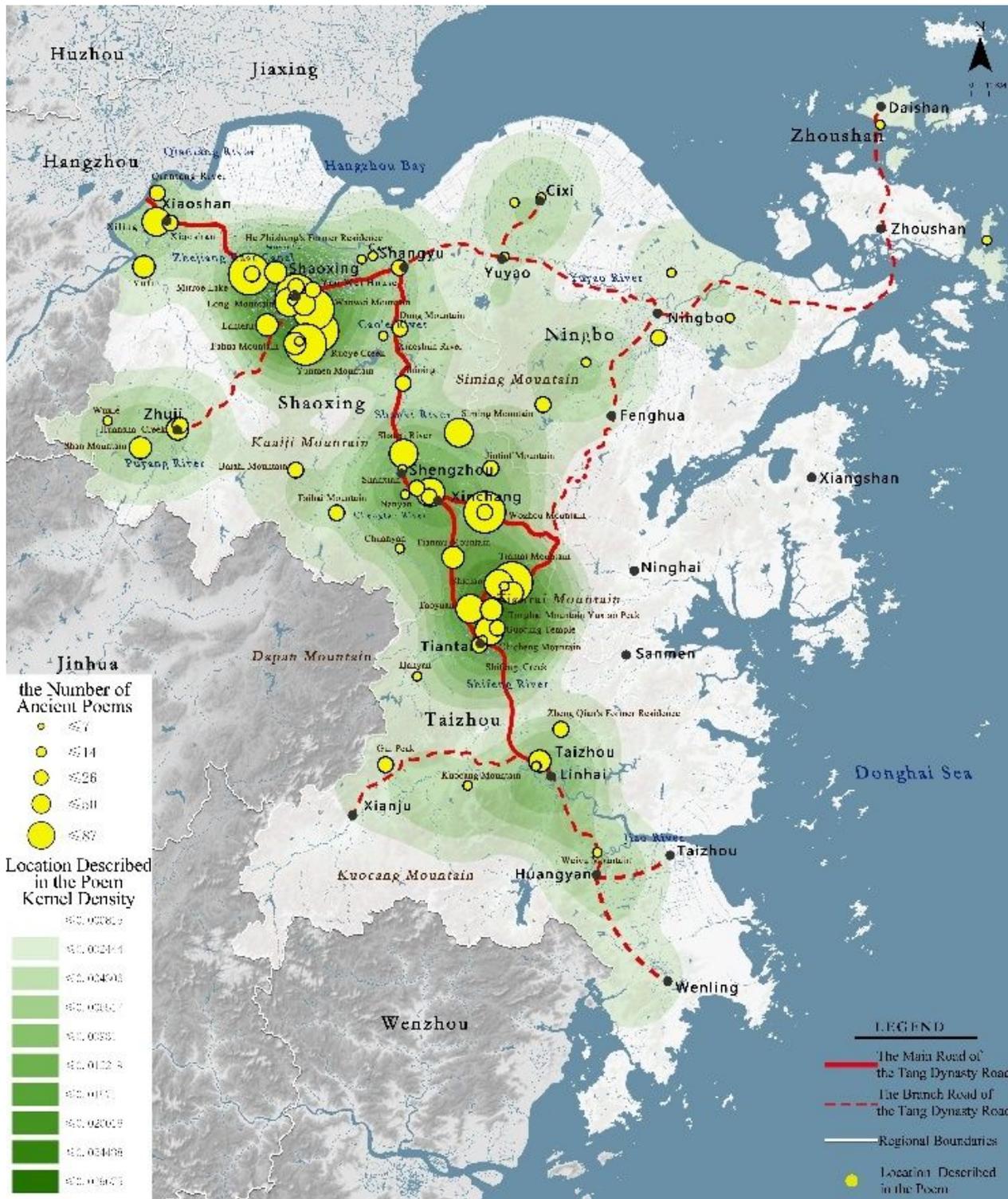


Figure 2

Poem quantitative relationship and kernel density analysis map of ancient poetry described

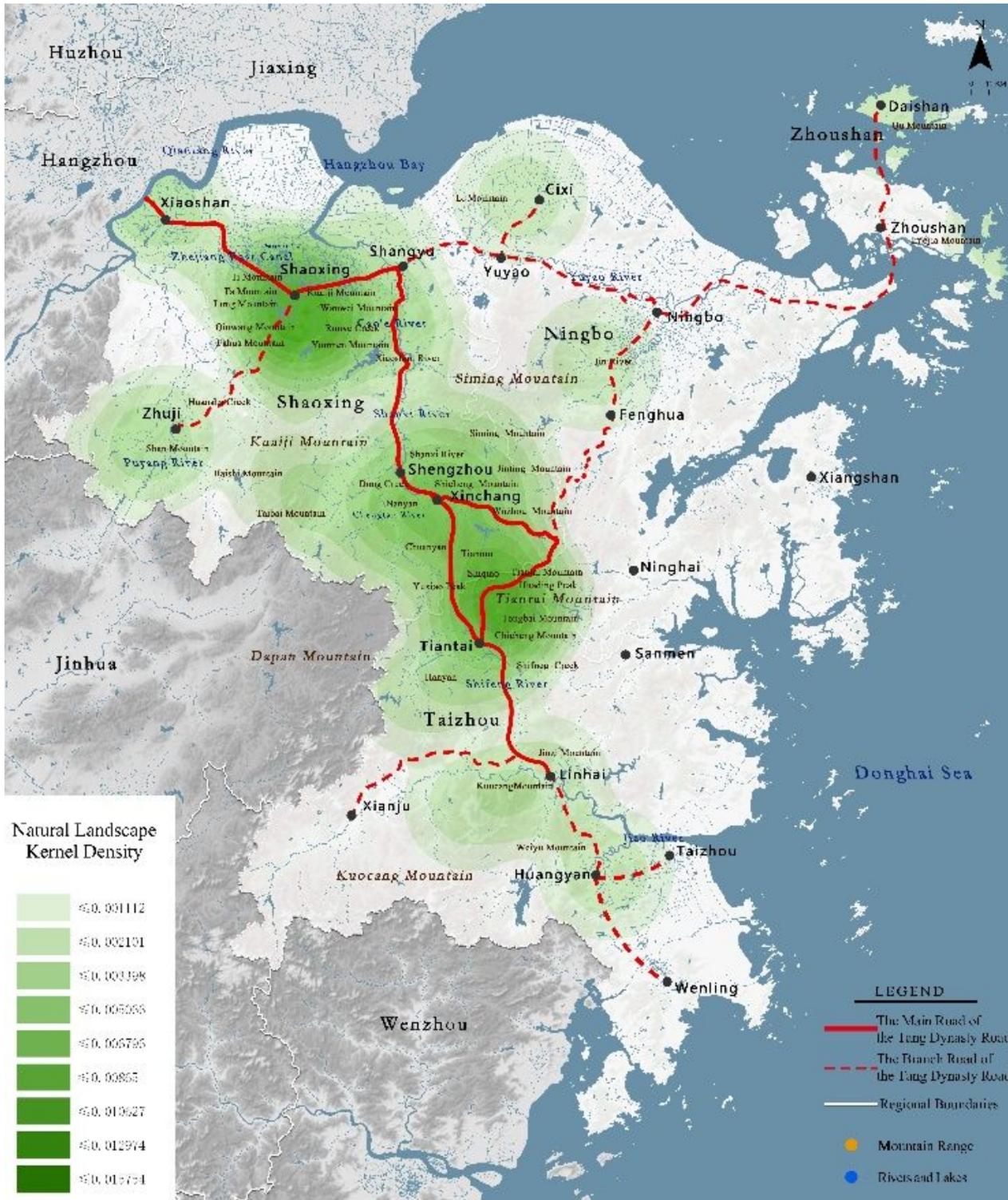


Figure 3

Spatial distribution and kernel density analysis map of natural landscape



Figure 4

Spatial distribution and kernel density analysis map of Buddhist and Taoist cultural landscape

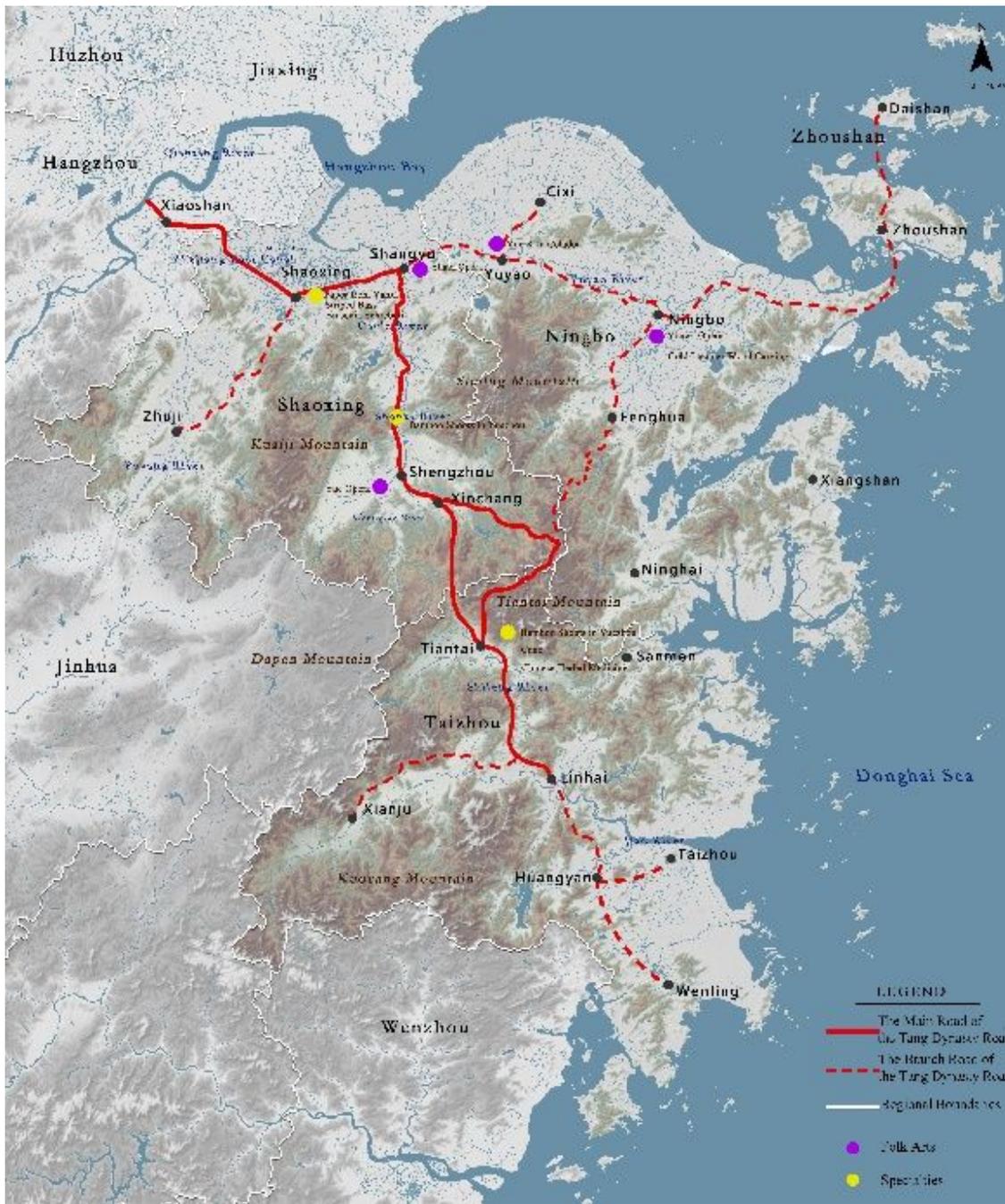


Figure 5

Spatial distribution map of celebrity cultural spot

Figure 6

Spatial distribution map of folk cultural spot

Figure 7

Poet-Person social network

Figure 8

Poet-Place social network

Figure 9

“Landscape – Poet” social network

Figure 10

Statistical chart of the distance from ancient poetry described places to the Road of Tang Poetry